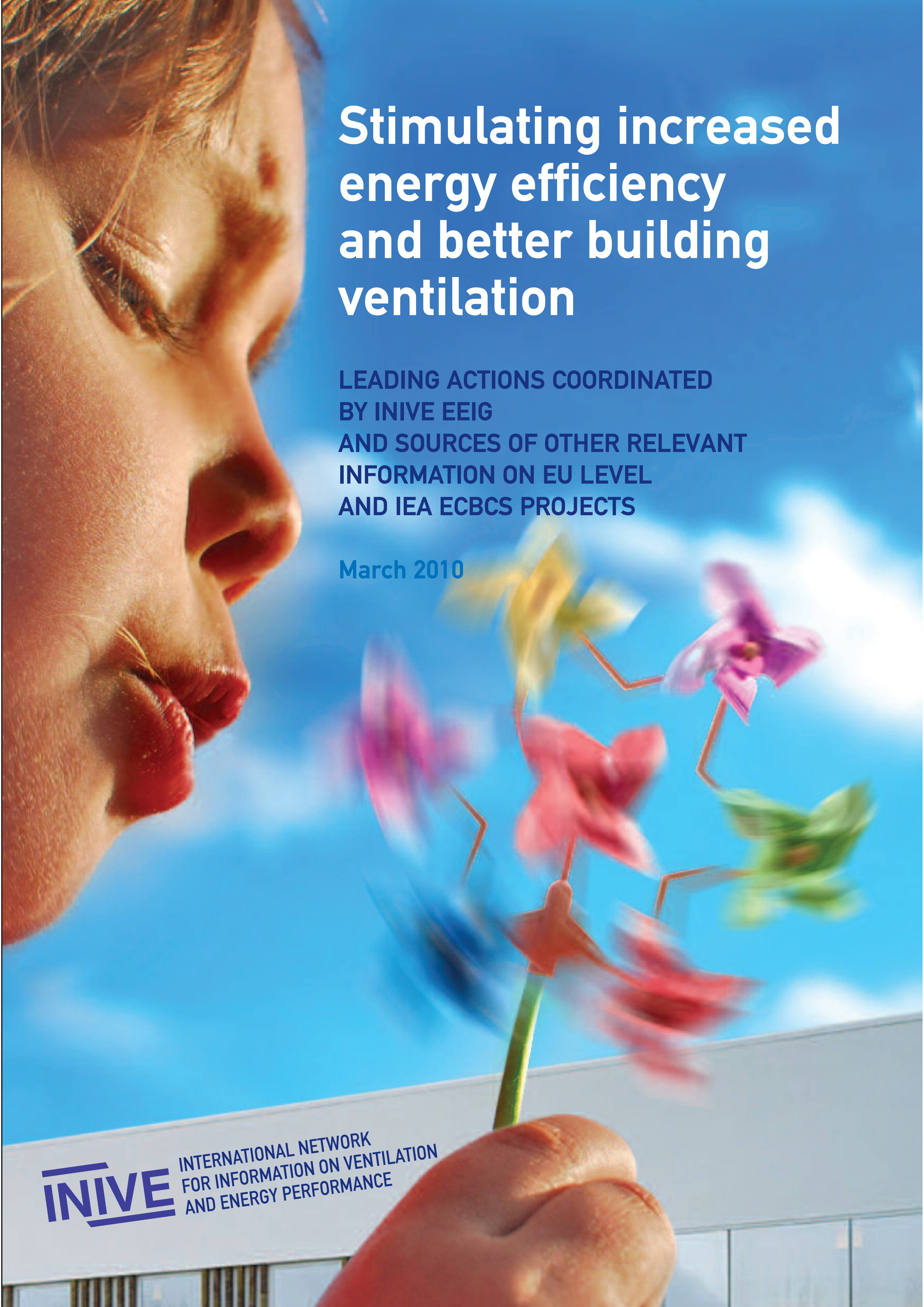

Stimulating increased energy efficiency and better building ventilation

LEADING ACTIONS COORDINATED BY INIVE EEIG AND SOURCES OF OTHER RELEVANT INFORMATION ON EU LEVEL AND IEA ECBCS PROJECTS

March 2010

INIVE
INTERNATIONAL NETWORK FOR INFORMATION ON VENTILATION AND ENERGY PERFORMANCE

Brussels, 2010
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Editors:
Marianna Papaglastra
Peter Wouters

This book is produced by INIVE EEIG
www.inive.org

with specific contributions from EACI and IEA ECBCS

http://ec.europa.eu/eaci *www.ecbcs.org*

including outcomes from ASIEPI, BUILD UP, AIVC and DYNASTEE

www.asiepi.eu *www.buildup.eu* *www.aivc.org* *www.dynastee.info*

This book is co-funded by the Community's Intelligent Energy Europe programme under the contract EIE/07/169/SI2.466278.

Dear Reader,

During the final phase of the ASIEPI project on Assessment and Improvement of the EPBD Impact, the idea of producing a book which presents the major findings from this project was launched. The proposal of producing this book received positive reactions from the members of INIVE EEIG (International Network for Information on Ventilation and Energy Performance) and was even strengthened by the suggestion of widening the scope and also including a presentation of the major outcomes of other projects in which INIVE EEIG and its members have acted or are acting as a coordinator or as key contributors. In the end, we even decided to include information on relevant projects or services related to energy efficiency in buildings from the European SAVE programmes, as well as from projects managed by the International Energy Agency Implementing Agreement on Energy Conservation in Buildings and Community systems (ECBCS).

The book finally consists of 2 parts:

- the 1st part highlights the major outcomes of INIVE led projects and services, i.e. the ASIEPI project, the BUILD UP portal, the Air Infiltration and Ventilation Centre (AIVC) and the DYNASTEE-PASLINK network;
- the 2nd part consists of a series of annexes which provide information on the European SAVE projects and projects managed by ECBCS.

On behalf of INIVE (and its 7 full and 4 associated member organisations), I wish to thank the European Commission and the European Agency for Competitiveness and Innovation for their financial support for ASIEPI, BUILD UP and DYNASTEE/PASLINK and the Executive Committee of ECBCS for their trust and support in relation to the AIVC. We also thank the sponsors of the ASIEPI project for their financial and technical support. Finally, I would like to thank Marianna Papaglastra for editing the book.

We wish you enjoyable reading,

INIVE

On behalf of all INIVE members

Peter Wouters, Manager INIVE EEIG

Europe faces a moment of transformation and 2010 marks a new beginning for many sectors of the economy, not least for the building sector. Europe 2020 has been launched: a strategy for smart, sustainable and inclusive growth. It is along the path to a resource efficient future that we need to give serious consideration to the energy consumption of our buildings. A wealth of tools and knowledge are in the hands of the design community and construction companies that build our homes and workplaces. Yet, although the buildings of the coming decades are being built today, concrete obstacles to their design and construction to high performance standards exist . This is equally true for new constructions or refurbishment, which has its own very demanding requirements both at a technical and socio-economic level.

With this in mind, Europe has adopted a major revision of its Energy Performance of Buildings Directive, setting the legal framework to substantially upgrade national building codes and launching an ambitious policy of nearly-zero energy buildings, so that all new buildings -and an increasing proportion of existing buildings- will be nearly zero energy as of 2020.

The Intelligent Energy – Europe supported project ASIEPI, as part of a suite of policy support actions, has provided valuable insight into pragmatic solutions for improving the impact of our existing building codes, as well as those being prepared for the future. It has been instrumental in demonstrating the benefits of an ambitious and effective implementation of the legislation. Only by sharing its knowledge on these issues can Europe as a whole reap the benefits of a sustainable economy based on knowledge and innovation. Likewise, building cleaner, greener buildings in Europe requires the commitment and the expertise of a variety of actors. This is why the European Commission has launched an initiative like BUILD UP which provides building professionals, public authorities, owners and tenants with a common (web) platform to start working today for the buildings of tomorrow.

Patrick Lambert, Director EACI

The Air Infiltration and Ventilation Centre operates within the framework of the IEA Energy Conservation in Buildings and Community Systems Programme. Since 2001 INIVE has worked in partnership with the AIVC Steering Group and the ECBCS Executive Committee to provide sound management of the operations of the Air Infiltration and Ventilation Centre. The technical output and information dissemination by the AIVC during this period has continued the AIVC's long tradition in strengthening knowledge transfer in the fields of energy efficient ventilation and controlling air infiltration in buildings, while providing good indoor air quality and thermal comfort.

The objective of the AIVC is to be the primary international information centre on research and development in these fields. The following is a summary of some of the highlights of their continuing programme of work:

- The Technical Note series of publications continues to provide authoritative international summaries of relevant technical issues.
- The Ventilation Information Papers present succinct overviews on specific technical issues and national trends.
- The quarterly AIR newsletter allows the research community to receive a summary of the latest information appropriate to their needs.
- The Annual AIVC conferences continue to be premier international research networking and technical events.

Therefore, on behalf of the ECBCS Executive Committee I am pleased to congratulate INIVE on their sustained efforts and activities in supporting energy efficient ventilation and thank them for continuing to support the vision of ECBCS' Air Infiltration and Ventilation Centre.

We are also very pleased with the publication of this book, which not only highlights the deliverables of the Air Infiltration and Ventilation Centre but which also gives information of the activities carried out by other projects within the IEA implementing agreement on energy conservation in buildings and community systems.

Dr Morad R. Atif, ECBCS Executive Committee Chair.

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BUILD UP

BUILD UP

BUILD UP
energy solutions
for better buildings

www.buildup.eu

The European portal for energy efficiency in buildings

Gilles Vaille, PRACSIS
Marianna Papaglastra, INIVE/NKUA

Directorate-General for Energy
EUROPEAN COMMISSION

executive agency eaci
EUROPEAN COMMISSION
for competitiveness & innovation

Intelligent Energy Europe

***BUILD UP** is a European Commission initiative funded by the Intelligent Energy Europe programme (2007-2013). The electronic service is provided by the service providers INIVE eeig, P.A.U. Education and PRACSIS in the form of a service contract signed with the Executive Agency for Competitiveness and Innovation (EACI) on behalf of the European Commission (contract number – EACI/2008/001).*

The electronic service of BUILD UP holds a wide range of interactive forums, resources (e.g. publications, cases, tools, guidelines, news, events) and links to websites from a number of organisations. The European Commission and the service providers take no responsibility for information contained in these interactive forums, resources or linked websites. The views expressed in the interactive forums, resources and linked websites have not been adopted or approved by the EACI or by the service providers and should not be relied upon as a statement of the EACI or the service providers. The EACI and the service providers do not guarantee the accuracy of the information given in the resources or in the forums nor they accept liability for any use made thereof.

Credit photos: shutterstock.com
Last update: March 2010

1. WWW.BUILDUP.EU: A EUROPEAN UNION INITIATIVE FOR IMPROVING THE ENERGY EFFICIENCY OF BUILDINGS

1.1 ROLE AND OBJECTIVES OF BUILD UP

Cutting energy consumption for buildings is essential for reducing costs to owners and occupants while helping meet the EU energy-savings targets to combat climate change and safeguard energy supplies.

On 16 June 2009, the European Commission launched the BUILD UP initiative as a means **of increasing awareness about the potential of energy-savings in buildings** which remains untapped.

www.buildup.eu, the BUILD UP interactive web portal, catalyses and releases **Europe's collective intelligence** for an effective implementation of energy-saving measures in buildings by:

a) **Transferring best practices** of energy savings measures to the market and fostering their uptake; and

b) **Keeping the market updated** about EU energy policy for buildings.

Fig. 1: Specific solutions offered depending on the audience

The key aim of BUILD UP is **to improve the energy performance** across Europe by enabling building professionals, public authorities and building occupants to share their experience on how to reduce energy consumption.

1.2 USERS OF THE WEB PORTAL

- **Building professionals** improve their skills, share expertise with their peers, learn more about the latest energy related legislation, get inspired by interesting realised case examples, discover useful tools and access the latest news, events and publications in the field.

Building professionals are directly impacted by the Energy Performance of Buildings Directive, so they benefit from the BUILD UP Initiative in two ways:

1. **Know-how**: BUILD UP informs them about best practices for energy performance of buildings while providing tools to meet their needs and raise their awareness about EU energy policy for buildings.

2. **Commitment & conviction**: By allowing them to network with their peers and foster new ideas for better buildings, BUILD UP contributes to including energy savings and renewable energy practices and criteria in the usual business of building professionals.

Fig. 2: How to enter the tailored database for BUILDING PROFESSIONALS

- **Public authority staff** responsible for energy issues at national or local levels have access to many resources on relevant European pieces of legislation and national policies, as well as to upcoming events, useful tools and guidelines produced by other cities, regions or countries.

Considering the existing communication channels, the BUILD UP web portal first helps policy makers (national/regional/local authorities, energy agencies, etc.) by **further improving their knowledge and communicating their own national legislation** throughout the building professionals and the citizens. For this purpose, BUILD UP gives simple as well as clear detailed information regarding the EPBD implementation in each Member State. Furthermore, public authorities are given access to (information on) tools, best practices and projects developed in Europe.

Fig. 3: How to enter the tailored database for PUBLIC AUTHORITIES

- **Home owners and tenants** learn about energy efficiency and how to reduce the energy costs of their homes and find out where to obtain practical information on energy-savings in their own country or region.

This target group is important as end-users are often in the best position to benefit from energy-saving measures. Through BUILD UP, citizens are informed by **simple and clear information** on relevant pieces of legislation (e.g.: Energy Performance of Buildings Directive), as well as **national or regional implementing measures**, and by easily re-routing them to the **relevant authorities or facilitators**. BUILD UP is therefore not substituting for national information campaigns, but really acts **as a catalyst**.

Fig. 4: How to enter the tailored website for citizens (http://www.buildup.eu/citizens/en)

2. FEATURES OF THE BUILD UP INTERACTIVE WEB PORTAL

2.1 INFORMATION AND COMMUNICATION TECHNOLOGIES

The BUILD UP web portal is a novel, state-of-the-art, fully dynamic and interactive communication platform, including all the latest generation elements and **advanced multi-media functionalities.**

BUILD UP allows its users to easily update and enhance web content themselves.
Once having registered free to BUILD UP, users can, through various information technology tools:

- **Stay alert to new submissions in the different sections** (e.g.: through RSS Feeds for News, Events, Publications, Links, Cases, Tools, Blogs, and/or Communities)
- **Rate available content** (Awesome*****, Great****, Good***, Okay**, Poor*)
- **Propose own contents** (e.g.: News, Events, Publications, Links, Cases, Tools, Blogs, and/or Communities)
- **Comment articles** and link to additional relevant information
- **Initiate discussions** (blogs)
- **Tell their networks**

The interface of www.buildup.eu is available in several languages, so that it is easy to find proper information.

2.2 EXPERTISE

BUILD UP enables the transfer of expert know-how by providing **resources of information, best examples and tools to improve the energy performance of buildings** in any of the official EU languages through the sections described below.

2.2.1 THE BUILD UP COMMUNITIES: LEARNING FROM EACH OTHER

Umbrella organisations such as energy agencies, industrial associations and non-governmental organisations with an interest in energy-savings in buildings **tell others about their activities and share their successes** directly and through thematic virtual communities.

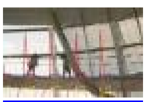
The concept of Communities is an essential new feature of the BUILD UP interactive web portal. **Communities are dedicated, dynamic and closed discussion forums on specific topics**, meant as instruments for **bringing together key actors with a common interest**, enhancing interaction by animating discussions and providing relevant inputs. The facilitator(s) and members of a Community:

- Share and exchange information on a certain energy efficiency related sub-topic
- Issue specific newsletters to members of the Community
- Talk about a particular issue
- Set up and share calendars

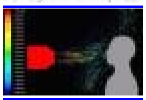
Fig. 5: The BUILD UP Communities' page (http://buildup.eu/communities)

The Community facilitator administers, animates and maintains the Community. The facilitator can invite new members to join the Community, assign additional facilitators and can also help to plan events or a workshop for the group. An active and stable Community rewards facilitator(s) with professional recognition, a larger network of contacts and extensive visibility on BUILD UP.

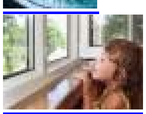
As of March 2010, there are 18 **BUILD UP Communities online**:

 Community on energy performance calculation procedures

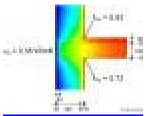
 Energy Performance of Buildings Directive Community

 Energy efficient ventilation for healthy buildings

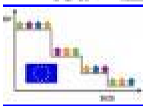
 Leading examples of public buildings

 Windows, Doors, Curtain Walls

 Solar shading



[Thermal Bridges Forum](#)



Minimum Energy Performance Requirements

Community on requirements for experts and inspectors

Certification schemes

Energy efficiency policies in 5 continents

Promoting passive house standard and very low energy buildings

Inspection of boilers and air-conditioning systems

Energy Performance Contracting (EPC)

Sustainable Social and Cooperative Housing

Software for Building Energy Performance

A Common Language for Sustainable Construction

Harmonization of Energy and Sustainability Metrics for the measurement of the impact of the built environment

2.2.2 Blogs

One part of the interactive features of BUILD UP is the Blogs section, where **users post comments to specific contents, initiate discussions on specific topics and share their opinions**.

Fig. 6: Example of the Blogs section

2.2.3 CASES

The database of cases is an important instrument for **sharing good practice experiences and transferring know-how through real life examples of efficient buildings**. Each month, a new case is being highlighted with pictures, and the lessons learnt are essential to take into account.

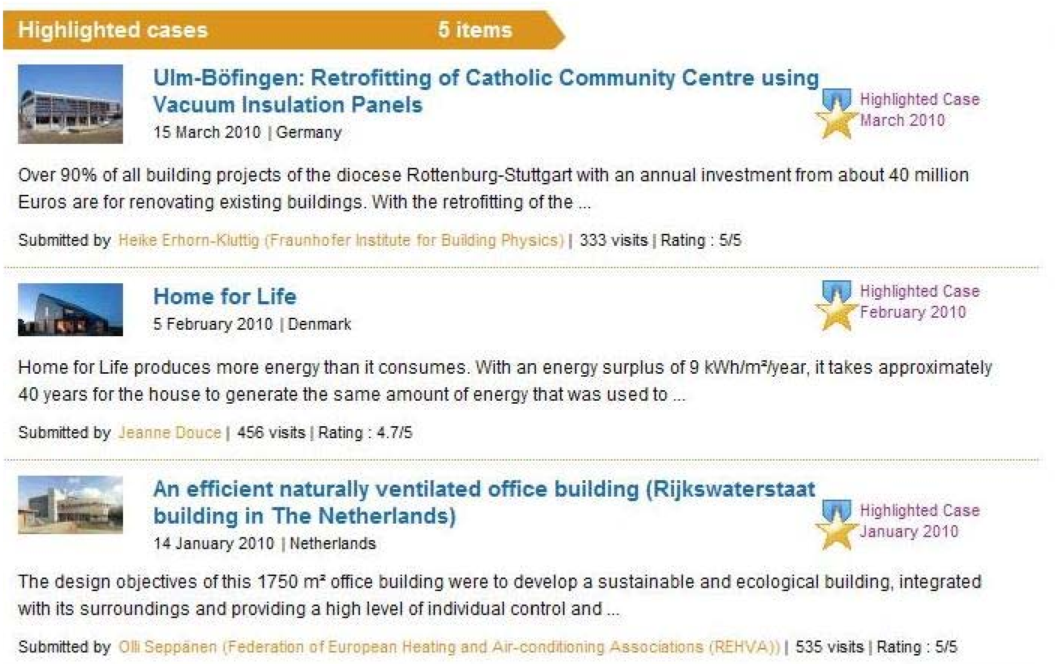
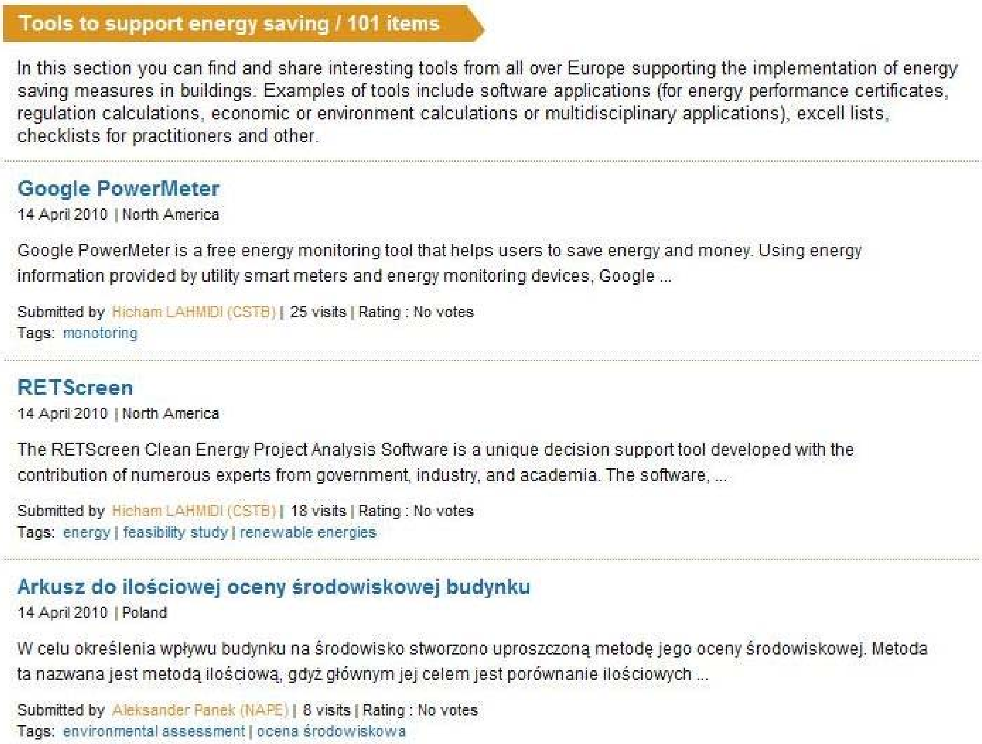


Fig. 7: Example of the sub-section of monthly highlighted cases

A short abstract and a detailed description are also provided together with links for further useful information.

2.2.4 TOOLS

This newly generated section presents interesting tools from all over Europe that **support the implementation of energy saving measures in buildings**. Examples of tools include **software applications** (for energy performance certificates, regulation calculations, economic or environment calculations or multidisciplinary applications), **Excel lists**, **checklists for practitioners** and others.



Tools to support energy saving / 101 items

In this section you can find and share interesting tools from all over Europe supporting the implementation of energy saving measures in buildings. Examples of tools include software applications (for energy performance certificates, regulation calculations, economic or environment calculations or multidisciplinary applications), excell lists, checklists for practitioners and other.

Google PowerMeter
14 April 2010 | North America

Google PowerMeter is a free energy monitoring tool that helps users to save energy and money. Using energy information provided by utility smart meters and energy monitoring devices, Google ...

Submitted by Hicham LAHMIDI (CSTB) | 25 visits | Rating : No votes
Tags: monotoring

RETScreen
14 April 2010 | North America

The RETScreen Clean Energy Project Analysis Software is a unique decision support tool developed with the contribution of numerous experts from government, industry, and academia. The software, ...

Submitted by Hicham LAHMIDI (CSTB) | 18 visits | Rating : No votes
Tags: energy | feasibility study | renewable energies

Arkusz do ilościowej oceny środowiskowej budynku
14 April 2010 | Poland

W celu określenia wpływu budynku na środowisko stworzono uproszczoną metodę jego oceny środowiskowej. Metoda ta nazwana jest metodą ilościową, gdyż głównym jej celem jest porównanie ilościowych ...

Submitted by Aleksander Panek (NAPE) | 8 visits | Rating : No votes
Tags: environmental assessment | ocena środowiskowa

Fig. 8: Example of the Tools section

2.2.5 NEWS

Short highlights of recent and important developments in the field of energy efficiency in buildings from across Europe are given.

Fig. 9: Example of Top News

On a monthly basis, an e-newsletter is being created and distributed for free among more than 3,000 subscribers. **Registration to the BUILD UP Newsletter is possible through** http://www.buildup.eu/newsletter.

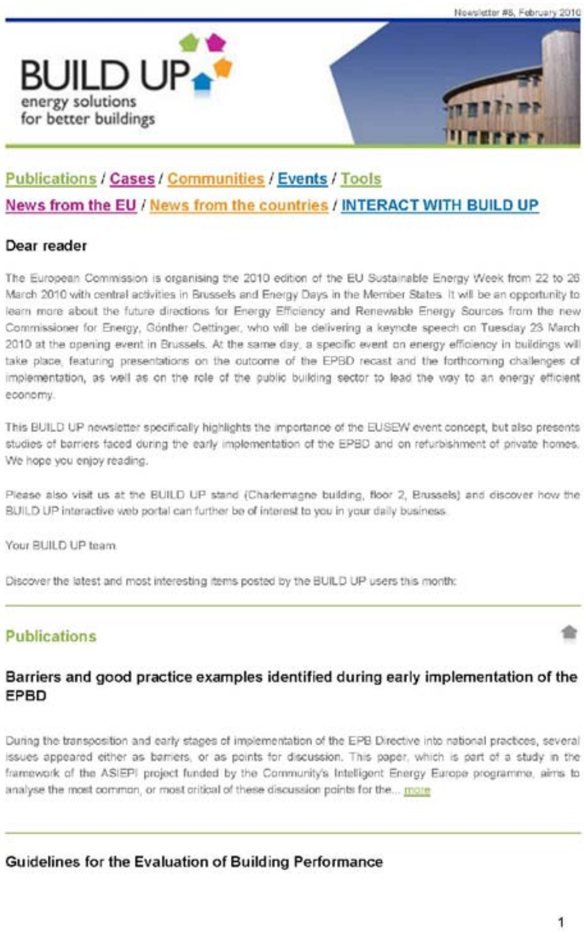


Fig. 10: BUILD UP Newsletter of February 2010

2.2.6 PUBLICATIONS

The Publications section is a **frequently updated database of energy efficiency related publications either technical or legislative**: guidelines, reports, regulations, information papers, studies and training material.

Fig. 11: Example of the Publications section

2.2.7 EVENTS

Fig. 12: Example of Top Events

In the Events section, users **announce relevant upcoming events in the field of energy efficiency in buildings**. The event programme, guidelines for registration and links for further information can be uploaded. A calendar overview facilitates access to this comprehensive database day by day.

Fig. 13: Example of the Calendar page of events in March 2010

2.2.8 LINKS

The Links section gives a list of resources to relevant information, official websites, **links to public, commercial, EU or national organisations** related to energy efficiency and buildings, targeted at building professionals, public authorities and citizens.

Fig. 14: Example of the Links section

2.2.9 FREQUENTLY ASKED QUESTIONS

The "FAQ" section is a selected list of key questions on technical or legislative topics related to the subject of energy efficiency in buildings, asked by third parties and answered by BUILD UP experts.

Fig. 15: Example of the FAQ section

3. THE BUILD UP EMBEDDED PAGE FUNCTION

3.1 INTRODUCTION

The BUILD UP embedded page function consists of a frame containing BUILD UP content, which is directly embedded on relevant external websites. BUILD UP Partners, professional associations or platforms advocating for energy efficient buildings, are eligible to integrate the BUILD UP embedded page function on their own websites. Concretely, the **items highlighted in a BUILD UP Community are automatically shown on the website** of an association, for instance, which is keen to enhance its website by using the data available on BUILD UP.

The BUILD UP embedded page function can boost your website. Within a win-win solution perspective, the concept **eases access to tailored information, avoids duplication of efforts to share best practices,** while ensuring a high-level quality of contributions taken from the official BUILD UP web portal.

3.2 A CONCRETE EXAMPLE

Fig. 16: Example of the BUILD UP embedded page function on REHVA's website

4. MARKETING ACTIVITIES

4.1 PARTNERS DESK

The **BUILD UP Public Relations Desk** delivers an improved Partnership Agreement with European organisations, and ensures a close follow-up of the implementation of these agreements. In addition, the BUILD UP Public Relations Desk ensures as much as possible a close cooperation with other key EU initiatives.
A Partnership agreement is set up with key umbrella and network organisations that have a powerful dissemination impact in the framework of the EPBD.

Fig. 17: The BUILD UP Partnership Agreement

4.2 MEDIA DESK

The **BUILD UP Media Desk** implements a focused and regular approach with journalists and media officers and deliver press clippings (http://www.buildup.eu/press). The promotional material includes adapted electronic and printed tools.
Webvertising actions are run on online specialised media in Member States.

4.3 VISIBILITY AT FAIRS AND LARGE EVENTS

A series of events, where the presence of BUILD UP is recommended, are identified and selected. They are **international, national or regional congresses, events, workshops or fairs on the construction / energy field**.
For example, the EU Sustainable Energy Week is the annual reference event dealing with energy efficiency and renewable energy sources in Europe. It takes place every year in Spring simultaneously in Brussels and in Europe.

4.4 ORGANISATION OF BUILD UP USERS AND STAKEHOLDERS COMMITTEES

A couple of meetings per year are organised regularly with the users of BUILD UP, so that needs and expectations from the end-user perspective are understood and undertaken.

4.5 PROMOTIONAL MATERIAL

Along all activities, a set of **comprehensive promotional material** is developed and available, in accordance to communication needs (http://www.buildup.eu/communicationstools).

- BUILD UP Leaflets in 22 EU languages

Fig. 18: One side of the BUILD UP Leaflet in English

Fig. 19: The BUILD UP Poster

- BUILD UP Logo in 22 EU official languages
- BUILD UP Print advertorial in English
- BUILD UP Standard Presentation
- BUILD UP Poster in English
- BUILD UP Stand (1 panel, 1 desk, 2 roll-ups)

Fig. 20: The BUILD UP Stand during the EU Sustainable Energy Week 2010

- Press releases in English
- Banners
- Etc.

5. BUILD UP PARTNERS

5.1 ELIGIBILITY TO BECOME A BUILD UP PARTNER

BUILD UP Partners are **well-established umbrella and network organisations committed to energy efficiency in buildings across Europe**. As they have a clear vocation to serve the public interest or represent the interest of industrial sectors, these organisations are able to offer a range of multiplier actions through their diverse and effective communication channels.

BUILD UP Partners contribute successfully to improving the energy performance of buildings through their **powerful network of contacts** and their own competencies in their respective areas of work. Through a range of promotional actions they significantly **increase the visibility of the BUILD UP initiative and its web portal**.

5.2 THE BUILD UP PARTNERS

Last update: March 2010

BUILD UP Partners are key allies of the European Commission in the pursuit of a common interest: the wider implementation of energy-saving measures for better energy efficient buildings throughout Europe.

As BUILD UP Partners (http://www.buildup.eu/partners), the following organisations commit themselves to share, on the BUILD UP interactive web portal, their experience on how to cut energy consumption in buildings.

For information on how to become a BUILD UP Partner:

6. THE BUILD UP CONSORTIUM

6.1 THE BUILD UP MANAGEMENT

The bringing together of contemporary information technologies, sound content expertise and modern marketing know-how requires excellent understanding of the various needs and languages spoken, that ensure **close interaction, information exchange and co-ordination of all the parties involved**. This is the main activity of the management team, together with the effective involvement of the stakeholders and users in the implementation of the strategy.

6.2 THE BUILD UP CONSORTIUM

International Network for Information on Ventilation (INIVE)
www.inive.org

Public Relations and Communication Strategy (PRACSIS)
www.pracsis.be

P.A.U. Education
www.paueducation.com

INIVE MEMBERS:

Belgian Building Research Institute (BBRI)
www.bbri.be

Centre Technique des Industries Aérauliques et Thermiques (CETIAT)
www.cetiat.fr

Scientific and Technical Centre for Building (CSTB)
www.cstb.fr

Fraunhofer Institute for Building Physics (Fraunhofer-IBP)
www.ibp.fraunhofer.de

National & Kapodistrian University of Athens (NKUA
http://grbes.phys.uoa.gr/

Netherlands Organisation for Applied Scientific Research (TNO)
www.tno.nl

6.3 SUBCONTRACTORS

Federation of European Heating, Ventilation and Air-conditioning Associations (REHVA)
www.rehva.eu

Danish Building Research Institute (SBi)
www.SBi.dk

Sympraxis Team
www.sympraxis.eu

Faculty of Engineering of the University of Porto (FEUP)
www.fe.up.pt

National Energy Conservation Agency (NAPE)
www.nape.pl

Dutch Building Services Research Institute (ISSO)
www.isso.nl


BUILD UP
energy solutions
for better buildings
www.buildup.eu
The European portal for energy efficiency in buildings

BUILD UP
energy solutions
for better buildings

- **Find the latest resources** concerning energy efficient buildings. A lot of publications are available as well as a great deal of news, free tools and best working practices gathered from all over Europe.

- **Post your own materials** on the web portal directly. By posting, for instance, your own guidelines, articles, events and news, you will gain visibility and recognition at EU level. All the materials can be posted in English or in your own language.

- **Share knowledge with your peers**. BUILD UP is an interactive web portal which allows you to exchange information with people who share the same interest. Join the virtual communities to be kept informed and have privileged access to specific calendar, news and publications. The communities are also great opportunities for networking.

www.buildup.eu the European portal for energy efficiency in buildings
Find resources *Post your materials* *Share knowledge…*

IEEE SAVE ASIEPI

ASIEPI

ASsessment and **I**mprovement of the **EP**BD **I**mpact
(for new buildings and building renovation)

www.asiepi.eu

ASIEPI is supported by

Intelligent Energy Europe

SUMMARY

The main objective of the ASIEPI project (www.asiepi.eu) has been to formulate suggestions to policy makers on how to improve the quality and the impact of the regulations on the energy performance of buildings with respect to 6 specific topics that constitute particular challenges in the Energy Performance of Buildings (EPB) regulations:

- intercomparison of the levels of the EP-requirements
- impact, compliance and control of legislation
- effective handling of thermal bridges
- stimulation of good building and ductwork airtightness
- support for the market uptake for innovative systems
- stimulation of better summer comfort and efficient cooling

This chapter on the ASIEPI project is a collective presentation of the project results: it comprises of a brief description of the main challenges, highlights the major recommendations and gives guidance on where to find additional and background information on each one of the above mentioned topics.

Disclaimer: ASIEPI has received funding from the Community's Intelligent Energy Europe programme under the contract EIE/07/169/SI2.466278.

General project description

INTRODUCTION

WHAT IS THE ASIEPI PROJECT

ASIEPI is the acronym of the full project name:

ASsessment and **I**mprovement
of the **EP**BD **I**mpact
(for new buildings and building renovation)

The project took two and a half years and was completed in March 2010.

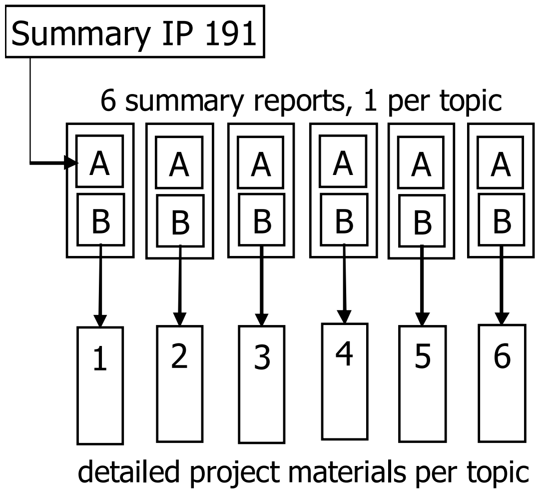
The main objective of the ASIEPI project has been to formulate suggestions to policy makers on how to improve the quality and the impact of the regulations on the energy performance of buildings with respect to 6 specific topics:

- intercomparison of the levels of the EP-requirements
- impact, compliance and control of legislation
- effective handling of thermal bridges
- stimulation of good building and ductwork airtightness
- support for the market uptake for innovative systems
- stimulation of better summer comfort and efficient cooling

Several major aspects of each of the topics have been analysed. The results are documented in a full suite of project data. Among others, these data provide insight in the potential problems and give guidance with respect to possible solutions. However, as the project had to conform to the objectives of the IEE-SAVE programme, no new, ready-to-use methods were developed, but instead awareness of the challenges was raised and existing best practice to achieve more effective EPB-regulations were highlighted.

PROJECT MATERIALS

The ASIEPI project has produced a broad set of dissemination materials.



As illustrated in the figure, the project results are structured as follows:

- An information paper (IP191) briefly summarises the main conclusions and constitutes the gateway to the project.
- 6 summary reports are each dealing with 1 of the topics listed above. The summary reports all consist of a Part A which describes the major findings and the final recommendations on the topic and a Part B that gives a synthetic overview of all the other information that the project has made available on that topic.
- Finally, a wide range of information materials provide a more comprehensive, in-depth coverage of

many different aspects of each of the topics.

The different project outcomes come in a variety of electronic formats:

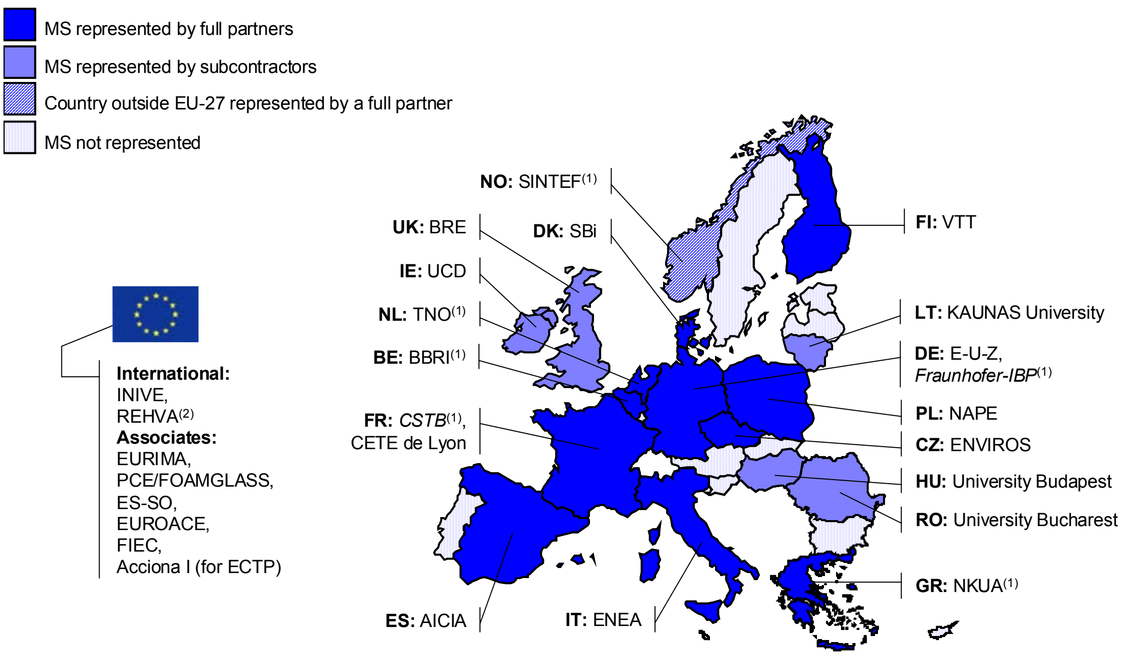
- summary reports
- detailed technical reports
- information papers
- recordings of internet information seminars
- presentations-on-demand
- conference abstracts and papers
- other related material, such as documents supplied by third parties

All materials are available on the project website www.asiepi.eu.

PROJECT PARTNERS

As shown in the figure, the project had full partners in 12 countries and subcontractors in 5 more countries. Furthermore, there were 6 Europe-wide associations acting as associated partners.

Through this large number of countries involved, a good reflection was obtained of the EPB-practices across all of Europe at the time of the project. For most topics, surveys have been made in these countries in order to see how the EPB-regulations deal with each of the issues.



(1) INIVE member
In the MS where there are two participants, the national contact point is in *italic*.

HOW TO READ THIS CHAPTER

This chapter on ASIEPI continues with Information Paper IP191, which is a comprehensive summary of all the main conclusions and recommendations of the project. This Information Paper constitutes the gateway to the project.

Consecutively, each one of the 6 specific topics is dealt with in detail. Per topic, first the summary report is presented, which includes Part A - Final recommendations and Part B - Bird’s eye view of the project results. Part C is a collection of all the produced Information Papers on the specific topic and in Part D the respective organised web events on the topic are briefly presented.

This structure allows the reader to choose whether to form a general idea about all the project findings and recommendations, or to focus specifically on all the details gathered and available on a certain topic of interest.

After the presentation of all 6 specific topics follow the general project acknowledgements. The first part of the acknowledgements is "Acknowledgements to contributors" which lists all the organisations that participated in the project, together with their contributing collaborators. Then, the 6 Europe-wide associations acting as associated partners are listed in "Acknowledgements to sponsors, other associates and funding partners", together with the national co-funding agencies.

Finally, the 4 ASIEPI sponsor organisations and their activities are briefly presented.

P191

31.03.2010

Summary of the recommendations of the ASIEPI project

Dirk Van Orshoven
Belgian Building Research Institute (BBRI)
Belgium

The other co-authors are mentioned on their respective pages.

All project materials are available on the project website: *www.asiepi.eu*

Note: in order not to burden this IP, it does not contain explicit references. The reader is referred to the summary reports and all the other project materials for the foundations of the recommendations and for more detailed treatment of the different topics: see §.8 on p.8 of this IP for further orientation.

Partner countries in ASIEPI

Similar Information Papers by ASIEPI and by other European projects can be found on the individual project websites and in the publications database of the BUILD UP Portal: *www.buildup.eu*

The main objective of the ASIEPI project has been to formulate suggestions to policy makers on how to improve the quality and the impact of the regulations on the energy performance of buildings with respect to 6 specific issues. This paper gives a brief overview of the major recommendations for each of these 6 topics, and serves as a general introduction to the project.

1 > What is the ASIEPI project?

The full project name is:

ASsessment and Improvement of the EPBD Impact
(for new buildings and building renovation)

This has been abbreviated to the acronym ASIEPI. The project took two and a half years and was completed in March 2010.

The focus has been on 6 specific topics that constitute particular challenges in the Energy Performance of Buildings (EPB) regulations:

- intercomparison of the levels of the EP-requirements
- impact, compliance and control of legislation
- effective handling of thermal bridges
- stimulation of good building and ductwork airtightness
- support for the market uptake for innovative systems
- stimulation of better summer comfort and efficient cooling

The main objective has been to formulate suggestions for policy development.

The project had full partners (dark blue) in 12 countries and subcontractors (light blue) in 5 more countries. Furthermore, there were 6 Europe-wide associations acting as associated partners. In this manner, a good reflection was obtained of the EPB-practices across all of Europe at the time of the project. For most topics, surveys have been made in these countries in order to see how the EPB-regulations deal with each of the issues.

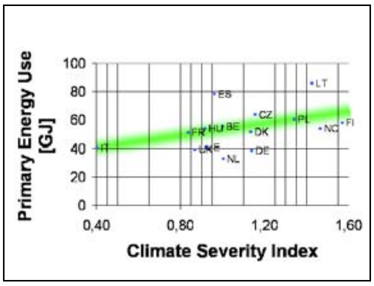
Different aspects of each of the major topics have been analysed. The results are documented in a full suite of project data. Among others, these data provide insight into the potential problems and give guidance with respect to possible solutions. However, as the project had to conform to the objectives of the IEE-SAVE programme, no new, ready-to-use methods were developed, but instead awareness of the challenges was raised and existing best practices to achieve more effective EPB-regulations were highlighted.

This paper briefly summarises the major suggestions with respect to each of the topics. These recommendations are then discussed in more detail in the final reports. The relationship between these reports and all the other project results is further explained in §.8 on p.8 of this paper.

Intelligent Energy Europe

Marleen Spiekman
TNO
Netherlands

All project material on this topic can be accessed through *http://www.asiepi.eu/wp2-benchmarking.html*, and its subordinate pages.



The comparison method developed in ASIEPI will lead to three groups: an average group, a group which is a bit better and a group which is a bit worse than average.

This ‘three-group approach’ is seen as a big advantage of the method, since there are a lot of catches in the rest of the method to give a robust ranking of countries anyway.

The graph shows the total primary energy use for the semi-detached houses used in the comparison method.

2 > Intercomparison of the levels of the EP-requirements

Comparing the energy performance requirement levels among the countries of Europe constitutes a major challenge. From the comparison of for instance the Dutch requirement level of 0,8 with the Flemish level of E80, it is obvious that direct comparison is not possible. Within ASIEPI a method for comparing EP requirement levels was developed and while doing so, several lessons were learned which led to the following conclusions and recommendations:

- Although it seems easy to make a comparison of EP requirement levels between countries, it is, in fact, difficult to propose a fair and effective comparison method. In this respect care must be taken when interpreting the comparison results, since it is hard to completely understand a comparison study if all the boundary conditions are not known, and conclusions might therefore be misleading.
- Countries take into account a different set of energy uses in the assessment method of the EP requirements. Some only take into account heating and cooling needs, while others also incorporate heating and cooling systems, hot water and/or lighting. This is a problem for comparison since the methods are *performance* methods not *component* methods: a moderately insulated house with an efficient hot water boiler can be as effective as a very well insulated house with a less efficient hot water boiler. If the boiler is not taken into account in some countries, by definition this is like comparing apples with oranges.
- In addition, there is no harmonised way of assessing building components and systems. Current standards often mix common procedures with national choices, which make comparing assessment results far from evident.
- The previous two issues make effective comparison at this stage simply impossible. The situation will partly change due to the recast of the EPBD which explicitly demands that countries broaden the scope of their EP assessment to include technical systems, hot water and lighting. Continuing the development of harmonising CEN Standards is recommended because these are crucial for proper comparison. Relevant measures should be a variable part of the national EP methods and also CEN Standards should address all these relevant national measures, to make a uniform assessment possible. To achieve this it is important that all countries support the European methods. Developing European methods should be done by the intensive involvement of Member States.
- The severity of energy performance requirement levels varies within countries with, for example, building types, shapes, and system choices. Therefore, a simple ranking among countries does not exist, which makes comparison prone to unfair comparisons or even manipulation.
- The method developed within ASIEPI is far from perfect, but taking into account the complexity of the task, it is a good start. It is designed to suit the expected future developments, e.g. within CEN and ISO, which will make the comparison method more suitable in the future. The method includes an index to incorporate the severity of the climate.
  In general accuracy of say more than 20% will probably never be achievable for a comparison, even if in the future improved boundary conditions, such as more uniform EP-methods, would be put in place.
- Since the need for European and worldwide comparison of energy use will expand, further development of the climate severity index within CEN and ISO is recommended.

Aleksander Panek
NAPE
Poland

All project material on this topic can be accessed through *http://www.asiepi.eu/wp-3-compliance-and-control.html*, and its subordinate pages.

The main achievement of the work package was the elaboration of state of the art reports on Impact, Compliance and Control in: Belgium, Czech, Denmark, Finland, France, Germany, Greece, Hungary, Italy, Lithuania, Netherlands, Norway, Poland and Spain

and 4 synthesis reports on
1. Evaluation of impact of national EPBD implementation in MS,
2. Evaluation of compliance and control in the different member states,
3. Barriers and good practice examples,
4. Identification of interesting approaches and possible bottlenecks for compliance and control of regulations

Above reports are also available in form of IP and can be found on *www.buildup.eu*

Schwartz's seven cultural value orientations

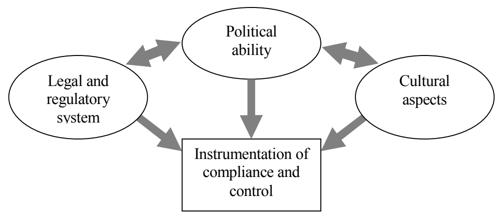
Was one of main dissemination activity of work package.

3 > Impact, compliance and control of EPBD regulations

The EPBD only imposes Member States (MS) to set requirements without any specification about the severity of the requirements, nor about the measures to be taken regarding the control on implementation. As such, MS can fulfil the requirements of articles 4 to 6 without increasing the original levels of requirement and without carrying out any kind of control.

A good view about the impact of the present EPBD on the requirements and how MS handle the compliance of requirements was a main goal of the ASIEPI project.

Compliance and control is an essential part of a successful implementation of the European Energy Performance of Buildings Directive (EPBD). The effectiveness of a compliance and control strategy is affected by three context related factors:



- How compliance and control is organised has to meet the **legal and regulatory system** of a country. For instance in case of a Member State where the responsibility is strongly delegated to regions, the federal legal structure might act as a framework to facilitate the regions to design their approach. In those Member States a centralised organization is not very likely and centralised control is not possible and diversity in compliance and control instruments can occur.
- Secondly, the **cultural aspects** related to the interaction between society and the government play an important role. The relationship between citizens and authorities depends on values that vary from country to country. In some countries a very strict enforcement is implemented, while in other countries the authorities can apply alternative control schemes partly based on self regulation.
- A third important aspect that affects the effectiveness is the **political views**. Policy priorities at a given time might not be fully in line with the objectives of the EPBD. The motivation to take the energy issue a step further does not always exist. Within the political spectrum the need for substantial CO_2-reduction is not endorsed by every party.

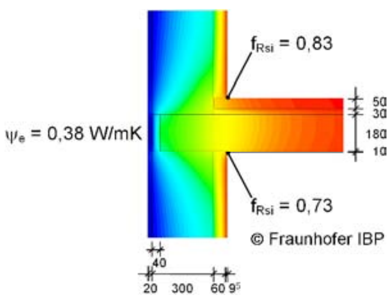
Main recomendations and findings from reports collected:
- The various reports show a **significant variation in EPBD implementation**, with considerable differences in impact, compliance and control. The proposed recast may accelerate harmonisation within this process.
- **Not all countries** have **yet fulfilled all the requirements imposed by EPBD**. As guardian of the European Treaty, the European Commission must continue its efforts regarding infringement procedures.
- **It is essential to have an integrated approach** which covers all energy related building components and service systems to stimulate cost-optimised energy performance targets. In several Member States **interesting compliance and control approaches exist,** which do not increase the administrative burden.
- In addition, it is also important (to continue) **to promote awareness and motivation actions** e.g. educational and information campaigns.
- There are **success stories regarding market uptake** of innovative systems and technologies, whereby the **EPBD regulations have worked as a major driver for market uptake**.

Hans Erhorn
Heike Erhorn-Kluttig
Fraunhofer Institute for
Building Physics
Germany

All project material on this topic can be accessed through *http://www.asiepi.eu/wp-4-thermal-bridges.html*, and its subordinate pages. A main result is the final report of the topic **"An effective Handling of Thermal Bridges in the EPBD Context"**.

Tasks concerning thermal bridges addressed within ASIEPI:

- EU Member States' approaches in regulations
- Quantification of thermal bridge effects to the energy balance
- Used software tools and thermal bridge atlases
- Available good practice guidance
- Promotion of good building practice
- Execution quality
- Advanced thermal bridge driven technical developments



Example of a thermal bridge effect at a concrete ceiling embedded in the external wall. Calculation of the thermal bridge loss coefficient and the dimensionless temperature coefficient. The colours illustrate the temperature distribution within the construction.

4 > An effective handling of thermal bridges

Thermal bridges can occur at various locations of the building envelope and can result in increased heat flow, lower interior surface temperature, moisture and mould problems and additional transmission losses. The additional transmission losses lead to a higher heating and cooling energy need and use and are becoming especially interesting with so-called low energy or high performance buildings. ASIEPI has collected and analysed international and national information from up to 17 EU Member States plus Norway on the topic of thermal bridges in building. Seven different tasks as listed on the left have been addressed. The results can be summarised as follows:

- For many of the tasks it can be said that various at least partly high quality information is available in most of the EU Member States such as software tools for calculating thermal bridges, thermal bridges atlases and the promotion of good practice guidance. It would be desirable that the material is used more often by building practitioners, and that some countries catch up with the others. Software for calculating thermal bridges should be validated and the validation results published.
- All EU Member States consider thermal bridges in the energy performance assessment of new buildings, but less in the assessment of existing building undergoing major renovation. A detailed assessment of thermal bridges allows for compensation of other energy influences due to better building junction solutions. The use of default values on the other hand makes the calculation of the energy performance quicker.
- Several Member States have included specific requirements concerning the quality of building junctions in their regulations. These can be maximum linear thermal transmittance coefficients or minimum dimensionless temperature factors.
- Some countries have a meticulous check of details during or after the design phase of a building. Few countries have a detailed quality assurance of the execution quality on the construction site. ASIEPI has collected methods to assess the execution quality, but also possible sticks and carrots to improve the realisation of building junctions.
- The search for thermal bridge driven industry developments was not an easy task. However we have found some products that can reduce thermal bridges in buildings significantly. It has to be mentioned that most of these products are produced and used in central Europe. A regulation that allows the detailed assessment of building junctions and is up-to-date with innovations supports these kinds of solutions.
- The project has derived detailed recommendations that are included in the final report of the task and are tailored to the different groups: policy makers, national standardisation bodies, CEN/ISO, building practitioners, associations of architects and engineers, universities, building owners, software companies and the building industry. The recommendations follow the results presented above.

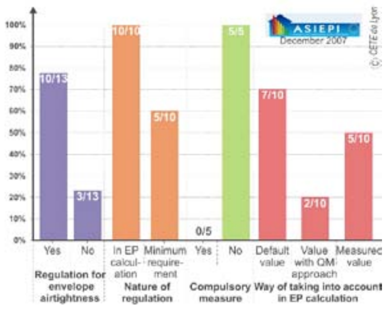
Future directions

One national study showed that the reduction of thermal bridges can have the same impact on the final energy of a single-family house as the gains by a solar thermal collector for domestic hot water.

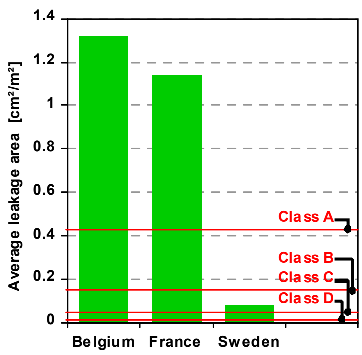
With the future of "nearly zero energy buildings" for both new and existing buildings good quality building component junctions will become even more important.

Gaëlle Guyot, Rémi Carrié
CETE de Lyon
France

All project material on this topic can be accessed through *http://www.asiepi.eu/wp-5-airtightness.html*, and its subordinate pages.



Envelope airtightness: results of an enquiry among 13 Europeans experts involved in the ASIEPI project



Except for Scandinavia, many European countries have very leaky ventilation systems

5 > Stimulation of good building and ductwork airtightness

Building and ductwork leakage are detrimental to energy conservation, comfort, hygiene, and can cause building damage and prevent proper control of the ventilation airflow rates. Today more than ever, with the objective of all new construction being “nearly zero energy buildings” in 2020, policy makers need to know how to implement improved airtightness. ASIEPI recommends the following on:

Promoting a market transformation of envelope airtightness?

- Airtightness is often included and can greatly benefit the national EP calculation methods (see figure) as it represents both a key element for low-energy buildings and a cost-effective measure to reduce energy consumption. Combined with compulsory measurements for claiming a reward in the EP-calculation,this has been identified as a major push for a market transformation. This also applies to labels or subsidies. Recent experience with quality control management as proof of compliance including measurement of random samples is also promising.
- Promote cooperation with building professionals through the development of practical tools with relevant recommendations to construct airtight building envelopes starting at the design stage (only existing in DE, NO and FR); and through pilot and research projects which are, in most countries, considered as significant drivers for a market transformation.
- Initiate and promote a global dissemination strategy that includes training, communication and events, tailored for each of the diverse target groups which include owners, builders, designers, craftsmen and measurement technicians.

Supporting a market transformation of ductwork airtightness?

Focussing on the Scandinavian success stories (see figure) produced the following recommendations :

- Develop information actions on the benefits of efficient ductwork airtightness for the building and industry professional communities. The building community should be more informed about the impact of inferior ductwork airtightness on energy efficiency, comfort, indoor air quality, ventilation efficiency and fire protection. It is also crucial to inform industries and then convince them that airtight circular duct systems have many additional benefits (low costs, space efficiency) over both rectangular duct systems and circular duct systems without gaskets.
- Support industrial development of efficient products because a technology push was clearly observed in Scandinavia where 90-95% of the ductwork installed is spiral-seam steel circular ducts with factory-fitted sealing gaskets.
- It is important to include requirements in the national regulations, with penalties for non compliance. Technical guidelines and/or standards exist in every Scandinavian country. As a result, requirements and references to the guidelines are commonly included in building contracts and great attention is paid to commissioning all ventilation and air conditioning systems. Penalties on the building energy labelling for instance in case of higher leakage rates are also an incentive for building professionals to pay particular attention to duct leakage.

As a global perspective, the main pitfall to avoid is underestimating the challenge. Standardising effective envelope and ductwork airtightness for every construction is a tremendous challenge that calls into question some traditions in the design and erection of buildings. It requires retraining, quality assurance processes and regulations, to develop specific regulation or certification frameworks.

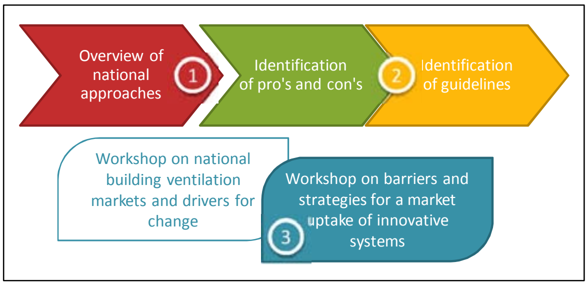
Nicolas Heijmans
BBBRI
Belgium

All project material on this topic can be accessed through *http://www.asiepi.eu/wp-6-innovative-systems.html*, and its subordinate pages.

6 > The EPBD as support for the market uptake for innovative systems

In the context of EPB regulations, *innovative systems* (or technologies) are defined as:

- Systems (or technologies) that, in most case, improve the building's energy performance, and
- Whose performance cannot be assessed by the standard EP calculation procedure in a particular country.

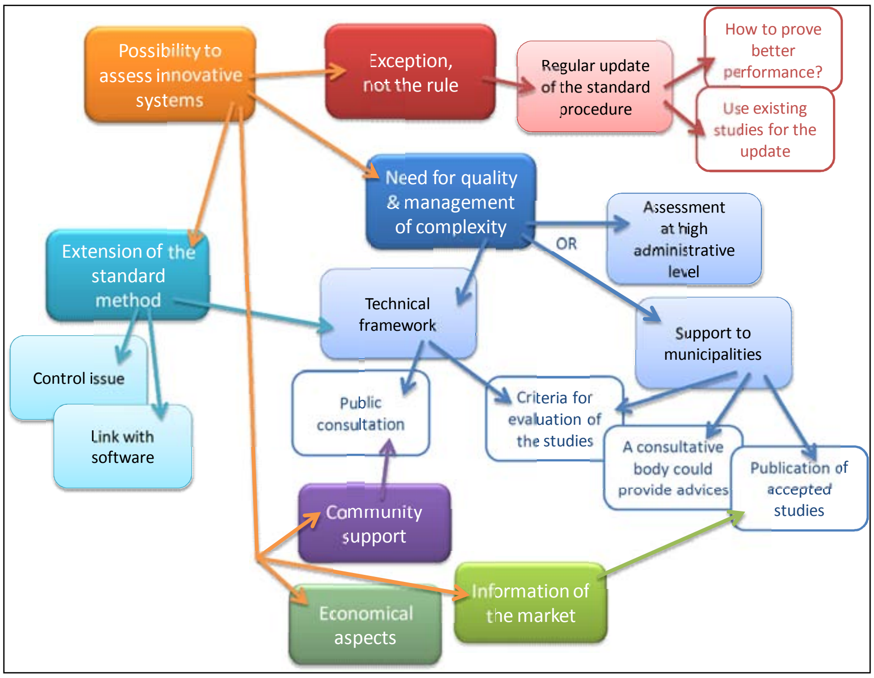


ASIEPI "innovative systems" issue was articulated in three main steps.

As a first step, ASIEPI has made an overview of the current situation regarding the assessment of innovative systems across the EU; this overview can be read in a *report* and has been discussed in a *presentation-on-demand*.

From the various ways innovative systems are handled by the national EPB approaches, some key points of attention have been identified, as shown in the figure. This information is available in a report and has been presented in the presentation-on-demand that summarised the project. Those points of attention could inspire both the Member States that do not have a framework for the assessment of innovative systems and those that would like to improve their existing framework.

The three main points of attention could be summarised as:



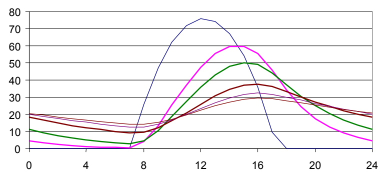
Identified key points of attention that could inspire Member States.

1. It is important that Member States explicitly foresee the possibility of assessing technologies not covered by the standard calculation procedure, so that their EPB regulation does not become a barrier for innovation. If a legal framework is defined, the extent of its application should be clearly defined. Is it applicable to systems not covered by the standard calculation procedure only? Is it also applicable to prove a better performance than that included in the standard calculation procedure? Is there also an approach for "innovative buildings" which are only valid for a single building?
2. As this alternative assessment procedure **should be the exception rather than the rule**, different approaches should be combined (if legally possible) to limit its use: the standard calculation procedure should be updated on a regular basis (on basis of the equivalence studies) and should include the specifications to prove better performances than the default value.
3. **Given the need for quality and the complexity of a coherent assessment of innovative systems, it is important to have a framework that can ensure the quality of the studies.** Several options have been identified to go in that direction: e.g. the assessment of the study should not be performed by the municipalities but by a sufficiently high administrative level, a technical framework could be defined, etc.

Marina Laskari
Mat Santamouris
Marianna Papaglastra
NKUA-University of Athens
Greece

All project material on this topic can be accessed through *http://www.asiepi.eu/wp-7-summer-comfort.html*, and its subordinate pages.

In the context of ASIEPI, ***alternative cooling techniques*** are considered to be the cooling techniques that improve summer comfort substantially, without (or in a very limited manner) increasing energy consumption and which in general do not rely on the vapour compression refrigeration cycle.



Solar heat gains released to the air of the space in a room depending on the thermal inertia of the room

7 > Stimulation of better summer comfort and efficient cooling

One of the main goals of the ASIEPI project is to increase the awareness of the challenges for an effective stimulation of summer comfort and efficient cooling of buildings. Another goal is to improve the relevant procedures in several MS.

The recommendations drawn from the ASIEPI project on summer comfort and efficient cooling can be summarised into 3 main points:

1. **Protect the building against overheating and against the need to install active cooling in the future.**

There are many techniques and methods available that have great potential in limiting the chances of active cooling system installation and overheating emergence in buildings in the future. As energy efficiency and reduced energy consumption during the cooling season have only recently become a primary concern for many countries, these techniques and methods still do not receive the attention they deserve in national EP regulations. These methods are critical mostly for buildings with no active cooling and they include: fictitious consumption for cooling, overheating analysis, use of floating conditions, comfort indicators (e.g. Balance Point Temperature indicator), use of the Adaptive Approach in non-air conditioned buildings.

2. **Make alternative cooling techniques a top priority in national regulations and practical applications against conventional cooling systems.**

Alternative cooling techniques have great potential of reducing the cooling load and the cooling energy consumption in buildings. However, their implementation in EP regulations is not very robust at the moment, a fact that constitutes a hurdle to their use. Ways of reversing the current trend towards the use of conventional cooling systems are: establishment of financial incentives for alternative cooling systems; inclusion of more alternative cooling techniques along with their performance calculation methods in national regulations; but also, mandatory requirements for using alternative cooling techniques, such as solar and heat protection and modulation and dissipation cooling techniques (see Figure), before using conventional systems.

3. **Improve the current national EP procedures and thus enhance energy savings from cooling.**

There are many restrictions that if integrated in the national EP procedures can result in decreased energy consumption for cooling and enhanced energy efficiency. Restrictions that can be considered are: reduction of the over sizing capacity of the A/C installations during the design phase; minimum COP requirements and consideration of the COP of cooling systems during the peak and part load conditions instead of only under the nominal conditions; restrictions on the use of cooling during peak periods; application of modular pricing policy for large cooling consumers.

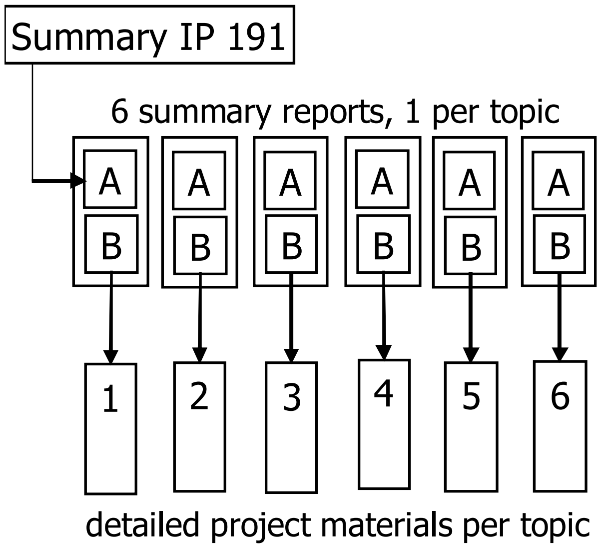
Other recommendations for the refinement of EP-procedures that involve summer comfort and cooling include: attention to proper setting of default values; integration of all aspects that have an impact on the cooling energy consumption in the procedures; avoidance of complex input data; make alternative cooling techniques part of the thermal balance equations but also integrate them in the global calculation method; revision of modelling levels and assumptions of the current calculation methods so that they become sensitive to relevant design decisions in summer performance.

8 > More information

The ASIEPI project has produced a broad set of dissemination materials.

As illustrated in the figure, the project results are structured as follows:

- This information paper briefly summarizes the main conclusions and constitutes the gateway into the project.
- The major findings and all the final recommendations are described more extensively in part A of the summary report on each of the 6 topics. Part B then gives a synthetic overview of all the other information that the project has made available on that topic.
- Finally, a wide range of information materials provides a more comprehensive, in-depth coverage of many different aspects of each of the topics.



The different project outcomes come in a variety of electronic formats:

- summary reports
- detailed technical reports
- information papers
- recordings of internet information seminars
- presentations-on-demand
- conference abstracts and papers
- other related material, such as documents supplied by third parties

All materials are available on the project website *www.asiepi.eu*.

Tip: Part B of the summary reports allows the reader to quickly identify the best source for the full, detailed information on any specific aspect(s) he is looking for at any given time.

ASIEPI partners:
BBRI (BE; technical co-ordinator), NKUA (GR; financial & administrative co-ordinator), TNO (NL), Fraunhofer IBP (DE), SINTEF (NO), CSTB (FR), CETE de Lyon (FR), REHVA (BE), ENEA (IT), AICIA (ES), NAPE (PL), VTT (FI), E-U-Z (DE), Enviros (CZ), SBi (DK)

Associated partners:
Eurima (BE), PCE (BE), ES-SO (BE), EuroAce (BE), FIEC (BE), Acciona I (ES)

Subcontractors:
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Link: www.asiepi.eu

Original text language: English

ASIEPI

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IEE SAVE ASIEPI

Comparison of Energy Performance Requirement Levels:

Possibilities and Impossibilities

Summary report

Main author:

Marleen Spiekman, TNO

SUMMARY

The main recommendations, which are described in more detail in part A, can be summarised as follows.

Comparing the energy performance (EP) requirement levels among the countries of Europe constitutes a major challenge. From the comparison of for instance the present Dutch requirement level (EPC) of 0,8 with the present Flemish level of E80, you can easily see that direct comparison is not possible. Within ASIEPI we developed a method for comparing EP requirement levels and while doing so, we learned several lessons which lead to the following conclusions and recommendations:

- Although at first sight it may seem easy to make a comparison of EP requirement levels among countries, in fact it is difficult to propose a fair and robust comparison method. In that respect: be careful when interpreting results of comparison studies, since it is hard to completely understand a comparison study if you don't know all boundary conditions and since conclusions might therefore be misleading.

- Countries take into account a different set of energy uses in the assesment method of the EP requirements. Some only take into account heating and cooling needs, while others also incorporate heating and cooling systems, hot water, various auxiliaries and/or lighting. This is a problem when making a comparison since the methods are overall performance methods not component methods: A moderately insulated house with an efficient hot water boiler can be as good as a house with much insulation and a less efficient hot water boiler. If the water boiler is not taken into account in some countries, by definition this means comparing apples with oranges.

- In addition, there is no harmonised way of assessing building components and systems. Current standards often mix common procedures with national choices, which make comparing assessment results far from evident.

- The previous two issues **make a robust comparison at this stage simply not possible**. The situation might partly change due to the recast of the EPBD which (again, but now explicitly) demands that countries enlarge the scope of their EP assessment to include technical systems and hot water. It is recommend to continue the development of harmonised CEN Standards because these are crucial for proper comparison. Measures which clearly influence the energy efficiency of a building in a country should be a variable part of the national EP methods and also CEN Standards should address all these relevant national measures (even if they are only relevant in only a small part of Europe), so a uniform assessment is possible. For this it is important that all countries support the European methods. Developing European methods should be done by the intensive involvement of the Member States.

- The severity of energy performance requirement levels varies within countries with, for example, building types, shapes, and system choices. Therefore, a simple rank among countries does not exist, which makes comparison prone to unfair comparisons or even manipulation.

- The method developed within ASIEPI is far from perfect, but taking into account the complexity of the task, it is a good start. It is designed to suit expected future developments, e.g. within CEN and ISO, which will make the comparison method more suitable in the future. The method includes an index to incorporate the severity of the climate.

In general a precision of say more than 20% will probably never be achievable for a comparison, even if in the future better boundary conditions, such as more uniform EP-methods, would be in place.

- Since the need for European and worldwide comparison of energy use will expand, we recommend to further develop the climate severity index and eventually incorporate it within CEN and ISO.

Part B gives an overview of all project material that is available on this topic.

Part C is a collection of all the Information Papers produced on this topic.

Finally, Part D presents the related organised web events.

Part A: Final recommendations

1. INTRODUCTION

EP stands for Energy Performance. This term is abbreviated throughout this rest of this report.

For outsiders, a national EP **requirement level** is quite a black box. It is almost impossible to have an idea of what such a national requirement level means exactly when one is not working with the national calculation method in question regularly. For instance, the EP requirement level for residential buildings in Flanders (Belgium) is presently E80, whereas the Dutch EP requirement level (EPC) is presently 0,8. What do these levels mean? What does it mean that recently in Flanders the EP requirement level has been tightened from E100 to E80? And is this step comparable, bigger or smaller compared to the planned tightening in the Netherlands from EPC 0,8 to 0,6?

The **calculation methods** to assess the EP levels differ from country to country. This is partly due to the fact that the EPBD is a good example of application of the subsidiarity principle: the framework is set in the directive, but the Member States have the control over the details. And even if in the future the EP methods will be fully harmonised by CEN, there are a lot of national differences which influence the energy use, as for instance national health regulations influence the building ventilation rates. Also more obvious differences between countries, like building use, indoor climate conditions, outdoor climate, construction traditions, availability, usability and cost of technologies and labour, to name a few, make a comparison of the requirement levels between the Member States far from evident. This is especially true in a legislative environment.

That energy uses calculated by national methods give incomparable results can be illustrated by a study performed for the Flemish Government (1) where the energy use of a single family house was calculated with the Flemish, Dutch, French and German method. Given that the climate in these neighbouring countries is very nearly the same, the energy uses should be more or less similar, which they were not, see figure 1. Taking into account the fact that in the Netherlands and France energy use for lighting was part of the total energy use, which wasn't the case in the other two countries, the results clearly show that the national methods give incomparable results. A uniform method to assess the energy use in a similar way is necessary (but not enough) for a robust comparison.

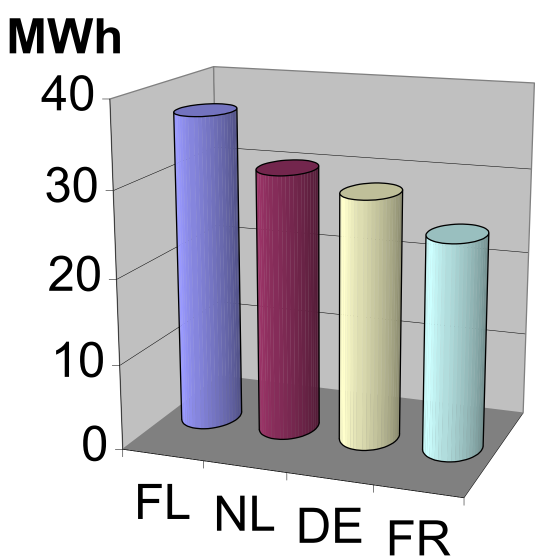

Figure 1: Energy use of the same single family house, calculated with 4 national EP calculation methods

A **method for comparing** EP requirement levels is an important tool for several groups.

- The ambition of the European Commission is for new European buildings to become 'near zero energy buildings' in 2020. Monitoring the

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progress of the individual countries and comparing the interpretation of this ambition among the countries of Europe is crucial to determine where extra resources are necessary to be able to reach the common goals.
- It would enable Member States to get an impression about where their EP requirement levels stand compared to their neighbours.
- And in the rapidly evolving European playing field of improving EP requirement levels, it is important that industrial companies and branch organisations are informed on the relative tightness among the countries: the EP requirement levels influence the market potential of energy saving products in countries.

Within ASIEPI we developed a method for comparing EP requirement levels and while doing so, we learned several lessons. The method and these lessons learned are summarised in the next paragraphs together with the conclusions and recommendations we drew from our experiences.

2. LESSONS LEARNED

2.1 INTRODUCTION

Developing a method to compare EP requirement levels is a challenging task. One of the most valuable results of this development probably isn't the actual method itself, but the lessons learned during the process. These lessons I provide an important source of information about possible pitfalls related to the comparison of energy uses and EP requirement levels among countries. This knowledge is crucial for a proper comparison, to avoid assessors stepping into various traps, and therefore form a crucial part of the comparison method.

Pilot studies
This chapter will focus on these lessons and will illustrate them with results of the pilot studies which were performed.

2.2 THE EP-REGULATIONS ARE DYNAMIC

It is important to realise that EP policies, methods and procedures are dynamic. During the ASIEPI project several countries tightened their EP requirement levels and changed, or are in the process of changing, the EP calculation method, like Italy, Germany, Denmark, France, Belgium and the Netherlands.
This has several consequences:

- The continuously and rapidly changing methods make a detailed analysis of the formulas used in the EP calculations for comparison reasons unrealistic. The CENSE project (2) has shown that at the moment various formulas incorporated by national standards are comparable globally, but vary in the details. That differences in details can have a significant effect can be seen from a comparison between the Dutch and the Flemish method. These two methods are quite similar, more similar than many of the other national methods in Europe, but of course they vary on details. The impact of these details can be seen in figure 1 in the introduction: The energy use of the house calculated by the Flemish method is higher than the energy use of exactly the same house calculated by the Dutch method. And this difference becomes even bigger if you would exclude the energy use for lighting, which is taken into account in the Dutch, but not in the Flemish calculation (and which doesn't fall in the category 'details'). During the particular comparison study (1) an effort was made to compare the Dutch and Flemish method in detail to see what exactly produced these differences. Even though the methods were written in the same language and the developers of both methods were involved themselves, a satisfying answer wasn't found. This illustrates that comparing formulas is difficult in the first place, because the differences will mainly be in the details, not only in the general philosophy of the methods. Adding to the fact that methods are changing rapidly, sometimes even continuously, the conclusion is that comparing methods on formula level is unrealistic.

- Another consequence of the rapidly changing national methods has been that the results of the studies done in this project age quickly as well. Some examples:
  - *During the project the EP requirement levels in Germany and Flanders were tightened. Part of the comparison studies done in ASIEPI give a too conservative picture of the German and Flemish requirement level.*
  - *During the project the Polish method became official. The official method differs drastically from the draft-method, which had been used in the first part of this study, while awaiting the formal method.*
  - *In the last phase of the project, the Italian method expanded, among other things, the energy uses which are taken into account.*

The result is that some comparison results within ASIEPI are outdated: The current situation of some countries may have changed to better insulation levels.

In conclusion, the lesson is clear: since national EP calculation methods and EP requirements are changing rapidly, the comparison method should be relatively simple (as opposed to comparing methods on formula level), and in any case the results will have a limited tenability.

2.3 NATIONAL METHODS CONTAIN DIFFERENT ENERGY USES

The first pilot study which was performed by all partners, gave crucial insight. In the first pilot study all partners were asked to perform an EP calculation for a specific single family house. A drawing of this house is given in figure 2.

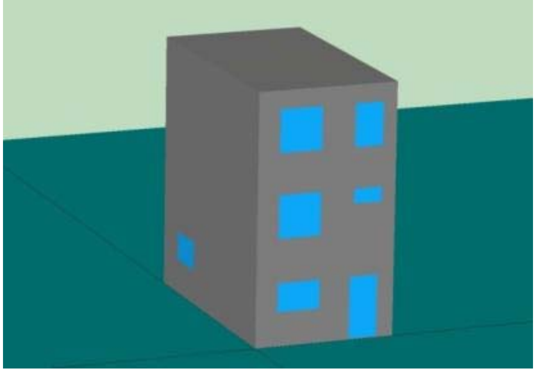

Figure 2: Pilot house

The task was to equip the house with a set of energy saving measures so as to fulfil the EP requirement level in their country. The result was a general list with energy saving measures for every country, like boiler types, insulation values, window types, etc. Two things were clear from these results:

1. Comparing these sets of measures would only be possible with fully harmonised CEN standards and experience from a previous study (1) learned that even than a precision of say more then 20% will probably never be reached.
2. In several countries various sets of energy saving measures needed to fulfil the national EP requirement level didn't contain heating and cooling systems, measures to reduce the energy use for domestic hot water and/or measures to reduce the energy use for lighting. This finding made it clear that a comparison of EP requirement levels in Europe isn't possible at this stage, since the performances which would be compared have completely different definitions.

   For instance: In Finland the EP requirement is based on the heating *need only, while in the Netherlands the EP requirement is based on the energy use for heating, cooling, domestic hot water and fans, including the energy use of the systems. To reach the EP requirement level in the Netherlands a relative poor efficiency of the domestic hot water boiler can be compensated by better insulation of the building and vice versa, while in Finland the efficiency of the domestic hot water boiler is no issue in the EP requirement level of a building. The insulation levels of the Finnish and Dutch building cannot be compared: a lower insulation level in the Netherlands could mean that the EP requirement is less tight, but it could for instance also mean that the energy requirement is more tight because the domestic hot water boiler has a very good efficiency which more than compensates for the lower insulation level.*

This second aspect makes it impossible to compare EP requirement levels at this moment, therefore the results of all the ASIEPI pilot studies cannot be used for comparison. However, they are still useful in the process of developing an assessment method for comparing EP requirement levels in the future, once the issue of different energy uses is solved.

2.4 ONE REQUIREMENT LEVEL DOESN'T MEAN ONE SEVERITY OF ENERGY SAVING MEASURES

By performing several pilot studies in a systematic way important issues were discovered related to the severity of the sets of energy saving measures in the different countries.

An important lesson was that there is not 1 level of energy saving measures for all situations attached to an EP requirement level in a country. It would have been nice if there was only one level of energy saving measures per building function, since ultimately many people like to rank all countries simply on one scale. But in fact some houses need more severe energy saving measures to reach the EP requirement than other houses.

Before further analysing this issue, the pilot studies briefly are explained: Because it wasn't possible to compare the sets of energy saving measures in the first step (see 2.3), the strategy was changed. In a second step, all partners were given a set of cases, including a detached house, a semi-detached house and a row house. All houses are equipped with a specific boiler, a specific ventilation system and a specific hot water system. The question to the partners was: "What is the average insulation level needed in the houses to fulfill the EP requirement in your country?." Each country representative thus needed to make an EP calculation for each of the three cases with his national EP method.
The result for one of the houses (the same house as shown in figure 2) can be seen in table 1.

MS	$U_{average}$ (W/m^{2}K)
BE	0.54
CZ	0.50
DE	0.47
DK	0.36
ES	0.80
FI	0.25
FR	0.56
IT	0.70
NO	0.23

Table 1: Average insulation levels, needed to fulfil the EP requirement level in various countries for a specific semi-detached house (values for 2008).

Note that a low U-value means a high insulation level.

Based on the results in table 1 in a first instance one could think that the EP requirement level is higher in Norway than in Italy because the insulation level is much higher in the former. But due to climate differences it is not as easy as it looks, as is shown later in this chapter.

One out of many aspects that influence the level of energy saving measures is the loss area and the way countries deal with loss area compensation. Table 2 illustrates different country approaches to heat loss area compensation. The table shows the average U-value for floor, roof and facades which is needed to reach the EP requirement in each country for a detached house, semi-detached house and row house of the same size and form. (Due to the fact that the ratio of window to opaque construction area differs among the three house types and the fact that these different ratios influence the average U-value and with this interfere in the comparison of the insulation levels, table 2 contains values of the average opaque U-level only.)

Detached house: MS	U_{opaque}	semi-detached house: MS	U_{opaque}	row-house: MS	U_{opaque}
ES	0,55	ES	0,52	ES	0,47
DE	0,33	DE	0.35	DE	0,38
BE	0,30	BE	0,33	BE	0,39
FR	0,34	FR	0,32	FR	0,29
FI	0,17	FI	0,15	FI	0,13
NO	0,11	NO	0,13	NO	0,16

Table 2: Average insulation levels of the opaque areas (floor, walls roof), needed to fulfil the EP requirement level for a specific detached, semi-detached and row house (values for 2008/2009, U-values in W/m^{2}K)).

In this example, in Germany, Belgium and Norway a detached house needs more insulation than a row house, which makes sense since the energy losses are higher for a detached house. In Spain, France and Finland it is the other way around in this example: the detached house needs less insulation than the row house, due to other compensation rules. Differences in compensation rules can for instance occur when countries deal differently with the fact that different building shapes often have different window to wall ratios.

Another example of an aspect that influences the level of energy saving measures is the effect of the compensation of certain heating system types. Table 3 shows the average insulation needed to fulfil the EP requirement level for a specific house with a condensing boiler versus an electric resistancec heater in Germany, Belgium and France. When calculating the absolute primary energy use of the houses in the three countries the primary energy uses increases strongly in all three countries when changing from a condensing boiler to an electric heater. But the amount of insulation needed in France doesn't change in this example, because the maximum allowed primary energy use also increases (since the reference house then also assumes electric resistance heating). This contrasts with Germany and Belgium where the amount of extra insulation to compensate for the electric heating is so big, that it is not realistic in practice.

CB = Condensing boiler

MS	$U_{average}$ (W/m²K)
DE	0.42
BE	0,42
FR	0,56

EH = Electric heating

MS	$U_{average}$ (W/m²K)
DE	Impossible*
BE	Impossible*
FR	0,56

*Not possible, even when house is better insulated than the house with the condensing boiler

Table 3: Average insulation levels, needed to fulfil the EP requirement level for a specific house with a condensing boiler versus an electric heater (values for 2009).

In conclusion: although there might be only one EP requirement level for houses in a country, the severity of the sets of energy saving measures will vary from 1 house to another, due to aspects as compensation of the loss area and compensation of certain heating system types.

2.5 CLIMATE SEVERITY IS A CRUCIAL FACTOR IN THE INTERCOMPARISON

It is clear that climate differences among the countries complicate the comparison. This is easily seen when the insulation level needed to reach the EP requirement level is compared between for instance Italy and Finland for a similar house. Table 1 shows that in Finland more insulation is used than in Italy: The U-value for the specific Finnish semi-detached house is 0,25 W/m²K, while the U-value for the specific Italian semi-detached house is 0,70 W/m²K (and all other energy saving measures are more or less comparable). But in figure 3 it can be seen that the energy use of the Finnish house is higher than the energy use of the Italian house, despite the extra insulation.

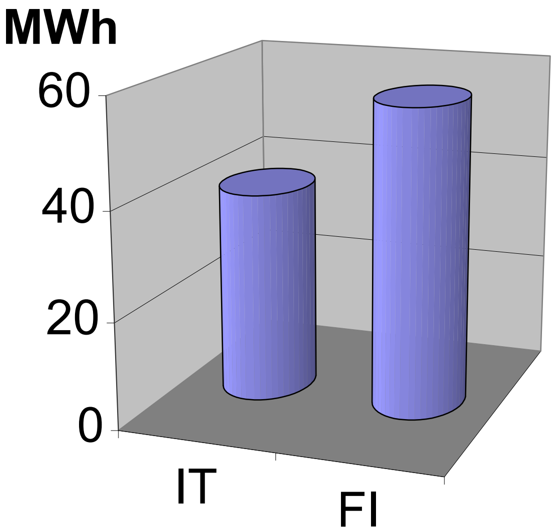

Figure 3: Energy use of a Italian house with an average U-value of 0,70 W/m²K and a Finnish house with an average U-value of 0,25 W/m²K.

So the question remains: in which country is the requirement level the most tight?

To answer this the climate severity index was introduced. This index is based on the method used in Spain where they face very hot climates in the south and rather mild climates in the north-west (8,11).
In short, the severity index is a sophisticated version of the degree days, taking into account the summer as well as the winter severity of a location. The higher the index is, the larger is the severity of the respective climate.

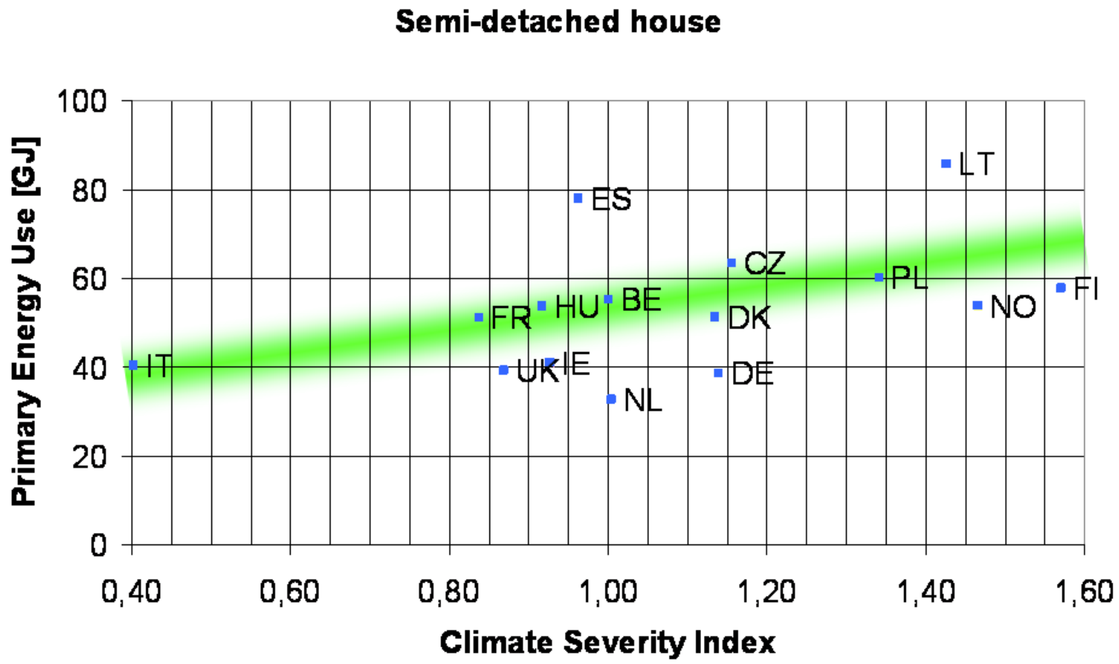

Figure 4: The graph shows the total primary energy use for the semi-detached houses used in the comparison method plotted against the climate severity indexes. Note that the results can only be interpreted in context of all remarks given in this report. Note that the figures in the graph should be handled with extreme care and can otherwise be misleading due to the fact that the energy performance calculations in some countries are based on energy needs and in other countries on total energy uses. Take for instance the case in Spain: in Spain the energy performance requirement is based on energy needs. The consequence is that mandatory measures on system level (like solar collectors) are not compensated within the energy performance requirement if they are left out, as has been done for the sake of the comparison study. In other countries, where solar collectors also are mandatory, but where the energy performance requirements are based on total energy uses, the lack of solar collectors in the comparison study is compensated by other measures. The consequence is that this results in a relatively higher energy use for Spain in the comparison. This example illustrates the fact that at this stage only apples and oranges are compared. The same holds for efficiencies of boilers and COP's of cooling systems.

Figure 4 illustrates how the severity index will work within the comparison method and contains the correlation between the severity index of the locations and the total energy use of a certain house on these locations. Every dot in the graph is a different city in Europe.

Instead of a relative ranking of all the countries in a list, the graph results in only 3 groups: the EP of all countries near the line is more or less equally tight, while the countries in the group above the line are a bit less tight than average and the group below the line are a bit more tight than average.

This '3 group approach' is seen as a big advantage of the method, since there are too many catches in the rest of the method to give a robust ranking of countries anyway.

Note that the method to determine the Climate Severity index is not yet fully developed and needs to be thoroughly evaluated and improved.

2.6 CONTEXT CANNOT BE OVERLOOKED

Another lesson which is discussed is the obvious fact that house typologies and the effectiveness of energy saving measures can differ largely per country or region. Ideally, the comparison methodology is not based on a set of fixed cases, but on a free choice of house typologies and a free choice of energy saving measures per country or region.

At this moment though, there is no harmonised method available to calculate the total energy use of different houses with different energy saving measures on different locations in a completely uniform way.

For now the comparison method will use the simplified calculation method EPA-NR which has been developed within a European project some years ago (3). Of course EPA-NR is not a completely uniform, harmonised method, but an umbrella based on simplified approaches and estimated performance values for several components. By deliberately using fixed cases with a selected set of energy saving measures we try to minimize the disadvantages of not having a good uniform calculation method.

Once the 2nd generation CEN and ISO standards become available, the fixed choices can be replaced by country and region specific choices. This flexibility will make the comparison method more suitable in the future.

2.7 COMPLIANCE AND CONTROL

Within the ASIEPI project the issue of compliance and control has been addressed [9]. Control is handled differently in the Member States and also related to compliance large differences can be seen. The level of compliance and control is factor which can have an effect on EP requirement levels. Some examples:

- Some countries, for instance Flanders (Belgium) chooses to implement a moderate EP requirement level (compared to a severe level) in combination with a heavy control system in order to achieve a high compliance. Whereas in other countries the EP requirement level can be more severe, while the compliance in practice might be much lower. In such cases, comparing the EP requirement levels might not reflect the energetic quality of the houses build.
- A more concrete example: In the Netherlands air tightness is a variable parameter within the EP requirement of a building. To get a building permit a certain air tightness of the future building is claimed. The value claimed is almost never tested after construction, so there is no proofwhether the building complies to the EP level which was promised in the request for the building permit. There is a reasonable chance the promised value will not be reached, and with this the severe EP requirement level will not be reached.

This example illustrates an EP requirement level itself does not say everything about the energetic quality of the houses build in a country.

2.8 CONCLUSIONS

During the development of the comparison method several lessons were learned regarding the development and use of EP calculation methods on national and European scale.
These lessons are worthwhile for developers of calculation methods related to legislation and policy makers, since it is important to know what the possibilities and the impossibilities are regarding the comparison of EP requirement levels. Knowledge of these lessons learned will help to avoid pitfalls in the actual comparison of energy uses and EP requirement levels. But also it will help to avoid pitfalls in developing methods and policies related to comparisons like this.

3. COMPARISON METHOD

3.1 INTRODUCTION

It is clear from the lessons learned that developing a comparison method is not easy. All the different methods, including the one we finally adopted, have their advantages, but also their disadvantages (a short overview of possible alternatives is given in [10]). Within the limits that exist at present, a fair and robust comparison seems impossible. However, to draw the conclusion that no comparison method should be delivered might be counter productive: there is a need for comparison and with or without the ASIEPI method people will compare.
Therefore ASIEPI presents a method which isn't completely fair and robust, but which is transparent about the pitfalls. The charm of the ASIEPI method is that it can be adapted in the future to expected developments, for instance within CEN and ISO. This will make the comparison method more suitable in the future.

The comparison method is divided into 5 steps. The following paragraphs describe each step and discuss various issues.

3.2 STEP 1: DESCRIPTION OF THE CASES

The first step contains several fixed cases: a detached house, a semi detached house and a row house. The houses are all equally large and all have the same shape. Figure 5 shows the floor plans and facades of the semi-detached house and Figure 2 shows a 3-D image of the same house.

The energy saving measures of the three houses are fixed to:

- A condensing boiler with an efficiency corresponding to the minimum imposed by the European Boiler Directive for heating and domestic hot water
- Natural ventilation supply and mechanical ventilation exhaust
- No cooling system, unless this is usual in a comparable house in a country
- No other energy saving measures as solar collectors, photo pholtaics, heat pumps, etc

Figure 5: Floor plans and façades of the semi-detached house

At this moment it is necessary to fix the houses as well as the energy saving measures. The form of the houses as well as the energy saving measures have been chosen in such a way to facilitate comparison. The form of the house is simple to minimise measurement errors (complete elimination of these kind of errors appeared to be impossible even with these simple forms, as we found out during the project).
The energy saving measures were also chosen for simplicity and comparability. For instance, the assumption was made that basic condensing boilers would be more or less similar all over Europe. That this assumption could be made, was shown in a study performed within ASIEPI. In this study the efficiency was compared of the basic condensing boilers which were used by the countries in the pilot studies (4). The study showed that the respective efficiencies were close to one another.
To avoid comparison problems due to the lack of harmonised assessment methods, the amount and complexity of systems and the complexity of the building physics was kept as low and simple as possible:

no heat recovery, no additional active or advanced passive heating or cooling systems (besides a basic condensing boiler and, if needed, a mechanical vapour compression cooling machine).

This choice has several disadvantages which are accepted for now, due to lack of proper alternatives:

- House typologies and the effectiveness of energy saving measures can vary largely per country or region. By fixing these choices, the method might not be comparing realistic situations in various countries, which puts into question the results of the comparison.
- Since more advanced or complex energy saving measures are excluded, countries where the EP requirement level is very tight have trouble to participate in the comparison, since more advanced or complex measures simply are needed here to fulfil the EP requirement in these countries. Since the tightening down to EPC 0.8 in 2006, the Netherlands faces these difficulties. And since Germany tightened its EP requirement in the fall of 2009, also for that country the fixed measures start to become a problem. So, in the near future, as the EP requirement level in more countries becomes tighter and tighter, new fixed measures are needed, along with good and harmonised methods to assess the efficiency and effect of these measures.
- Even though the main energy saving measures are fixed in a way to make the national calculations as comparable as possible, many details cannot be excluded or fixed in this way. These aspects will introduce an error in the comparison study. Two of these aspects are for instance the severity of thermal bridges and the level of air tightness. The impact of these aspects can be quite large, therefore a study was performed into how they could be taken into account in the comparison (5, 6). Since the results were inconclusive, these aspects are not taken into account for now. The same goes for many other details, often related to building use.

It is expected that with future developments of harmonised CEN and ISO standards, it will be possible to make a shift from fixed house typologies and fixed energy saving measures to free choices of both for each country or region. This eliminates the first two disadvantages. And with these developments also the third disadvantage would be reduced, because more and more aspects can be properly taken into account. But these developments won't eliminate this problem entirely: In general a precision of say more than 20% will probably never be achievable for a comparison, even if in the future better boundary conditions, such as more uniform EP-methods, would be in place.

3.3 STEP 2: NATIONAL CALCULATIONS OF AVERAGE INSULATION LEVELS

The second step is that all countries calculate the average insulation level needed to fulfill the EP requirement level in their country. This is calculated for each of the three houses from step 1. For each country the calculations are performed with the respective national EP calculation method. The result is a list of average insulation levels for each house and each country of which examples are given in table 1 and table 2.

This lists of average U-values form a good basis for comparing the EP requirement levels, although of course the issues described in step 1 should always be kept in mind. A direct comparison of the U-values makes no sense for countries with different climates, therefore step 3 is necessary.

3.4 STEP 3: UNIFORM CALCULATED ENERGY USE

To make the results comparable, the total primary energy use of the houses is calculated for each country, taking into account the country's or region's climate and the average U-value needed to fulfil the EP requirement level in each country or region.

Since there is no good and fully harmonised method available to do such calculation, for now EPA-NR is used. EPA-NR (3) was developed within a European project some years ago. It is not a completely uniform, harmonised method, but an umbrella based on simplified approaches and estimated performance values for several components. Although a good and fully harmonised method is preferred, EPA-NR is a reasonable alternative as long as the comparison method uses simple cases only.

3.5 STEP 4: CLIMATE SEVERITY INDEX

But also total energy uses are not comparable directly, as could be seen in paragraph 2.5. Therefore the energy uses are correlated with the climate severity index, as described in the same paragraph, resulting in a graph for each house typology, as illustrated in figure 4. For each house typology it can now be determined if a country or region has an average, a bit worse or a bit better EP requirement level, compared to the other countries.

To show the potential of the Climate Severity Index, within ASIEPI a first attempt has been made to determine the Climate Severity Index for the countries involved in ASIEPI, which resulted in the indices given in table 4. The methodology used to determine these figures is described in (7) and (8).

Country	City	CSI_H	CSI_C	CSI_T
BE	Brussels	1.00	0.00	1.00
CZ	Prague	1.16	0.01	1.17
DE	Berlin	1.14	0.02	1.16
DK	Copenhagen	1.13	0.00	1.13
ES	Madrid	0.52	0.44	0.96
FI	Helsinki	1.57	0.00	1.57
FR	Paris	0.84	0.05	0.89
HU	Budapest	0.92	0.23	1.15
IE	Dublin	0.93	0.00	0.93
IT	Rome	0.40	0.45	0.85
LT	Vilnius	1.43	0.01	1.43
NL	De Bilt	1.00	0.00	1.00
NO	Oslo	1.47	0.00	1.47
PL	Warsaw	1.34	0.00	1.34
UK	London	0.87	0.01	0.88

Table 4: Climate Severity Index for heating (CSI_H), cooling (CSI_C) and both (CSI_T), as determined with the provisional method (not generally usable for instance for non-residential buildings)

It should be noted that the climate severity index derived for this purpose has not yet been thoroughly evaluated, so the use of these values should be handled with extreme care. Looking at the potential strengths of the climate severity index, and the expectation that the need for European and worldwide comparison of energy use will expand, it is highly recommended to further develop the climate severity index and eventually incorporate it within CEN and ISO.: With a thorough foundation, a proper evaluation and wide international support, the climate severity index can become a powerful tool in the comparison of energy uses among different climates.

3.6 STEP 5: QUALITATIVE EVALUATION

As discussed before, making a fair and robust comparison method seems impossible at this moment (see 3.1) and it should be clear that the proposed method of ASIEPI is a pragmatic method. Although designed with care to reduce the error resulting from these pragmatic choices, unwanted differences between countries cannot be avoided. With this a certain amount of "comparing apples with oranges" will take place.
Therefore the final step in the comparison method is a qualitative assessment: all countries are able to review the results of step 1 to 4 for all countries and comment on the findings. This qualitative evaluation will not be able to change the quantitative results, but they can put them in perspective. It is stressed that quantitative results of the ASIEPI comparison method can never be judged without the qualitative feedback of the countries and the results should always be nuanced with this.

3.7 CONCLUSIONS

The proposed comparison method developed by ASIEPI clearly is a pragmatic method. The fact is that at this moment there are no good and harmonised measurement and calculation methods available to assess the energy use of buildings in a comparable way despite contextual differences. This lacune makes a fair and robust comparison impossible. By being transparent about the issues related to the comparison method, by focusing on lessons learned and by giving room to a qualitative evaluation of possible differences, the ASIEPI method tries to deal with this lack in the best possible way.
The ASIEPI method is designed in a way that future developments within for instance CEN and ISO can be incorporated. These future adoptions will make the method more fair and robust, gradually shifting towards the original goal. Although it needs to be emphasised again that a precision of say more than 20% will probably never be achievable for a comparison, even if in the future better boundary conditions, such as more uniform EP-methods, were be in place.

4. CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

From the previous chapters the following can be concluded:

It is clear that making a comparison of EP requirement levels among countries is easy, but making a fair and robust comparison is not. **At this stage a robust comparison is not possible** due to the variety in the types of energy uses which is taken into account in the various national methods and due to a lack of a harmonised way of assessing building components and systems.

There is not one level of energy saving measures for all situations attached to an EP requirement level in a country. A simple order among countries does not exist, which makes comparison prone to unfair comparisons or even manipulation.

And the final conclusion is that although the developed comparison method is far from perfect, it is designed to suit expected future developments, for instance within CEN and ISO, which will make the comparison method more suitable in the future. Although one should realize that in general a precision of say more than 20% will probably never be achievable for a comparison, even if in the future better boundary conditions, such as more uniform EP-methods, were in place.

4.2 RECOMMENDATIONS

This leads to the following recommendations:

Be careful when interpreting comparison studies: it is hard to completely understand an intercomparison study if you don't know all boundary conditions and conclusions might therefore be misleading.

It is recommended to continue the development of high quality and harmonised CEN Standards because these are crucial for proper comparison. And to expand the comparison method developed within ASIEPI with these harmonised methods.

All energy saving techniques that are relevant in a given country should be included in the national EP-methods. And CEN Standards should incorporate all these relevant national techniques, so a uniform assessment is possible.
For this it is important that all countries support the European methods. Developing European methods should be done by the intensive involvement of Member States and can never be a one man job.

And finally, since the need for European and worldwide comparison of energy use will expand, it is recommended to further develop the climate severity index and eventually incorporate it within CEN and ISO.

5. REFERENCES

(1) Flemish study: small scale comparison of the EP-requirements between Flanders, the Netherlands, Germany and France. Links to several reports related to this study can be found on: *http://www.asiepi.eu/wp2-benchmarking/related-information.html*

(2) "Why we need a 2nd generation of CEN standards on energy performance of buildings", Presentation of Dick van Dijk (TNO) on ASIEPI web event "Comparing Energy Requirements Across Europe", February 24, 2010. *http://www.asiepi.eu/fileadmin/files/WebEvents/WebEvent_2.2/ASIEPI_WP2_WebEvent2_05_CENSE.pdf*

(3) Website of EPA-NR: *http://www.epa-nr.org/*

(4) Pilot study EP comparison. Step 4: Comparison of components by experts. (Space heating and domestic hot water systems, fans). Heike Erhorn-Kluttig, Hicham Lahmidi

(5) Pilot study EP comparison. Step 4: Comparison of components by experts. Quantification of air tightness. Antoine Tilmans, Dirk Van Orshoven

(6) Pilot study EP comparison. Step 4: Comparison of components by experts. Quantification of thermal bridges. Antoine Tilmans, Dirk Van Orshoven

(7) "Climate influence on Energy Performance levels - Towards a new (simplified robust and transparent) version of the Climate Severity Index approach", Dick van Dijk, Marleen Spiekman (TNO) and Servando Alvarez and Jose Luis Molina (AICIA), PowerPoint presentation, March 31, 2010

(8) "Comparison between minimum requirements for different climates", Servando Alvarez and Jose Luis Molina, AICIA- University of Seville, December 2009

(9) Website ASIEPI on Compliance and Control: *http://www.asiepi.eu/wp-3-compliance-and-control.html*

(10) '"Comparing Energy Performance Requirements over Europe: Tool and Method (ASIEPI deliverable D2.1c)", Marleen Spiekman (TNO), 31 March, 2010

(11) "How can we deal with climate differences? Experiences from Spain and adaptation to Europe", Presentation of Servando Alvarez (AICIA) on ASIEPI web event "Comparing Energy Requirements Across Europe", February 24, 2010 *http://www.asiepi.eu/fileadmin/files/WebEvents/WebEvent_2.2/ASIEPI_WP2_WebEvent2_04_ClimateDifferences.pdf*

Part B: Bird's eye view of the project results

6. INTRODUCTION

To develop a method for comparing EP requirement levels, various steps have been taken, like the development of a set of reference buildings and the development of several pilot studies, resulting in lessons learned about possibilities and impossibilities of the comparison and resulting in a first impression of a cross section overview of EP requirement levels in Europe. All these steps resulted in 3 main topics :

1. The comparison method itself, with background information on main aspects of the method, like the climate severity index used within the method;
2. The cross section overview of EP requirement levels in Europe, although it should be noted that from the lessons learned mentioned before it is clear that at this stage a robust cross section overview of EP requirement levels is not possible;
3. The description of the set of European reference building, which initially was developed to be used in the comparison method, but is useful in European wide energy calculation and comparison studies in general.

This information was made available in the following publications.

7. PUBLISHED RESULTS

7.1 TECHNICAL REPORTS

A summary on the main results related to the development of for comparing EP requirement levels are described in the final report: *Comparison of Energy Performance Requirement Levels: Possibilities and Impossibilities - Part A: Final recommendations*, published 31 March 2010. This final report contains a global description of the comparison method developed within ASIEPI and the lessons learned during the development process.

In addition to the final report three working reports and an Excel Tool have been published (*>link)*:

- *"Reference buildings for EP calculation studies"*, published in November 2009. The choice of the building geometry is often one of the first determinations during comparison studies of energy performance levels over Europe, but also during other European calculation studies. With this in mind, one of the subtasks of ASIEPI has been to gather a set of reference buildings. The aim of the set of reference buildings is to give an idea of typical houses build in Europe. When we make calculations on the European level, we often extrapolate the results of one house, without the results that houses in Finland might look totally different from houses in Spain. Of course it is not possible to determine a typical house for a whole country. With this report a handle is given for information on the variety of typical houses in Europe.
- *"Comparing Energy Performance Requirements over Europe: Tool and Method",* was published in March 2010. One of the challenging tasks of the ASIEPI project was to develop a method to compare the energy performance requirement levels of the countries of Europe. We found that all

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alternatives we considered have their advantages and disadvantages. And although the method we finally developed is far from perfect, it is designed to suite expected future developments, for instance within CEN and ISO, which will make the comparison method more suitable in the future. This report describes the ASIEPI comparison method and accompanying tool.

- "*ASIEPI Excel Tool*", was published in March 2010. The comparison method is accompanied by the ASIEPI Excel Tool. The tool is based on EPA-NR and is a first step in harmonising the total primary energy calculations of the houses used in the comparison approach.

- "*Comparing Energy Performance Requirements over Europe: Cross section overview*", was published in March 2010. During this development of the comparison method several pilot studies were performed. These give a global impression of the severity of the energy performance requirement levels for dwellings of the participating countries. Although one of the main conclusions of the development of the comparison method was that a robust comparison of energy performance requirement levels at this moment is not possible, this report shows a first impression of a cross section overview of EP requirement levels in Europe.

In addition to the working reports some expert material has been produced:

- As part of the pilot studies performed for the development of the comparison method three reports have been produced on detailed comparison of components:

    - *"Pilot study EP comparison. Step 4: Comparison of components by experts. (Space heating and domestic hot water systems, fans)"*, published March 2010.

    - *"Pilot study EP comparison. Step 4: Comparison of components by experts. Quantification of air tightness"*, published March 2010.

    - "Pilot study EP comparison. Step 4: Comparison of components by experts. Quantification of thermal bridges.", published March 2010.

- Also as part of the development of the comparison method first development steps have been taken to incorporate a climate severity index in the method. Information on the role of the climate severity index in the comparison method can be found in the final report "*Comparison of Energy Performance Requirement Levels: Possibilities and Impossibilities - Part A: Final recommendations*" (as described above) and the working report "*Comparing Energy Performance Requirements over Europe: Tool and Method*" (as described above). More information about the climate severity index can be found in the following material:

    - *"Climate influence on Energy Performance levels - Towards a new (simplified robust and transparent) version of the Climate Severity Index approach*", PowerPoint presentation, March 31, 2010.

    - *"Comparison between minimum requirements for different climates"*, December 2009.

    - *"How can we deal with climate differences? Experiences from Spain and adaptation to Europe"*, Presentation on ASIEPI web event "Comparing Energy Requirements Across Europe", February 24, 2010

Finally, also a brainstorming document has been drawn up that deals with the tightening of the EP requirement levels in relation to economic aspects:

- *"Tightening the EPB-requirements: turning the potential into reality*", published in March 2010. The work programme of ASIEPI, as established in 2006, set as objective to investigate possible methods to compare the energy performance requirements among different countries. In the mean time, the recast of the EPBD has been developed. Observing that comparing the requirements between countries is not only extremely difficult at the present time, but also not the most relevant approach (given the different boundary conditions in different countries, e.g. for costs of labour and materials), the recast now calls for an internal economic analysis within each country in order to establish requirements that are cost-optimum or better. This new approach was outside the contractual scope of the ASIEPI project, and not many resources could be allocated to study the issues related to this different way of doing. Still, based on the general familiarity of the project partners with EPB regulations, some elementary considerations on this complementary topic have been put onto paper in the framework of the project. This brainstorming paper may serve as an inventory of some of the many challenges in order to achieve a sustained reduction of the energy consumption in reality.

7.2 INFORMATION PAPERS

Four Information Papers have been published (> link):

- **P065** "Comparing Energy Performance Requirements over Europe", published in March 2008. This information paper summarises the aims of the study on comparing the energy performance requirement levels between the EU Member States, which is one of the tasks in the ASIEPI project. For everyone involved in the discussion on the comparison of energy performance requirement levels in Europe, it is crucial to understand the challenges involved in this task. Therefore this paper gives an overview of the most important lessons learned from a preliminary comparison study of the EP requirement levels in four Member States.

- **P158** "A set of reference buildings for energy performance calculation studies", published in March 2009. The choice of the building geometry is often one of the first determinations during comparison studies of national energy performance requirements. Experiences with intercomparisons carried out show that the results are influenced already by this choice as they can depend on the type of the building and because of different calculations methods for floor and envelope areas also on the building geometry. ASIEPI has collected possible reference buildings from various EU Member States which are presented in this paper. Earlier intercomparison studies have shown that already the calculation of floor areas, envelope areas etc. lead to different results when national calculation standards of several European Member States have to be followed. In most cases one or several representative buildings for the country that launched the study have been used for the comparison. As many influence factors are related to the floor area, other areas or volumes (e.g. default values for internal gains or the ventilation losses), this can produce the first differences regarding the energy performance results. Also the results of the comparison can be quite dependent on the type of building that has been chosen as reference building. This is valid for different types of dwellings (single-family house vs. multi-family house) as well as for residential vs. non-residential buildings.

- **P164** "Developing a Method for Comparing Energy Performance Requirement Levels among Europe", published in December 2009. Within

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ASIEPI a methodology was developed to make possible a comparison of energy performance requirement levels among Member States of the EU. An unexpected finding has been that far from all the EU countries consider all energy uses in their energy performance calculation method required by the EPBD (Energy Performance of Buildings Directive). The energy use for fans, domestic hot water and cooling are among the energy uses which are not taken into account by various countries. This largely complicates the comparison over Europe. What also complicates the comparison is that sets of energy saving measures are not equally relevant in all climates in Europe. The paper summarises the difficulties in comparing the national regulations and presents options for the comparison.

- **P192** "*Comparing Energy Performance Requirement Levels: Method and Cross Section Overview*", published in March 2010. One of the challenging tasks of the ASIEPI project was to develop a method to compare energy performance requirement levels. During this development pilot studies were performed. These give a global impression of the severity of the energy performance requirement levels for dwellings of the participating countries. This information paper describes the comparison method which has been developed during the project and shows the results of the cross section overview.

7.3 WEB EVENTS

In a series of 10 web event organised by ASIEPI, two web events were held on the topic of comparison of EP requirement levels, being web event no. 2 and web event no.10 (*> link*):

- **ASIEPI web event 2** on "*Comparing Energy Performance Requirements Across Europe*", was held in January 2009. This web event on January 27 has given a glance of some pilot study results of the comparison of requirements and share with you why comparing the requirements among the countries in Europe isn't evident. For everyone involved in the discussion on the comparison of energy performance requirement levels in Europe, it is crucial to understand the challenges involved in this task.

  The strictness of the requirement levels is set on national level- Already the Member States are obliged by the EPBD to tighten the energy performance requirement levels every few years on national level. This development of the EP requirement levels in the Member States will be monitored. The results of the ASIEPI project will contribute to this monitoring.

  To increase the impact of the Energy Performance of Buildings Directive (EPBD) the EPBD is being recast. A proposal of the recast was published two months ago. The key issues of the recast has been discussed during this web event.

Introduction
Welcome and Introduction, *by Peter Wouters, BBRI, coordinator of the ASIEPI project*
Presentations
EU Energy Policy for Buildings - Recast Directive proposed *by Gergana Miladinova, DG TREN*
Introductionr to the comparison study *by Marleen Spiekman, TNO, WP5 leader*
Lessons learned from comparing Germany, France, Netherlands and Flanders *by Peter D'Herdt, BBRI*
Comparing EP requirements over Europe. First results of ASIEPI project *by Marleen Spiekman, TNO*
Discussions
Questions
Conclusion and closure *by Peter Wouters, BBRI*

Program of ASIEPI web event n°2

- **ASIEPI web event 10** on "[*Comparing Energy Performance Requirements across Europe: possibilities and impossibilities*]", was held on February 2010. The tightness of the energy performance (EP) requirement levels is a hot topic in a lot of European countries. For instance Germany just tightened its EP requirements with 30% per October 1 and various other countries, like the Netherlands and Denmark have a long term planning for tightening their EP requirements in several steps. But how can we compare these EP requirements among the countries of Europe? Within the EU project ASIEPI we have developed a method for comparison. This second webevent on this topic gives an update on the results of the development of the method, addressing several issues like: how can we deal with climate differences and what is happening with the European Standards, how will the recasted EPBD change and what are challenges ahead. It also gives a glimpse of what is happening in the U.S. in the field of Energy Performance of Buildings.

.Introduction
Welcome and introduction to ASIEPI *by Marleen Spiekman, TNO*
Presentations
Recast of the EPBD: How will the EPBD change and what are challenges ahead? *by Eduardo Maldonado, CA-EPBD coordinator, with an intervention of Martin Elsberger, DG TREN*
Developing a method for intercomparison of EP-requirement levels: Did we succeed? *by Marleen Spiekman, TNO*
How can we deal with climate differences? Experiences from Spain and adaption to Europe *by Servande Alvarez, AICIA*
Intercomparison of EP requirements without harmonized Standards? Why we need a 2nd generation CEN standards *by Dick van Dijk, TNO & Coordinator CENSE project*
How does Europe deal with Energy performance requirements for renovation and public buildings? Results from an European enquiry *by Anna Wiszniewska, NAPE*
Energy performance in the U.S. developments at ASHRAE *by Jaap Hogeling, CEN*
Discussions
Questions
Conclusion and closure *by Marleen Spiekman, TNO*

Program of ASIEPI web event n°10

7.4 PRESENTATIONS-ON-DEMAND

The following presentation-on-demand are available:

- **ASIEPI presentation-on-demand 1** "*Inter-comparison of requirement levels in Member States*", published in January 2009, gives an overview of the development of the comparison method at the time the presentation was published. Although the presentation dates from the middle of the project, it gives an explanation of the two first pilot studies conducted in the development of the method. Many interesting lessons can be learnt from these pilot studies and this information stays current.(*> link*).

- **ASIEPI presentation-on-demand 6** "*Main lessons learned and recommendations from the IEE SAVE ASIEPI project*", published in March 2010 in several different languages, focuses on guidelines for Member States on all the topics ASIEPI has focussed on.

7.5 ABSTRACTS AND CONFERENCE PAPERS

Two conference abstracts were accepted for the AIVC conference 2009:

- "*Comparing Energy Performance requirement levels among Member States of Europe (EU ASIEPI project)*", was presented at 30th AIVC Conference "Trends in High Performance Buildings and the role of Ventilation". Held in Berlin, Germany, in October 2009. Abstract:: For outsiders, a national energy performance (EP) requirement level is quite a black box. Within the EU ASIEPI project (www.asiepi.eu) we are developing a methodology to make a comparison of EP requirement levels possible among member states of the EU. An unexpected finding was that far from all EU countries consider all energy uses in their EP method required by the EPBD (Energy Performance of Buildings Directive). The energy use for fans, domestic hot water and cooling are among the energy uses which are not taken into account by various countries. This largely complicates the comparison over Europe. What also complicates the comparison is that sets of energy measures are not equally relevant in all climates in Europe. The recast of the EPBD proposes to take into account a cost optimal level. This might be a way of properly reflecting local issues, although developing such a method on European level is a big challenge.

- *"Treatment of envelope airtightness in the EPB-regulations: some results of a survey in the IEE-ASIEPI project."*, was presented at 30th AIVC Conference "Trends in High Performance Buildings and the role of Ventilation". Held in Berlin, Germany, in October 2009. Abstract: One of the topics studied in the European IEE-ASIEPI project (www.asiepi.eu) is the way envelope airtightness is dealt with in the EPB-regulations of the Member States. To this end, a number of surveys was made among the participating countries. Also a quantitative comparison on a sample building was performed. The results of this study are used in the development of an instrument to compare the energy performance requirement levels among the Member States. The results illustrate that the different national EPB-calculation methods show different tendencies, revealing sometimes diverging underlying philosophies. Notably the concept and numeric figures of a default value are different, as well as the treatment of very good airtightness: in some methods the stimulus to do better than a certain threshold value becomes very small or is nil. In other countries, the incentive remains proportional all the way to the limit value of perfect air tightness. All these observations are illustrated and explained in the paper.

Part C. Information Papers

on

Comparison of Energy Performance Requirement Levels

Comparing Energy Performance Requirements over Europe

Marleen Spiekman
Dick van Dijk
TNO Built Environment and Geosciences
The Netherlands

ASIEPI

More information can be found at the ASIEPI project website:
www.asiepi.eu

Similar Information Papers on ASIEPI and/or other European projects can be found at the Buildings Platform website:
www.buildingsplatform.eu

This information paper summarizes the aims of the study on comparing the energy performance requirement levels between the EU Member States, which is one of the tasks in the ASIEPI project. For everyone involved in the discussion on the comparison of energy performance requirement levels in Europe, it is crucial to understand the challenges involved in this task. Therefore this paper gives an overview of the most important lessons learned from a preliminary comparison study of the EP requirement levels in four Member States.

1 >Why comparing energy performance levels?

As requested by the Energy Performance of Buildings Directive (EPBD) all Member States of the European Union have implemented energy performance requirements for new buildings, or will do this in due time. The strictness of the requirement levels is set on national level. The Member States are already obliged by the EPBD to tighten the energy performance requirement levels every few years on national level. This development of the EP requirement levels in the Member States will be monitored.

At the moment the EPBD is being recast. As part of the recasting, it is considered to somehow set EP requirements on European level. This consideration makes our study on how to compare EP requirement levels between Member States even more urgent and important.

For outsiders, a national energy performance **requirement level** is quite a black box. It is almost impossible to have an idea of what such a national requirement level exactly means when one is not working with the national calculation method in question regularly. For instance, the energy performance requirement level for residential buildings in Flanders (Belgium) is E100, whereas the Dutch energy performance requirement level is 0,8. What do these levels mean? And what does tightening of the levels mean, e.g. from E100 to E90? Let alone, how can we compare the Flemish E100 with the Dutch 0,8?

The **calculation methods** to assess the energy performance levels differ from country to country too. This is partly due to the fact that the EPBD is a good example of application of the subsidiarity principle: the framework is set in the directive and all Member States have the control over the details. And even if in the future the EP methods will be fully harmonized by CEN, there are a lot of national differences which influence the energy use, as for instance national health regulations influence building ventilation rates. Also more obvious differences between countries, like building use, indoor climate conditions, outdoor climate, construction practice, availability, usability and cost of technologies and labour, to name a few, make a comparison of the requirement levels between the Member States far from evident. This is specially true in a legislative environment.

Besides the usefulness of this project's results in the light of the upcoming recasting of the EPBD, the intercomparison of EP requirement levels are interesting for various stakeholders. It would enable Member States to get an impression about where their EP requirement levels stand compared to their neighbours. This information is also useful for industrial companies and branch organizations. Depending on the requirement levels certain new technologies could become of interest in a country.

2 >The ASIEPI project - tasks concerning intercomparison

In October 2007, the new European project 'ASIEPI' was launched. One of the goals of this project is to investigate ways to compare the energy performance requirement levels in the EU Member States. The task focuses on three items:
First, an **instrument** needs to be developed for the intercomparison of the energy performance requirement levels in the Member States.
Secondly, the **actual comparison** needs to be performed. The intercomparison results will show the range of energy performance requirement levels in the Member States.
Countries are facing different challenges related to their requirement levels. It will be interesting to see how other countries with similar requirement levels solved their problems. Therefore a third action within this task is to look at possible barriers and **good practice examples** of several such challenges.

3 >Challenges related to intercomparison

Some research has already started to compare the energy performance requirement levels of a few neighbouring countries in Europe. The Flemish [1], Irish [2], Scottish [3] and German Governments have for instance started initiatives in this field. Lessons learned from these smaller scale studies already reveal some of the challenges when comparing the energy performance levels all over Europe.

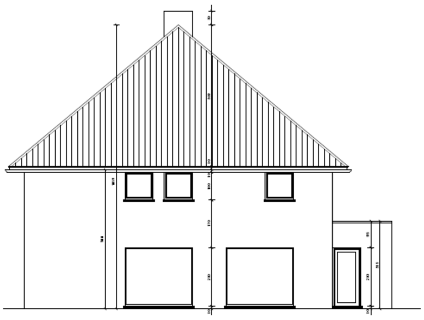
The following lessons were learned, mainly from the Flemish study:

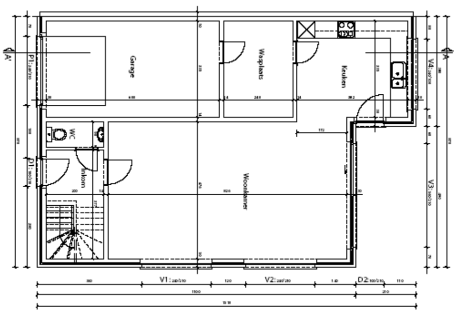
1) One of the potential instruments is to select one example building at EU level and to calculate how this building "rates" in each country, related to the national minimum levels. The calculation of a fully described foreign building in your national EP method seems a simple task when you have experience with this kind of calculations. But it appears to be a 'painful' and time consuming process.
   - Despite the detailed description, many input parameters are missing, simply because they are of no importance in the original country. Example: a Dutch description for residential buildings doesn't contain information on the ventilation rate, because the Dutch method uses a default value. For the French calculation, however, information on the ventilation rate is needed.
   - Another example: a Flemish description will not contain information on thermal bridges, because these are not taken into account. For the Portuguese calculation, thermal bridge details are needed. This poses an extra challenge for the intercomparison: some houses in Flanders will have few thermal bridges and some will have many. The choice of the thermal bridge details will not influence the Flemish EP value, but will significantly influence the Portuguese EP value. And so, it will influence the intercomparison

between the two countries, especially because thermal bridges are of large importance in the Portuguese method.

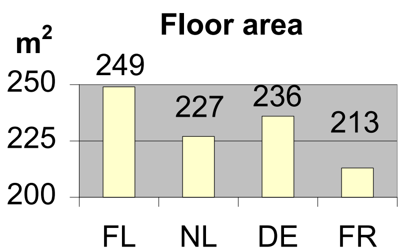
- The different description of input parameters between countries leads to misunderstandings. Example: The power for lighting can be given with or without the power for ballast. The way the information is given and is taken into account may differ as per country. Assessors in different countries will often not be aware that such differences exist and will thus assume that the power given is the power they normally use in their national method.
  The amount of discussion needed to solve such misunderstandings is large. Imagine this process having to take place for 27 or more countries: misunderstandings might not readily and systematically be detected.

2) One of the biggest challenges for intercomparison studies is the fact that building components and systems are described by different characteristics in different countries. The proper information is often lacking for foreign products: measurements are only performed according to the national measurement standards of the countries in which the product is sold. An example: the generation efficiency of a Flemish domestic hot water boiler is not measured according to the Dutch standard. For domestic hot water, no harmonized CEN standards exist at the moment. The Dutch EP method uses a default efficiency value of 30% when there is no measurement according to the Dutch standard available, whereas in fact the hot water boiler could be a very efficient boiler which would have received a high efficiency label (60% or even 70%) if it would have been measured according to the Dutch standard.





3) Differences between countries begin with the assessment of floor and envelope areas. The standards used for this differ by country, using outdoor, indoor and mixed measurements (all in agreement with the EN ISO standard on this issue), excluding different parts (e.g. supporting walls, stairwells, etc) and last but not least using different definitions for which spaces are heated and which are outside the heated zone. The graph on the left shows the differences in the calculated floor area of a house for Flanders, the Netherlands, Germany and France. In this example, by convention, all four countries included the same spaces (although national rules in some of the countries might actually stipulate that the garage and the attic should not be within the insulated fabric). The example shows that the floor area can easily differ by 15% and even more when such spaces are considered according to the national imperatives.
   This clearly shows that comparing national energy uses per square meter might be misleading.



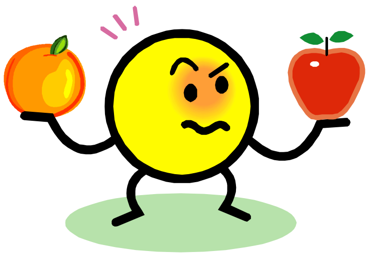
The graph shows the result of the calculation of the floor area of a house in four countries

4) Comparing the results of the EP calculations doesn't appear to be evident either. Calculated total energy use (e.g. in kWh/m^2 or CO_2/m^2) cannot be compared. To start with, they include different sub-uses. France for instance takes the energy use for lighting into account in residential buildings, while for instance Flanders doesn’t. This is a very clear difference for which correction is perhaps easy, provided that more information is available than just the black box result. But more hidden differences also occur, for which correction isn’t that simple, like different national default values for e.g. ventilation rates based on national health regulations, leading to lower or higher calculated energy use. For the same reasons, the comparison of the maximum allowed energy use is also not fair. A better comparison results from the **ratio** of the calculated total energy use and the maximum energy use, because then some of the national choices cancel out. But one should be aware that this result can also be largely influenced by all the issues mentioned above.

Due to the differences in the calculation procedures used in the different countries, to the complexity of these methods and to the fact that they are not static but will change every few years, a detailed comparison of the calculation procedures is not evident, and a more 'black box' approach seems more appropriate, despite it's limitations.

The issue of different outdoor climates

Most intercomparison studies focus on a relative small region of Europe. One of the reasons is that large differences in climate make an intercomparison less easy. The question is how useful it is to compare buildings in Helsinki to buildings in Athens. Good building design takes climate into account, resulting in climate specific energy measures. A low energy use for cooling can be due to the mild climate (e.g. in Finland) or due to a good design or even due to a poor indoor climate (e.g. a high indoor temperature). The same can be said about a low energy use for heating.



Are we comparing apples to oranges?

Not only does the outdoor climate make the comparison complex, but also the levels of required or desired indoor conditions differ strongly from country to country, as for instance the required ventilation flows to provide a healthy indoor environment. Another example in this area is the present-day understanding about the acceptable indoor temperature, namely that it is related to the outdoor temperature. So even the same person would desire a different indoor climate in Helsinki as in Athens.

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4 >Next steps

It is clear that the comparison of the energy performance requirement levels between the Member States is a very interesting and challenging task. Armed with the lessons learned from the mentioned studies, the next step of this task within the ASIEPI project will be to find several alternative methods for intercomparison and to put these options to a test. The results of these tests will be presented in a future information paper.

5 >References

[1] BBRI, "Energy performance regulations: small scale comparison between Flanders, the Netherlands, Germany and France", Under preparation.

[2] ERG, University College Dublin, 'Energy efficiency regulations for new dwellings and options for improvement', Brophy, V., 2007.

[3] Scottish Building Standards Agency, "International comparison of energy standards in building regulations: Denmark, Finland, Norway, Scotland, and Sweden", September 2007.

Intelligent Energy Europe

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More information can be found at the ASIEPI project website: www.asiepi.eu

Similar Information Papers on ASIEPI and/or other European projects can be found at the individual project websites and in the publications database of the BUILD UP Portal: www.buildup.eu

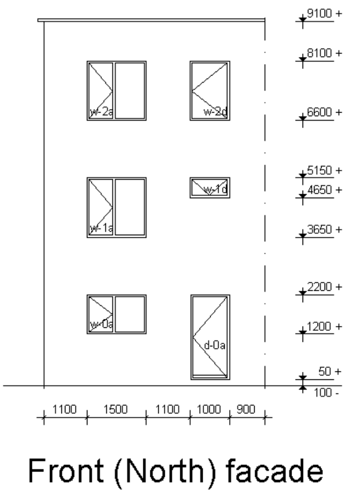

Figure 1: Side views of the test dwelling

Developing a Method for Comparing Energy Performance Requirement Levels among Europe

For outsiders, a national energy performance (EP) requirement level is quite a black box. Within the EU ASIEPI project (*www.asiepi.eu*) we are developing a methodology to make a comparison of EP requirement levels possible among Member States of the EU.

An unexpected finding has been that far from all EU countries consider all energy uses in their EP method required by the EPBD (Energy Performance of Buildings Directive). The energy use for fans, domestic hot water and cooling are among the energy uses which are not taken into account by various countries. This largely complicates the comparison over Europe. What also complicates the comparison is that sets of energy saving measures are not equally relevant in all climates in Europe.

1 > Introduction

In the Netherlands the energy performance (EP) of a house needs to be below 0.8 and in Belgium (Flanders) a house should reach a maximum EP level of E100. Due to the EPBD (Energy Performance of Buildings Directive) every Member State of the EU is obliged to have a methodology in place to assess the EP of new buildings and buildings that undergo major renovations and to set minimum EP requirement levels. As can be seen from the examples in the Netherlands and Flanders, a national EP requirement level is quite a black box. Is the Dutch requirement level of 0.8 stricter than the E100 in Flanders? What do these levels mean and how can we compare these values? In the EU project ASIEPI we are developing a methodology to make a comparison between EP requirement levels possible among Member States of the EU.

2 > Developing a method

Generally there are two main alternatives to make a comparison of EP requirements: The first alternative uses fixed energy saving measures, the second route uses measures per country. The first alternative, "using fixed measures", means that each country rates how a given building with these fixed measures rates against the same building with such measures that the building complies with the national energy performance requirement level. Because previous research showed that the first alternative is far from optimal, within ASIEPI we have focused on the second alternative to see if this would lead to more feasible results (in the end it turned out that both routes unfortunately have pros and cons). The principle of this route is as follows: The starting point is a test building with fixed areas of the building construction and shell. In the project we use the semi-detached house which is shown in figure 1. All countries were asked to determine

Table 1: Average U-value with which the house in figure 1 complies with the national energy performance requirement level in the participating countries (calculations done in 2008).

Member State	Average U-value [W/m²K]
Denmark	0,36
Poland	0,38
Czech Republic	0,50
Spain	0,80
Germany	0,47
Belgium (Flanders)	0,54
France	0,56
Italy	0,70
Finland	0,25
Netherlands	<<0,25[1]

what measures are needed for this house to meet the national EP requirement level in their country. The result is a set of energy saving measures per country needed to comply with the respective national minimum energy performance levels.

It appeared, however, to be difficult to compare two completely different sets of energy saving measures. Therefore we predefined part of the measures. This resulted in sets of energy saving measures which all contained a condensing boiler to heat the building and domestic hot water and a mechanical exhaust system for ventilation. Globally, the main variation between the sets of measures is the average thermal insulation value of the construction (insulation of walls, floor and roof and type of glazing and doors).

3 > Results and discussion

This first step of our study resulted in a list of average insulation values (U-values) for the house in figure 1, with which the house (with the predefined measures) complies with the national energy performance requirement level in each participating country (calculations were done in 2008). The list is given in table 1. The lower the average U-value is, the better the house is insulated. Note that this average U-value is, among other things, a function of the fixed building characteristics predefined in the study, because it is an area-weighted average of walls, roof and windows/doors. From this first step in our comparison study it looks as if we can simply conclude that countries which need a low average U-value to comply with the national minimum energy performance requirement have a stricter EP requirement level than countries with a high average U-value. Following this route, we could for instance conclude that the Netherlands and Finland lie on one end of the spectrum and Spain and Italy on the other end.

However, this conclusion is a bit too simple, as discussed in the following paragraphs:

Firstly, the optimal set of energy saving measures depends on national and even regional aspects, of which climate is the most obvious, but certainly not the only one. In this line of thinking the U-value is not per definition the optimal energy saving measure in all regions, so basing the strictness of the EP requirement level on the U-value is not evident. After all, is it logical to state that, if the set of measures (including thermal insulation) is the same, the EP requirement level in a hot Mediterranean region is as strict as the one in a cold Scandinavian region? Is thermal insulation a comparable optimal energy saving measure in the North and in the South of Europe?

Secondly, we found that the national energy performance calculation methods differ fundamentally in the type of energy uses which are taken into account. Where France and Czech Republic even consider daylight in their national EP method for dwellings, other countries, like Finland and Spain, do not consider for instance the energy use for domestic hot water heating and electricity use of fans. Not all countries do take into account cooling, some focus only on the heating and cooling needs and leave out the systems or take these into account by using default values only.

It is easy to imagine that these fundamental differences complicate the comparison. A key aspect of an integrated energy performance approach is that the choice of measures is not fixed, but that it is possible to choose between different sets of measures. A national method which looks at heating need only will need a high insulation level when the requirements are strict, while a national method which includes a broad range of energy

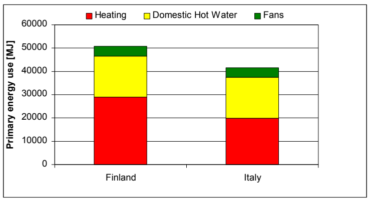

Figure 2: Energy use of the test house for the Finnish set of energy saving measures and the Italian set of energy saving measures as specified in national building for a cold Finnish and hot Italian climate respectively.

uses could be strict by various sets of measures, including ones with much lower insulation levels, because this can be compensated by for instance a solar collector, a heat pump or efficient heat recovery.

Thirdly, by stating the preconditions (the predefined set of measures) we assumed that the building conditions in all national calculations in the study are the same except for the insulation value. Of course this assumption is too simple. Consider for instance the condensing boiler. There are various different condensing boilers on the market with significantly different efficiencies, different auxiliary energy uses, etc. Prescribing a concrete condensing boiler (brand X, serial type Y) proved not functional: boilers sold for instance in Poland are not sold, in other countries, in Spain and vice versa and the declared efficiency values differ between countries due to different measurement methods. The consequence is that it is not evident how to take into account a Spanish boiler in a non-Spanish calculation method. What we finally did was that we prescribed a “non-improved” condensing boiler and performed an in depth study to look into possible differences among the heating systems which were used in the assessment by the countries. The preliminary results of this study show that a spread among the efficiencies of the heating systems exists, but is smaller than we expected.

Another issue with the preconditions is that, for practical reasons, they are quite global. They don’t address building details, like air tightness and thermal bridges. With in depth studies we have also looked into these aspects. The results of the study on air tightness are described in [1]. One of the issues on thermal bridges is that some national methods do and some don’t take them into account. Thermal transmission losses of course are higher when you do consider thermal bridges, while on the other hand you could imagine that countries which take into account thermal bridges have an incentive for improving them. It is beyond the scope of this paper to go into these aspects in detail. The essence is that these issues complicate a fair and robust comparison of national EP requirement levels.

As discussed above, it is questionable whether the average U-value is a proper comparison variable. To be able to take into account climate aspects we performed calculations to transform the national sets of energy saving measures into energy use. The calculation method used for this has been EPA-NR [2]. EPA-NR is a European energy performance calculation model, developed in a European project between 2005 and 2007, and is based on the European (CEN) EPBD Standards. An example of the results of this part of the study is given in figure 2. The figure presents the energy use of the test house for the Finnish set of energy saving measures and the Italian set of energy saving measures as specified in national building codes for a cold and hot climate respectively.

Interesting is to see that while the average U-value of the Finnish test house is much lower than the average U-value of the Italian test house, due to the severe climate the actual energy use of the Finnish house is higher. The question remains whether the Finnish energy performance requirement level is stricter than the Italian one.

4 > Conclusions and further considerations

There are several ways of making a comparison of energy performance requirement levels among the Member States of the EU. We have demonstrated that producing values for comparison is easy, but producing values which are fair and robust is less evident. And even if you’ll find fair and robust comparison values, interpreting them in terms of more or less strict minimum requirement levels also isn’t trivial. In this paper we have evidently looked at climate as an aspect which complicates matters, but

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there are a lot more aspects like that, like building practice, social and cultural aspects, legislation, control, and so on.

The recast proposal of the EPBD asks to link the energy performance requirement level to a cost optimal level. Apart from the challenge to develop a common methodology to determine a cost optimal level, it is the opinion of the author of this paper that it might be a partial solution to judge sets of energy saving measures based on cost effectiveness, because hopefully by looking at cost effectiveness several of these complicating matters will be reflected. On the other hand, costs may strongly depend on market penetration and competition may strongly influence price settings. EP-requirements can strongly influence this market penetration and competition. Tightening the EP-requirements to a cost optimal level and not beyond, might sometimes not be enough to overcome such temporary barrier. In these situations, we need to go one step beyond the cost-optimal level to get the market moving.

We can conclude that developing a methodology linked with cost effectiveness, as asked for in the EPBD recast proposal, will be a big challenge, that will require a clear understanding of all the lessons learned in the ASIEPI project

ASIEPI

5 > Acknowledgements

Different national contributions were made by many of the project partners. The partners are all listed on *www.asiepi.eu*.

6 > References

1. Tilmans, A., Orshoven, D. van, D'Herdt, P., Mees, C., Wouters, P., Carié, F.-R., Guyot, G. and Spiekman, M., 'Treatment of envelope airtightness in the EPB-regulations: some results of a survey in the IEE-ASIEPI project', AIVC conference paper, Berlin, 2009.
2. www.epa-nr.org

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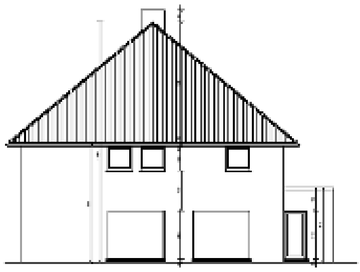
A set of reference buildings for energy performance calculation studies

The choice of the building geometry is often one of the first determinations during comparison studies of national energy performance requirements. Experiences with realised intercomparisons show that the results are influenced already by this choice as they can depend on the type of the building and because of different calculations methods for floor and envelope areas also on the building geometry. A European project has collected possible reference buildings from various EU Member States which are presented in this paper.

1 > The influence of reference buildings on intercomparison studies of energy performance requirements

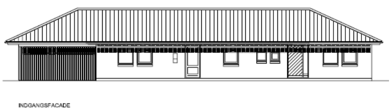
As explained in P65 “Comparing energy performance requirements over Europe” [1] earlier intercomparison studies have shown that already the calculation of floor areas, envelope areas etc. lead to different results when national calculation standards of several European Member States have to be followed. In most cases one or several representative buildings for the country that launched the study have been used for the comparison. As many influence factors are related to the floor area, other areas or volumes (e.g. default values for internal gains or the ventilation losses), this can produce the first differences regarding the energy performance results. Also the results of the comparison can be quite dependent on the type of building that has been chosen as reference building. This is valid for different types of dwellings (single-family house vs. multi-family house) as well as for residential vs. non-residential buildings.

The IEE ASIEPI project (Assessment and Improvement of the EPBD Impact (for new buildings and building renovation)) has collected possible reference buildings from various EU Member States. As the main task of ASIEPI in the field of intercomparison is to develop an instrument for making meaningful comparisons of minimum EP requirements in the individual Member States and to test this instrument, the collection of reference buildings had to be limited. The project concentrated therefore on presenting an exemplary collection of representative single-family houses. However the authors of this information paper suggest to mirror the intercomparison results achieved with single-family houses in the future with corresponding calculations for other building types such as:



Belgium

Czech Republic



Denmark

Finland

France

Germany

Greece

Views of the collected national representative single-family houses of 7 EU Member States.

- multi-family houses
- office buildings
- schools
- hospitals

and if possible even more.

2 > Overview on the collected national representative single-family houses

The single-family houses collected in the project and documented in more detail in the report "Reference buildings for EP calculation studies" [2] cover examples from the following EU Member States:

Country		Single-family house type
1	Belgium	Semi-detached house
2	Czech Republic	Detached house
3	Denmark	Detached house
4	Finland	Semi-detached house
5	France	Semi-detached house
6	Germany	Semi-detached house
7	Greece	Detached house
8	Italy	Detached house
9	The Netherlands	Row house
10	Norway	Detached house
11	Poland	Detached house
12	Spain	Row house

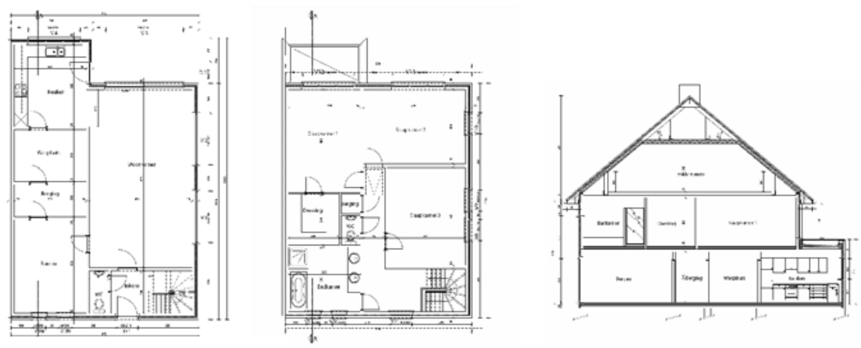
The views of the national representative buildings show already how different these buildings can be, not only in being detached, semi-detached or row houses, but also in size, height, roof type, with or without cellar, garage or attic. As representative buildings they are also dependent on national building traditions.

3 > Comparison of the Belgian, German and Dutch representative single-family houses

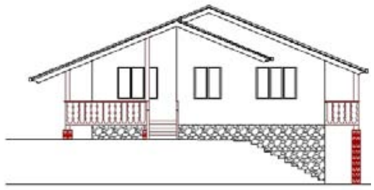
Three neighbour countries have been chosen for a first comparison of their single-family reference houses.

Belgium

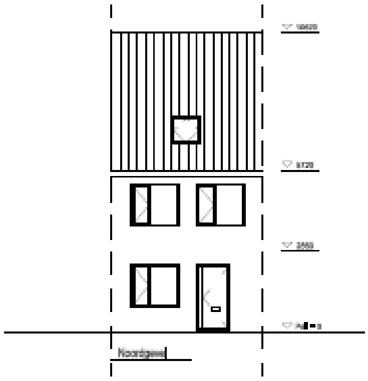
The Belgian representative single-family house is semi-detached and has a volume of more than 700 m³ and a net floor area of more than 200 m². This corresponds closely to the average of new single-family construction in Belgium. The attic is part of the heated volume.



Floor plans and cross section of the Belgian single-family house.



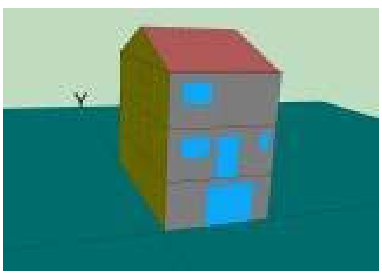
Italy



The Netherlands

Norway

Poland

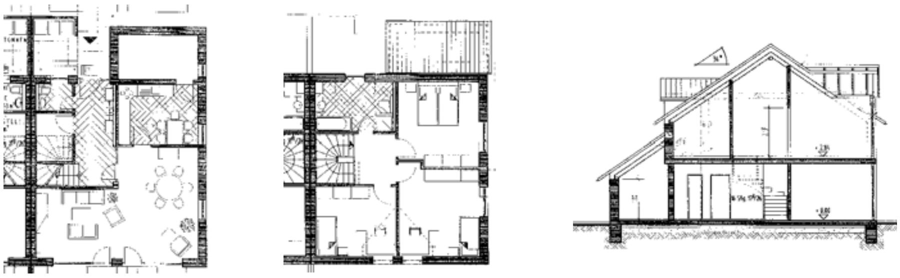


Spain

View of the collected national representative single-family houses of additional 5 EU Member States.

Germany

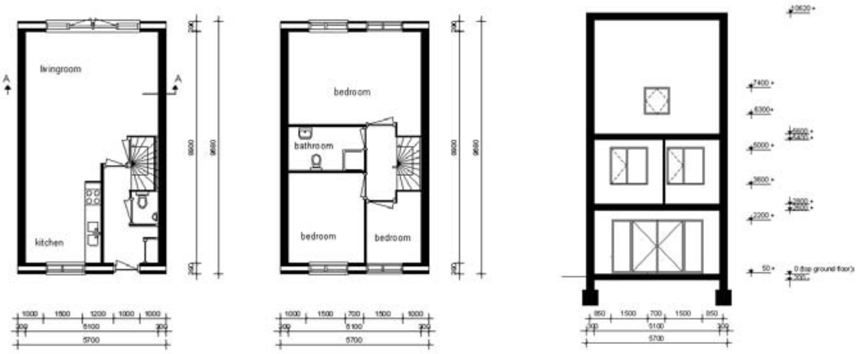
More than 35 % of the existing houses in Germany are either double houses, row houses or two family houses accoding to the building statistic of the German Federal Office for Statistics. The chosen reference building with about 170 m² floor area covers two types: double house and end of row house. Sloped roofs and brick constructions are quite common. The attic is included in the heated volume.



Floor plans and cross section of the German representative single-family house.

The Netherlands

Almost 50 % of the newly built houses in the Netherlands are row houses. The average floor area of these row houses is 125 m². There is a variety of designs of row houses, including different types with sloped or flat roofs. Sloped roofs are most typical. The attic is part of the heated zone.

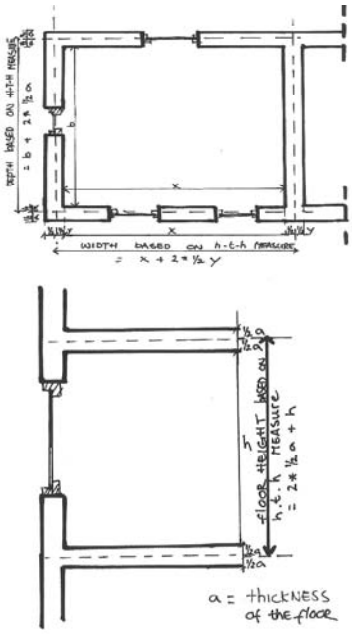


Floor plans and cross section of the Dutch representative single-family house.

The following table presents some of the geometrical characteristics of the three houses, calculated with heart to heart measures:

Characteristics	Belgian house	German house	Dutch house
General dimensions	8.6 m * 12.8 m	8.5 m * 11.7 m	5.4 m * 9.3 m
Total floor area	248 m²	168 m²	150 m²
Floor height	2.65 m	2.8 m	2.8 m
Ground floor area	99 m²	90 m²	50 m²
Total façade area (incl. windows)	159 m²	139 m²	60 m²
Window area	40 m²	36 m²	24 m²
Roof area	120 m²	93 m²	72 m²
Total transmission loss area	378 m²	322 m²	182 m²

How to calculate with heart to heart measures is described in [2]. A scheme on the principle of heart to heart measures is shown on the next page. For lengths, widths and heights the centre of the building components is used as limit.



Principle of heart to heart measures.

The differences in the presented values are quite large. The Belgian house is much bigger than the other two houses, both in floor area, but also in the transmission loss area. The total transmission loss area is more than double as high as for the Dutch building. On the other hand the comparison of the German and Dutch houses which have nearly the same total floor area shows that the facade area and the ground floor areas of the German house are much bigger. The quality of the U-values of these surface areas will therefore have a bigger relative influence on the energy balance of the German building than in the Dutch building.

The influence of the recalculation with heart to heart measures compared to the national foreseen method is shown for the example of Germany in the next table:

Characteristics	German semi-detatched house	
	Calculated with heart to heart measures	Calculated with external dimensions (as foreseen in the German energy performance calculation standards)
General dimensions	8.5 m * 11.7 m	8.8 m * 12.1 m
Total floor area	168 m²	169 m² (=0.32*V_e)
Floor height	2.8 m	2.8 m
Ground floor area	90 m²	97 m²
Total façade area (incl. windows)	139 m²	154 m²
Window area	36 m²	36 m²
Roof area	93 m²	101 m²
Total transmission loss area	322 m²	352 m²

The impact of the different measurements for calculating the thermal loss areas can be quite significant. It is transferred directly to the thermal losses, but also via default values dependent on for example the floor area (e.g. internal gains and thermal bridge surcharges) on other energy balance parts.

4 > Summary

A collection of nationally representative single-family houses to be used in intercomparison studies on the energy performance requirements of different EU Member States was performed in the IEE ASIEPI project. 12 buildings varying from detached houses to row houses are presented in detail in a report soon to be available on the BUILD UP platform (www.buildup.eu). The paper at hand summarises the work but gives also information on how different the representative buildings look like and how this is expressed in characteristic geometrical values that have influence on the energy performance of buildings.

5 > References

1. Spiekman, M.; van Dijk; D.: “Comparing energy performance requirements over Europe.” Information Paper P65 of the EPBD Buildings Platform (2008).
2. Spiekman, M. Westerlaken, N.: „Reference buildings for EP calculation studies. Report of ASIEPI WP2 (2009).

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Comparing Energy Performance Requirement Levels: Method and Cross Section Overview

One of the challenging tasks of the ASIEPI project was to develop a method to compare energy performance requirement levels. During this development pilot studies were performed. These give a global impression of the severity of the energy performance requirement levels for dwellings of the participating countries. This information paper describes the comparison method which has been developed during the project and shows the results of the cross section overview.

1 > The comparison method

Introduction

It is clear from the lessons learned [1] that developing a comparison method is not easy. All the different methods, including the one finally adopted, have their advantages, but also their disadvantages. Within the limits that exist at present, a fair and robust comparison seems impossible. However, to draw the conclusion that no comparison method should be delivered might be counterproductive: there is a need for comparison, and with or without the ASIEPI method people will compare.

Therefore ASIEPI presents a method which is not completely fair and robust, but which is transparent about its pitfalls. The benefit of the ASIEPI method is that it can be adapted to expected future developments, for instance, within CEN and ISO. This will make the comparison method more suitable in the future.

The comparison method is divided into 5 steps. The following paragraphs will describe each step and discuss various issues.

Step 1: Description of the cases

The first step contains several fixed cases: a detached house, a semi detached house and a terrace house. The houses are all equally large and all have the same shape. Figure 1 shows a 3-D image of the semi-detached house and Figure 2 shows the floor plans and facades of the same house.

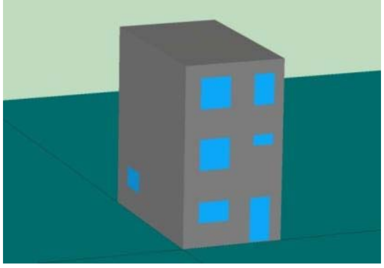

Figure 1: 3D image of pilot house

The energy saving measures of the three houses are fixed to:

- A basic condensing boiler for heating and domestic hot water
- Natural ventilation supply and mechanical ventilation exhaust
- No cooling system, unless this is usual in a comparable house in a country
- No other energy saving measures as solar collectors, photo voltaics, heat pumps, etc

Intelligent Energy Europe

Figure 2: Floor plans and façades of the semi-detached house

At this moment it is necessary to fix the form of the houses as well as the energy saving measures. Both the form of the houses as well as the energy saving measures have been chosen in such a way to facilitate comparison. The shape of the house is simple and therefore minimises measurement errors (complete elimination of these kind of errors appeared to be impossible even with these simple shapes, as we found out during the project).

The energy saving measures also were chosen for simplicity and comparability. For instance, it was assumed that basic condensing boilers would be more or less similar throughout Europe. That this assumption was feasible, was shown in a study performed within ASIEPI. In this study the efficiency of the basic condensing boilers which were used by the countries in the pilot studies [2] was compared. The study showed that the respective efficiencies were very similar.

To avoid comparison problems due to the lack of harmonized assessment methods, the amount and complexity of the systems and the complexity of the building physics was kept as low and simple as possible: no heat recovery, no additional active or advanced passive heating or cooling systems (besides a non-improved condensing boiler and, if needed, a mechanical vapour compression cooling machine).

This choice has several disadvantages which are accepted for now, due to lack of suitable alternatives:

House types and the effectiveness of energy saving measures can vary largely per country or region. By setting these choices, the method might not be comparing realistic situations in various countries, therefore producing questionable comparison results.

Since more advanced or complex energy saving measures are excluded, countries, where the energy performance requirement level is very tight, have trouble participating in the comparison, since more advanced or complex measures simply are needed here to fulfil the energy performance requirement in these countries. Since the tightening down to EPC 0.8 in 2006, the Netherlands for instance faces such difficulties. And since Germany tightened its energy performance requirement in the autumn of 2009, the fixed measure becomes a problem. So in the near future, as the energy performance requirement level becomes tighter and tighter in more countries, new fixed measures will be needed, along with reliable and harmonized methods to assess the efficiency and effect of these measures.

› Even though the main energy saving measures are set in a way to make the national calculations as comparable as possible, many details cannot be excluded or fixed in this way. These aspects will introduce an error in the comparison study. For instance, two of these aspects are the severity of thermal bridges and the level of air tightness. The impact of these aspects can be quite large, therefore a study was performed to ascertain how they could be taken into account in the comparison [3, 4]. Since the results were inconclusive, these aspects have not taken into account for now. The same goes for many other details related to building use.

It is expected that with future developments of harmonized CEN and ISO standards, it will be possible to change from fixed house types and fixed energy saving measures to free choices of both, for each country or region. This eliminates the first two disadvantages. And with these developments also the third disadvantage would be reduced, because more and more aspects can be taken into account. But these developments will not eliminate this problem entirely. In general precision of (roughly) more than

20% will probably never be achievable for a comparison, even if, in the future, better boundary conditions such as more uniform EP-methods, would be in place.

Step 2: National calculations of average insulation levels

The second step is that all countries calculate the average insulation level needed to fulfil the energy performance requirement level in their country. This is calculated for each of the three houses from step 1. For each country the calculations are performed using the respective national energy performance calculation method. The result is a list of average insulation levels for each house and each country.

These lists of average U-values form a solid basis for comparing the energy performance requirement levels, although of course the issues described in step 1 should always be kept in mind. A direct comparison of the U-values makes no sense for countries with different climates, therefore step 3 is necessary.

Step 3: Uniform Calculated energy use

To make the results comparable, the total primary energy use of the houses is calculated for each country, taking into account the country's or region's climate and the average U-value needed to fulfil the energy performance requirement level in each country or region.

Since there is no reliable and fully harmonized method available to do such calculations, for now EPA-NR is used. EPA-NR [5] was developed within a European project some years ago. It is not a completely uniform, harmonized method, but an umbrella based on simplified approaches and estimated performance values for several components. Although a reliable and fully harmonized method is preferred, EPA-NR is a reasonable alternative as long as the comparison method uses simple cases only.

To make it possible to perform uniform calculations for all step 2 results an ASIEPI excel calculation tool was developed, based on the EPA-NR tool, but adding default climates, user behaviour and other variables [8].

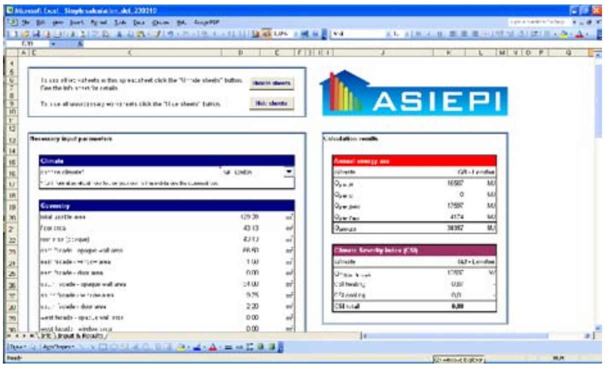

Figure 3: Screen dump of Asiepi excel calculation tool.

Step 4: Climate severity index

One should also realize that total energy uses are not directly comparable due to climate differences. Therefore the energy uses are correlated with the climate severity index. This index is based on the method used in Spain where they face very hot climates in the south and rather mild climates in the north-west. In short, the severity index is a sophisticated version of the degree days, taking into account the summer as well as the winter severity of a location. The higher the index, the greater the severity of the respective climate.

Figure 4 (on page 6) illustrates how the severity index works within the comparison method and contains the correlation between the severity index of the locations and the total energy use of a certain house in these locations. Every dot in the graph is a different city in Europe. Instead of a relative ranking of all the countries in a list, the graph results in globally 3 groups. The energy performance of all countries in the middle is more or less equally tight, while the countries in the group above the middle are less tight than average and the group below the middle are tighter than average.

Table 1: Climate Severity Index for heating (CSI_H), cooling (CSI_C) and both (CSI_T), as determined with the provisional method (not generally usable for instance for non-residential buildings)

Country	City	CSI_H	CSI_C	CSI_T
BE	Brussels	1.00	0.00	1.00
CZ	Prague	1.17	0.02	1.17
DE	Berlin	1.14	0.02	1.17
DK	Copenhagen	1.13	0.00	1.13
ES	Madrid	0.52	0.44	0.97
FI	Helsinki	1.57	0.00	1.57
FR	Paris	0.84	0.07	0.89
HU	Budapest	0.92	0.23	1.15
IE	Dublin	0.93	0.00	0.93
IT	Rome	0.40	0.45	0.85
LT	Vilnius	1.43	0.01	1.43
NL	De Bilt	1.00	0.00	1.00
NO	Oslo	1.47	0.00	1.47
PL	Warsaw	1.34	0.00	1.34
UK	London	0.87	0.01	0.88

This '3 group approach' is seen as a big advantage of the method, since there are a lot of catches in the rest of the method to give a robust ranking of countries anyway.

To show the potential of the Climate Severity Index, within ASIEPI a first attempt has been made to determine the Climate Severity Index for the countries involved in ASIEPI, which resulted in the indices given in Table 1. The methodology used to determine these figures is described in [6] and [7] and the calculation of the climate severity is taken into account in the ASIEPI excel calculation tool [8].

It should be noted that the climate severity index derived for this purpose has not yet been thoroughly evaluated, so the use of these values should be handled with extreme care. Looking at the potential strengths of the climate severity index, and the expectation that the need for European and worldwide comparison of energy use will expand, it is highly recommended to further develop the climate severity index and eventually incorporate it within CEN and ISO. With a thorough foundation, a proper evaluation and wide international support, the climate severity index can become a powerful tool in the comparison of energy uses among different climates.

An example of an issue which will come forward in the qualitative evaluation:

Within the ASIEPI project the issue of compliance and control has been addressed [9]. The level of compliance and control is a factor which can have an effect on EP requirement levels:

Some countries, for instance Flanders (Belgium) chooses to implement a moderate EP requirement level (opposed to a severe level) in combination with a heavy control system in order to achieve a high compliance. Whereas in other countries the EP requirement level can be more severe, while the compliance in practice might be much lower. In such cases, comparing the EP requirement levels might not reflect the energy quality of the houses built in a specific country.

Step 5: Qualitative evaluation

As discussed before, producing a fair and robust comparison method seems impossible at this time and it should be clear that the proposed method of ASIEPI is a pragmatic method. Although designed with care to reduce the errors resulting from these pragmatic choices, unwanted differences between countries cannot be avoided, in consequence there will be a certain amount of "comparing apples with oranges".

Therefore the final step in the comparison method is a qualitative assessment. All countries are able to review the results of steps 1 to 4 for all countries and comment on the findings. This qualitative evaluation cannot change the quantitative results, but they can put them in perspective. It is stressed that the quantitative results of the ASIEPI comparison method can never be judged without the qualitative feedback from the countries and the results should always be influenced by this.

Conclusions

The proposed comparison method developed by ASIEPI is clearly a pragmatic method. The fact is that at this moment there are no reliable and harmonized measurement and calculation methods available to assess the energy use of buildings in a comparable way despite contextual differences. This lack makes a fair and robust comparison impossible. By being transparent about the issues related to the comparison method, by focusing on lessons learned and by giving access to a qualitative evaluation of possible differences, the ASIEPI method tries to deal with this lack in the best possible way.

The ASIEPI method is designed in a way that future developments within for instance CEN and ISO can be incorporated. These future adoptions will make the method more robust and fair, gradually moving towards the original goal. Although it needs to be emphasized again that precision of (roughly guessed) more than 20% will probably never be achievable for a comparison, even if in the future improved boundary conditions, such as more uniform EP-methods, would be in place.

2 > Cross section overview

Limitations of the cross section overview

It is important to realize that the results of the cross section overview should be treated with great care. One of the main conclusions of the development of the comparison method was that a robust comparison of energy performance requirement levels at this moment is not possible due to the variety in the types of energy uses which is taken into account in the various national methods and due to a lack of a harmonized way of assessing building components and systems. In addition there is not one level of energy saving measures for all situations attached to an EP requirement level in a country. A simple order among countries does not exist, which makes comparison prone to unfair comparisons or even manipulation. [1]

The comparison method is designed to suit expected future developments, for instance within CEN and ISO, which will make the comparison method more suitable in the future. Although one should realize that in general a precision of say more than 20% will probably never be achievable for a comparison, even if in the future improved boundary conditions, such as more uniform EP-methods, would be in place. [1]

The figures given in this paper should be seen in light of these limitations: all results only give global impressions and no solid conclusions can be drawn from these results.

Cross section overview results

During the ASIEPI project the 5 steps have been performed by the project partners for their countries. Table 2 shows the results of the national calculations of the average insulation levels for the semi-detached house, the terrace house and the detached house, in order to fulfil the energy performance requirement level in the respective countries (step 2).

Table 2: Results of the national calculations of the average insulation levels for the semi-detached house, the terrace house and the detached house, in order to fulfil the energy performance requirement level in the respective countries (for notes: see side column).

	Semi-detached	Terrace	Detached
Country	$U_{average}$ [W/m^{2}K]	$U_{average}$ [W/m^{2}K]	$U_{average}$ [W/m^{2}K]
BE	0.48	0.71	0.42
CZ	0.50	0.70	0.49
DE[1]	0.47	0.55	0.44
DE[2]	0.17		0.17
DK	0.37	0.50	0.29
ES	0.80	0.83	0.77
FI	0.25	0.27	0.25
FR	0.57	0.71	0.53
HU	0.50	0.51	0.41
IE	0.35	0.40	0.31
IT[3]	0.70		
LT	0.57	0.59	0.53
NL[4]			
NO	0.23	0.33	0.18
PL[5]	0.38	0.40	0.40
UK[7]	0.33		

Notes with Table 2:

BE: values correspond to an E-level of E100 following the Flemish calculation procedure. The Flemish requirement as of 1 Jan. 2010 is E80.

DE[1]: values correspond with the energy performance requirement before 2009 (values are outdated)

DE[2]: values correspond with energy performance requirement of EnEV2009 (new requirements since Oct. 2009)

IT[3]: In 2009 a new calculation method was introduced. The value given in the table was calculated with the former method. For the terrace house and the detached house no calculations have been made.

NL[4]: The energy performance requirement in the Netherlands is too tight. It was not possible to reach the requirement level with any realistic insulation level, without additional measures besides the measures used in the pilot house.

PL[5]: During the project the Polish method became official. The official method differs drastically from the draft-method, which had been used to calculate the values in this table.

UK[7]: Only the insulation level for the semi-detached house was calculated.

ES: for Madrid

To make the results comparable, the total energy use of the houses is calculated for each country by using the ASIEPI excel calculation tool [8].

The results are plotted against the climate severity indices of Table 1. Note that all houses, except the Spanish house do not contain a cooling system, therefore the Climate Severity Index for heating is used for these climates. To be able to compare the Spanish houses with the rest, for Spain the Climate Severity Index for both heating and cooling is used.

The results are shown in Figure 4 for the semi-detached house. The results for the other houses are not given here, but despite different energy uses the trend for these houses is the same.

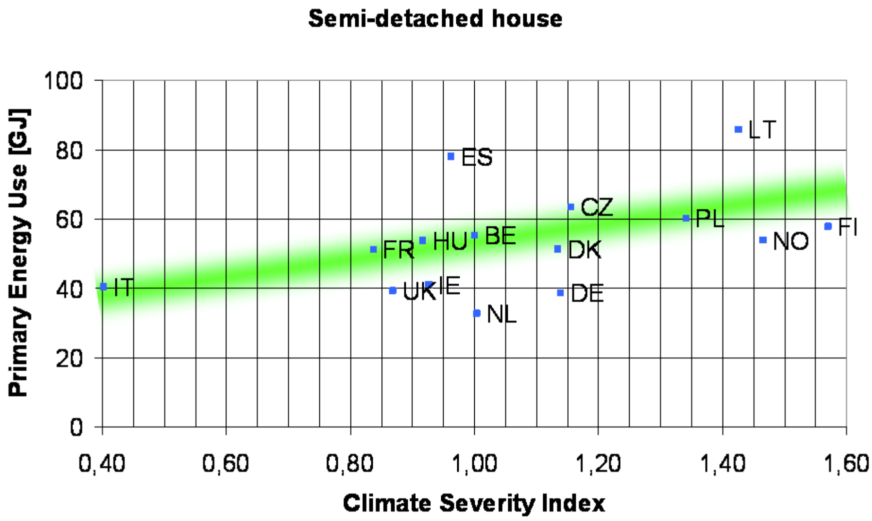

Figure 4: Total primary energy use for the semi-detached houses of Table 2 plotted against the climate severity indexes of Table 1. Note that the results can only be interpreted in context of all remarks given in chapter 1 of this paper. See [6, 7] for more information on the Climate Severity Index.

An initial interpretation of the graph could be that the energy performance requirement levels of most of the countries are within the same range: the differences in energy use of the countries on or near the green area are not significant because of the great uncertainty of the method.

In principle countries below the green area perform a bit better than average and countries above the green area perform a bit worse. However, at this stage one should be very careful to make such conclusions due to the fact that a robust comparison of energy performance requirement levels at this moment is not possible, as highlighted previously in this paper.

Once a fully harmonised assessment method is available to assess the total primary energy use of the houses in all countries a more robust comparison will be possible.

[7]***Note with figure 4:***

Note that the figures in Figure 4 should be handled with extreme care and can otherwise be misleading due to the fact that the energy performance calculations in some countries are based on energy needs and in other countries on total energy uses. Take for instance the case in Spain: in Spain the energy performance requirement is based on energy needs. The consequence is that mandatory measures on system level (like solar collectors) are not compensated for within the energy performance requirement if they are left out, as has been done for the sake of the comparison study. In other countries, where solar collectors also are mandatory, but where the energy performance requirements are based on total energy uses, the lack of solar collectors in the comparison study is compensated for by other measures. The consequence is that this results in a relatively higher energy use for Spain in the comparison. This example illustrates the fact that at this stage only “apples and orange”s are compared. The same holds for efficiencies of boilers and COP's of cooling systems.

ASIEPI partners:
BBRI (BE; technical co-ordinator), NKUA (GR; financial & administrative co-ordinator), TNO (NL), Fraunhofer IBP (DE), SINTEF (NO), CSTB (FR), Cete de Lyon (FR), REHVA (BE), ENEA (IT), AICIA (ES), NAPE (PL), VTT (FI), E-U-Z (DE), Enviros (CZ), SBi (DK)

Associated partners:
Eurima (BE), PCE (BE), ES-SO (BE), EuroAce (BE), FIEC (BE), Acciona I (ES)

Subcontractors:
Kaunas University (LT), University of Budapest (HU), University of Bucharest (RO), BRE (UK), UCD (IE)

Link: www.asiepi.eu

Original text language: English

3 > Recommendations

Based on the previous findings the following is recommended:

- To be careful when interpreting comparison studies: it is hard to completely understand an intercomparison study if all the boundary conditions are unknown and any conclusions might therefore be misleading.
- Continue the development of high quality and harmonized CEN Standards as these are crucial for proper comparison, and expand the comparison method developed within ASIEPI with these harmonized methods.
- All energy saving techniques that are relevant in a given country should be included in the national EP-methods. CEN Standards should incorporate all these relevant national techniques, so a uniform assessment is possible.
- For this it is important that all countries support the European methods. Developing European methods should be done by the intensive involvement of Member States and can never be a one man job.
- Finally, since the need for European and worldwide comparison of energy use will expand, it is recommended to further develop the climate severity index and eventually incorporate it within CEN and ISO.

4 > References

1. "Comparison of Energy Performance Requirement Levels: Possibilities and Impossibilities", ASIEPI Final report, Marleen Spiekman (TNO), 31 March, 2010
2. Pilot study EP comparison. Step 4: Comparison of components by experts. (Space heating and domestic hot water systems, fans). Heike Erhorn-Kluttig, Hicham Lahmidi
3. Pilot study EP comparison. Step 4: Comparison of components by experts. Quantification of air tightness. Antoine Tilmans, Dirk Van Orshoven
4. Pilot study EP comparison. Step 4: Comparison of components by experts. Quantification of thermal bridges. Antoine Tilmans, Dirk Van Orshoven
5. Website of EPA-NR: *http://www.epa-nr.org/*
6. "Climate influence on Energy Performance levels - Towards a new (simplified robust and transparent) version of the Climate Severity Index approach", Dick van Dijk, Marleen Spiekman (TNO) and Servando Alvarez and Jose Luis Molina (AICIA), PowerPoint presentation, March 31, 2010
7. "Comparison between minimum requirements for different climates", Servando Alvarez and Jose Luis Molina, AICIA- University of Seville, December 2009
8. Asiepi Excel Tool (ASIEPI deliverable D2.1b)
9. Website ASIEPI on Compliance and Control: *http://www.asiepi.eu/wp-3-compliance-and-control.html*

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IEEE SAVE ASIEPI

ASIEPI

Part D. Web events

on

Comparison of Energy Performance Requirement Levels

ASIEPI web event 2: Comparing Energy Performance Requirements Across Europe

ASIEPI web event 10: Comparing Energy Performance Requirements across Europe: possibilities and impossibilities

ASIEPI web event 2

Comparing Energy Performance Requirements Across Europe

27 January 2009, 10:00-12:00 GMT+1 (Paris time)

One of the goals of ASIEPI is to investigate ways to compare the energy performance (EP) requirement levels in the EU Member States.

For outsiders, a national energy performance requirement level is quite a black box. It is almost impossible to have an idea of what such a national requirement level exactly means when you are not working with the national calculation method in question regularly. For instance, the energy performance requirement level for residential buildings in Flanders (Belgium) is E100, whereas the Dutch energy performance requirement level is 0,8. What do these levels mean? And what does tightening of the levels mean, e.g. from E100 to E90? Let alone, how can we compare the Flemish E100 with the Dutch 0,8?

This web event on January 27 has given a glance of some pilot study results of the comparison of requirements and share with you why comparing the requirements among the countries in Europe isn't evident. For everyone involved in the discussion on the comparison of energy performance requirement levels in Europe, it is crucial to understand the challenges involved in this task.

The strictness of the requirement levels is set on national level. Already the Member States are obliged by the EPBD to tighten the energy performance requirement levels every few years on national level. This development of the EP requirement levels in the Member States will be monitored. The results of the ASIEPI project will contribute to this monitoring.

To increase the impact of the Energy Performance of Buildings Directive (EPBD) the EPBD is being recasted. A proposal of the recast was published two months ago. The key issues of the recast has been discussed during this web event.

Event page: *http://www.asiepi.eu/wp2-benchmarking/web-events0/web-event-2.html*

Comparing Energy Performance Requirements Across Europe
Welcome and Introduction *by Peter Wouters, BBRI, coordinator of the ASIEPI project*
EU Energy Policy for Buildings - Recast Directive proposed *by Gergana Miladinova, DG TREN*
Introductionr to the comparison study *by Marleen Spiekman, TNO, WP5 leader*
Lessons learned from comparing Germany, France, Netherlands and Flanders *by Peter D'Herdt, BBRI*
Comparing EP requirements over Europe. First results of ASIEPI project *by Marleen Spiekman, TNO*
Questions
Conclusion and closure *by Peter Wouters, BBRI*

ASIEPI web event 10

Comparing Energy Performance Requirements across Europe: possibilities and impossibilities

24 February 2010, 10:00-12:00 GMT+1 (Paris time)

The tightness of the energy performance (EP) requirement levels is a hot topic in a lot of European countries. For instance Germany just tightened its EP requirements with 30% per October 1 and various other countries, like the Netherlands and Denmark have a long term planning for tightening their EP requirements in several steps. But how can we compare these EP requirements among the countries of Europe? Within the EU project Asiepi we have developed a method for comparison. This second webevent on this topic will update you on the results of our challenging task, addressing several issues like: how can we deal with climate differences and what is happening with the European Standards, how will the recasted EPBD change and what are challenges ahead. We also will have a glimpse of what is happening in the U.S. in the field of Energy Performance of Buildings.

Event page: http://www.asiepi.eu/wp2-benchmarking/web-events.html

Comparing Energy Performance Requirements across Europe: possibilities and impossibilities
Welcome and introduction to ASIEPI *by Marleen Spiekman, TNO*
Technical discussions
Recast of the EPBD: How will the EPBD change and what are challenges ahead? *by Eduardo Maldonado, CA-EPBD coordinator, with an intervention of Martin Elsberger, DG TREN*
Developing a method for intercomparison of EP-requirement levels: Did we succeed? *by Marleen Spiekman, TNO*
How can we deal with climate differences? Experiences from Spain and adaption to Europe *by Servande Alvarez, AICIA*
Intercomparison of EP requirements without harmonized Standards? Why we need a 2nd generation CEN standards *by Dick van Dijk, TNO & Coordinator CENSE project*
How does Europe deal with Energy performance requirements for renovation and public buildings? Results from an European enquiry *by Anna Wiszniewska, NAPE*
Energy performance in the U.S. developments at ASHRAE *by Jaap Hogeling, CEN*
Discussions
Questions
Conclusion and closure *by Marleen Spiekman, TNO*

IEEE SAVE ASIEPI

Impact, compliance and control of legislation

Summary report

Main author:

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SUMMARY

While the European Energy Performance of Buildings Directive (EPBD) imposes Member States (MS) to set requirements, it does not specify the severity of those requirements, nor the measures to be taken to control implementation. Consequently, MS can fulfil the requirements of articles 4 through 6 without increasing the existing levels of requirement and without carrying out any kind of control. The main goal of this task of the project was to provide a good view about the impact of the present EPBD on the requirements and how MS deal with the respect of requirements. Compliance and control are essential parts of successfully implementing the EPBD. The main recommendations and findings from reports collected vary significantly regarding EPBD implementation, the large potential for further savings, the needs for infringement procedures by the European Commission, the importance of an integrated approach to buildings and their systems, support for innovative technologies, the necessity of investment in awareness and motivation actions.

Part A: Final recommendations

1. INTRODUCTION

1.1 OVERVIEW

While the EPBD imposes Member States to set requirements, it does not specify the severity of the requirements, nor the measures to be taken to control implementation. Consequently, Member States can fulfil the requirements of articles 4 through 6 without increasing the existing levels of requirement and without carrying out any kind of control. The aims of the study were:

1. To obtain a good view on how EPBD implementation has changed (or is changing) the national requirements.
2. To obtain a good overview of the way Member States deal with compliance handling and control measures. This includes not only governmental actions, but also non-governmental actions.
3. Identification of interesting approaches and possible bottlenecks for improved compliance and control.
4. Recommendations regarding independent control systems and penalties, as listed in the proposal by the European Commission for recast of the EPBD.

1.2 WORKSHOP

An international workshop was organised on September 1-2, 2009 in Brussels. This open workshop was attended by around 80 participants from 17 countries. The participants came from industry, research and governmental organisations.

The workshop programme consisted of expert presentations on the issue of impact, compliance and control in 13 Member States (Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Netherlands, Norway, Poland, Portugal, Spain), -four presentations from European Federations (ES-SO, EuroAce, EURIMA and REHVA) and four synthesis presentations on the previously-mentioned four topics. At the end, there was a brainstorming session regarding pros and cons, as well as concerns regarding the envisaged recast of the EPBD.

This document has been prepared and reviewed by the ASIEPI partners, taking into account suggestions expressed during the workshop. In annex, there is a pdf file containing all final expert reports on each country's status. All country reports, as well as the four synthesis reports, are published as Information Papers and available on www.asiepi.eu and www.buildup.eu .

2. FINDINGS AND RECOMMENDATIONS FOR THE RECAST

2.1 GENERAL REMARKS

The findings below are summarised from presentations and information papers on country status reports that address the control and compliance issues. Full reports are available on (1). The general recommendations reviewed by project partners are as follows:

1. The various reports show significant disparity in EPBD implementation, with big differences in impact, compliance and control. Some variation can be justified because of MS diversity. However, emphasising consistent and sound implementation can or could release the large potential for further savings. The proposed recast may accelerate this process.
2. Several MS have performed lifecycle cost analysis studies before tightening the building code requirements. This is the case in both past and present. Various MS have developed roadmaps for further improving the energy efficiency of new and existing buildings.
3. Not all countries have yet fulfilled all the requirements imposed by EPBD. As guardian of the European Treaty, the European Commission must continue its efforts regarding infringement procedures. (2)
4. It is essential to have an integrated approach that covers all energy-related building components and service systems to achieve cost-efficient (cost-optimised) energy performance targets. Indoor climate aspects must also be taken into consideration.
5. In several MS, innovative compliance and control approaches exist, which do not increase the administrative burden. These approaches depend strongly on cultural aspects.
6. In addition to compliance and control measures, it is also important (to continue) to invest in awareness and motivation actions, e.g. educational and information campaigns.
7. In several countries, there is a difference between the national requirements and the cost-optimum requirements concerning U-values of the building envelope.
8. There are success stories showing a major change in the energy performances of the new building stock due to the EPBD-related regulations. At the same time, there are also success stories regarding market uptake of innovative systems and technologies, in which the EPBD regulations have had a catalysing effect (3).

2.2 COST-OPTIMAL REQUIREMENTS (ARTICLE 5 OF RECAST MARCH 2010)

The cost-optimal requirements are referred to in the text of RECAST in several places. Provision 10, in box below, describes its meaning. The following, most important aspects have been raised in this regards by project participants:

1. The definition of cost-optimal levels is crucial and requires further discussion.
2. The calculation methodology for determining the cost-optimal levels of energy performance is an essential element of the recast. A consultation with the MS and stakeholders is felt to be important, and the validity of a method should be proven for the intended application(s).
3. Given the importance of guaranteeing good indoor climate conditions, combined with the increasing evidence of poor indoor climate conditions in many buildings, MS are expected to report on the actions undertaken in relation to indoor climate.
4. In order to facilitate an efficient and cost-effective implementation and to allow the various stakeholders to prepare properly, it is very important that each MS develops a detailed roadmap for tightening the national requirements.

> It is the sole responsibility to set minimum requirements for the energy performance of buildings and building elements. The requirements should be set with a view to achieving the cost-optimal balance between the investments involved and the energy costs saved throughout the lifecycle of the building, without prejudice to the right of Member States to set minimum requirements which are more energy efficient than cost-optimal efficiency levels. Provision should be made for the possibility for Member States to regularly review their minimum energy performance requirements for buildings with regard to technical progress. **(Provision 10)**

2.3 INDEPENDENT CONTROL SYSTEM (ARTICLE 18 AND ANNEX II)

The main features foreseen for an independent control system, in line with RECAST, should be characterised by the following.

1. The competent authorities, or the bodies to whom the competent authorities have delegated the responsibility for implementing the independent control system, shall make a random selection of at least a statistically significant percentage of all the energy performance certificates issued annually, and subject these to verification. Given the major differences in regulatory systems, political visions and cultural aspects, alternative approaches should be justified on the condition that the MS can prove that the approach is effective.
2. The effectiveness of any control scheme largely depends on the intrinsic quality of the overall implementation, i.e. how the criteria are expressed, the unambiguity of the requirements, etc. Therefore, attention should be drawn to the fact that regulations should be thoroughly checked regarding the possibilities for carrying out controls and, if necessary, imposing sanctions.

2.4 PENALTIES (ARTICLE 24)

One of the reasons for RECAST is the lack of execution power for EPBD regulations (Article 24). Two following recommendations are crucial in this case:

1. Additional control activities should not extend the administrative burdens in the MS.
2. Sanctions in the case of non-compliance of building specifications can take different forms: financial penalties, the obligation to put the building in-line with the specifications, prohibiting occupancy of the building, withdrawal of professional rights, etc. Allowing a flexible sanction handling in order to best fit the cultural behaviour differences of the MS is advisable.

> Member States shall lay down the rules on penalties applicable to infringements of the national provisions adopted pursuant to this Directive and shall take all measures necessary to ensure that they are implemented. The penalties provided for must be effective, proportionate and dissuasive. Member States shall communicate those provisions to the Commission by* at the latest and shall notify it without delay of any subsequent amendment affecting them. **(Article 24)**

3. REFERENCES

(1) materials from Workshop: www.asiepi.eu/wp-3-compliance-and-control/workshop.html

(2) Identification of interesting approaches and possible bottlenecks for improved compliance and control: http://www.asiepi.eu/information-papers.html http://www.buildup.eu/publications/7126

(3) Overview of national approaches for the assessment of innovative systems in the framework of the EPBD: http://www.asiepi.eu/wp-6-innovative-systems/related-information-and-first-re.html#c82

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Part B: Bird's eye view of the project results

4. BIRD'S EYE VIEW OF THE PROJECT RESULTS

The research on impact, compliance and control of EPBD regulations in Member States (MS) was organised in three steps:

1. One of the main tasks of the research was to determine the state of the art for impact, compliance and control in countries represented by ASIEPI project partners and subcontractors, in the form of country reports. Every report includes the following: the impact of EPBD on national requirements, compliance and control of requirements and certification schemes.

2. Four synthesis reports based on country reports and additional information provided by partners on the following subjects:
   - Evaluation of the impact of national EPBD implementation in MS,
   - Evaluation of compliance and control in the different MS,
   - Barriers and good practice examples,
   - Identification of interesting approaches and possible bottlenecks for compliance and control of regulations

3. An international workshop was organised for September 1-2, 2009 in Brussels, with industrial organisations and approximately 80 attendees

5. PUBLISHED RESULTS

5.1 COUNTRY REPORTS

The structure of country reports includes a description of the impact, compliance and control of new, EPBD-related, national requirements and certification schemes. Country reports prepared by ASIEPI partners and subcontractors in Belgium, Czech Republic, Denmark, Finland, France, Germany, Hungary, Greece, Italy, Lithuania, Netherlands, Norway, Poland, Spain are in the form of Information Papers and can be found either on www.buildup.eu or on www.asiepi.eu/wp-3-compliance-and-control/

In addition, two subcontractors, for Hungary and Lithuania, prepared reports that can also be found on the ASIEPI and BuildUp sites.

5.2 SYNTHESIS REPORTS

Additional analysis is provided in the four synthesis reports prepared based on country status reports and additional data collected from ASIEPI partners:

1. Synthesis report on the identification of interesting approaches and possible bottlenecks for compliance and control of regulations.
2. Synthesis report evaluating the handling of compliance and control in the different MS.
3. Synthesis report evaluating the impact of national EPBD implementation on the severity of requirements.
4. Synthesis report on barriers and good practice examples.

The synthesis reports are available under the IP numbers in the table below, on www.asiepi.eu and www.buildup.eu.

5.3 WORKSHOP

The workshop programme consisted of expert presentations on the issue of impact, compliance and control in 13 Member States (Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Italy, Netherlands, Norway, Poland, Portugal, Spain), four presentations from European Federations (ES-SO, EuroAce, EURIMA and REHVA) and four synthesis presentations. At the end, there was a brainstorming session regarding pro and cons as well as concerns regarding the envisaged recast of the EPBD.

The presentations reflect the views of the persons/institutions that have prepared them, but may be not in line with the official position of the MS. The table below presents the programme of the workshop together with references to country reports prepared by 12 project partners and Portugal, and additional contributions from Hungary and Lithuania that were prepared after the workshop.

Introduction	**PPT**	**IP**
General welcome INIVE – Presentation of AIVC & ASIEPI *by P. Wouters, INIVE*	[01]	-
Proof of Performance: Supporting the quest for efficient and effective compliance *by A.-G. Sutherland, EACI*	[02]	-
Objectives of the workshop *by A. Panek, NAPE*	[03]	-
The EPBD Concerted Action *by E. Maldonado, ADENE*	[04]	-
Country presentations	**PPT**	**IP**
Belgium *by A. Tilmans, BBRI*	[BE]	P174
Netherlands *by M. Spiekman, TNO*	[NL]	P169
Greece *by M. Santamouris, M. Papaglastra, NKUA*	[GR]	P173
Germany *by H. Erhorn, H. Erhorn-Kluttig, Fraunhofer IBP*	[DE]	P177
Norway *by P. Schild, SINTEF*	[NO]	P170
Portugal *by P. Santos, ADENE*	[PT]	-
Italy *by M. Zinzi, G. Fasano, M. Citterio, ENEA*	[IT]	P168
Spain *by J.L. Molina, AICIA*	[ES]	P172
Poland *by A. Panek, M. Popiolek, NAPE*	[PO]	P171
Finland *by J. Shemeikka, M. Haakana, VTT*	[FI]	P167
Denmark *by K. Engelund Thomsen, S. Aggerholm,* SBi	[DK]	P175
France *by R. Carrié, G. Guyot, W. Lecointre, CETE de Lyon*	[FR]	P176
Czech Republic *by J. Pejter, ENVIROS s.r.o.*	[CZ]	P166
Hungary *by A. Zöld, Budapest University of Technology and Economics*	-	P182
Lithuania *by R. Bliudzius, Institute of Architecture and Construction of Kaunas University of Technology*	-	P184
Industry point of view	**PPT**	**IP**
EURIMA *by R. Bowie*	[07]	-
ES-SO *by D. Dolmans*	[12]	-
EuroACE *by K.E. Eriksen*	[16]	-
REHVA *by M. Virta*	[21]	-
Lessons learned from country status reviews (syntheses)	**PPT**	**IP**
Evaluation of EPBD impact on requirements *by M. Papaglastra, NKUA*	[22]	P180
Evaluation of compliance and control in Member States *by H. Lahmidi, CSTB*	[23]	P179

Barriers and good practice examples *by M. Papaglastra, NKUA*	[24]	P181
Interesting approaches and bottlenecks *by M. Spiekman, B. Poel, L. van den Brink, TNO*	[25]	P178

A pdf file with all the presentations is available on www.asiepi.eu .

Part C. Information Papers and Country Reports

on

Impact, Compliance and Control of legislation

Bart Poel
Linde van den Brink
TNO
Delft, the Netherlands

More information can be found at the ASIEPI project website:
www.asiepi.eu

Similar Information Papers on ASIEPI and/or other European projects can be found at the individual project websites and in the publications database of the BUILD UP Portal:
www.buildup.eu

Approaches and possible bottlenecks for compliance and control of EPBD regulations

As a part of the ASIEPI project funded by the Community's Intelligent Energy Europe programme, a survey was done on the compliance and control approach in 13 EU Member States. Based on the information gained the control strategies are categorized and discussed in the context of cultural differences.

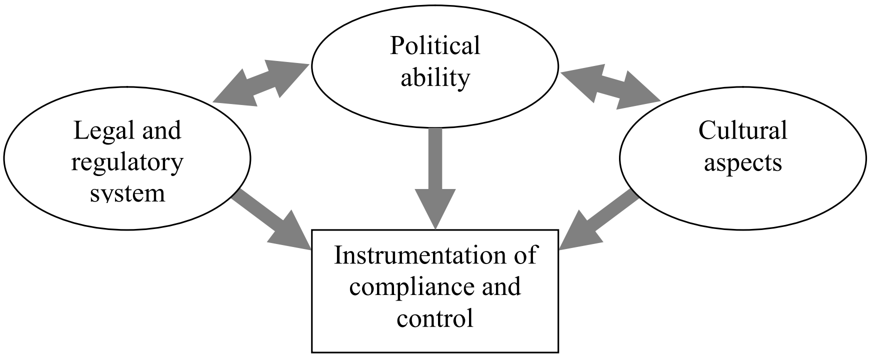
1 > National context of compliance and control approaches

Compliance and control is an essential part of a successful implementation of the European Energy Performance of Buildings Directive (EPBD). The EPBD requires adequate compliance and control; Member States have to ensure that the EPBD is executed properly. The effectiveness of a compliance and control strategy is affected by three context related factors:

- The way compliance and control is organized has to meet the **legal and regulatory system** in a country. For instance in case of a Member State where the responsibility is strongly delegated to regions the federal legal structure will probably be a framework to facilitate the regions to design their approach. In those Member States a centralized organization is not very likely and centralized control is not possible and diversity in compliance and control instruments can occur.
- It is not just the legal and regulatory system that influences compliance and control, also the **cultural aspects** related to the interaction between society and government play an important role. The relationship between citizens and authorities depends on values that vary from country to country. In some countries a very strict enforcement is the common approach, while in other countries the authorities can apply alternative control schemes partly based on self regulation.
- A third important aspect that affects the effectiveness is the **political ability** which is the consequence of the democratic reality that policy objectives at a certain moment might not match with the objectives of the EPBD. For the energy issue the urge to go a step further in the ambition is not always self-evident. Within the political spectrum the need for substantial CO_2-reduction is not endorsed by every party.

Consequently government policies may not be fully in line with the goals of the EPBD. Member States may decide to implement a light version of the EPBD without stressing the compliance and control.

These three factors are of course strongly intertwined.



Three antecedents of control and compliance approaches.

The influence of cultural aspects is not as direct as presented in the above diagram. Cultural aspects are omnipresent in societal matters and will affect the legal and regulatory system, and the political ability to comply with EU directives. When assessing differences in systems and ability, differences in culture are tacitly taken into account too.

2 > Cultural differences and political attitudes

Though the term "culture" is used in different senses, in this survey we are mainly interested in culture as a concept that influences behavior and systems, and that causes differences across Member States of the European Union. To measure cultural differences across countries, cross-cultural researcher Shalom Schwartz identified seven cultural value orientations *[1]*. From a (social) psychological viewpoint, these internalized values are seen as deeper drives of behavior because people act in accordance with their values even when they do not consciously think about them *[2]*. As such, cross-cultural differences in values determine differences in behaviour. According to Schwartz, the seven value orientations that influence behaviour in different countries form the following three value dimensions:

1. the relationship or boundaries between the person and the group (autonomy vs. embeddedness);
2. the way to guarantee that people behave in a responsible manner to maintain society (hierarchy vs. egalitarianism);
3. the way that people manage their relations to the social and natural world (harmony vs. mastery).

The dimensions are related in a circular structure, which reflects their compatibility (adjacent in the circle) or incompatibility (distant around the circle).

Schwartz's seven cultural value orientations [1]

Countries can be plotted across the seven cultural value dimensions after which their levels on each dimension can be compared. In general, countries that form a geographical region in the real world are proximate on the value dimensions too, though there also is substantial cultural variation within regions. See for more detailed information and a spatial plot of 76 countries across the seven value orientations the publication of Shalom Schwartz *[1]*.

3 > The transposition of EU directives by the member states

The cultural value dimensions represent the common and shared ideals of individuals within a society. Knowing how countries differ across these values helps us understand why inhabitants of those countries differ in their social behaviour and attitudes towards authority, but also can explain differences in political systems. Though there has been extensive research into individual behaviour, there is only little literature available about the relation between these values and political systems. However, there exists some literature in which institutional and political differences across countries are acknowledged to directly influence the path to and level of transposition of European legislation into domestic legislation to European legislation. One study, of political scientist Gerda Falkner and her colleagues *[3]*, offers a typology of attitudes towards transposition performance in the European Union. They distinguish four "worlds of compliance", by typical modes of treating transposition duties *[3] [4]*. We would like to emphasize that the offered typology can be helpful as an illustration of how countries may differ in their approach to the implementation of EU directives, but it is explicitly not meant to be read as a moral judgment.

According to Falkner and her colleagues, the first typology, the **"world of law observance",** is characterized by an approach in which complying with EU directives typically overrides domestic concerns. Transposition of EU directives is usually done in time, even when they conflict with domestic policies. In the "**world of domestic politics**", there is a tendency that in case of a major conflict between domestic and EU policies, domestic concerns may prevail which can result in (in part) non-compliance. In the countries that form the "**world of transposition neglect**", transposition proceeds after intervention of the European Commission, but is often not initiated without such encouragement. In a later study *[4]* the typology was extended to a fourth world: the "**world of dead letters**". Countries belonging to this world possess domestic legislation that enables them to implement the EU directives, but because of a lack of institutional organization, they are not able to do so in practice.
Though this typology gives insight in the differences in transposition approaches between countries, cannot be applied straightforward on the attitude of the EU member States. The study is not wholly uncriticized. For instance, one researcher trying to replicate these findings argues that there is no empirical evidence for this typology or the regional distinction *[5]*. Besides that, compliance to EU policies can explicitly be part of domestic policies in which case the distinction between EU and domestic policies that lies at the base of Falkner's typology does not exist.

Altogether, because policy issues are part of a complex and rich field of actors and influences, differences in cultural values cannot directly be connected to differences in compliance and control approach between Member States. It is clear that cultural aspects contribute to a great extent to the choice of a transposition approach for EU directives through their influence on values, attitudes and behaviour.

As a consequence, it is likely that compliance and control approaches that are effective in one Member State, cannot effectively be transferred to other Member States without taking their cultural context into account.

4 > Compliance and control according to the EPBD

The EPBD is not very explicit about compliance and control. Nevertheless several articles urge the Member States to ensure that the obligations are fulfilled.

In the proposal for a recast of the EPBD (13-11-2008) there is more emphasis on compliance and control. The recast proposal introduces a new article concerning penalties to be imposed in case of infringement of the national provisions adopted pursuant to the EPBD. In addition annex II is included. This annex is devoted to independent control systems for energy performance certificates and inspection reports, giving guidance to the control scheme to be implemented by the Member States. In several articles the recast puts more emphasis on the reinforcement of the implementation of the EPBD. It is important to acknowledge that no final version of the recast iss available at the time this paper iss written (summer 2009), as the recast proposal is still under discussion. However it is expected that control and penalties will be addressed more explicitly.

5 > Comparison of the compliance and control approach

Within ASIEPI, the compliance and control approach of various Member States is being surveyed for the EPBD obligations of setting energy performance requirements and for issuing energy performance certificates. In total thirteen Member States provided information about their compliance and control scheme. In order to structure the information a number of categories are distinguished.

- First of all compliance can be enforced by withholding permits or withdrawing accreditation. These measures directly affect the process by obstruction and are very powerful, when executed and controlled in a proper way. The assumption is that this approach is combined with an active control strategy by an authority, since a lack of control will undo the effect of the measure.
- The second set of measures is indirect and does not obstruct the process but inflicts a penalty, like a fine or even prosecution. For those categories there is a distinction between active and passive control. Regular control by an independent authority is characterized as active control, whereas the possibility for the consumer to start a procedure in case of non-compliance is labelled as passive control; the initiative is taken by the client instead of an authority.

Both approaches can be applied on setting energy requirements for new buildings and major renovation and for issuing energy performance certificates as well as for the accreditation of assessors.

This categorization leads to the typology of measures as shown on the vertical axes of the table below. The results of the survey of the 13 Member States are plotted against this typology. For Belgium a distinction is made for the three Regions (Brussels, Flanders and Wallonia). Per country comments are added to better understand the national situation.

Overview of Control strategies:

Control categories	Implementation schemes 13 MS: BE – B	BE – F	BE – W	CZ	DE	DK	FR	FI	GR	HU	IT	NO	NL	PL	ES
Requirements; new buildings, major renovation															
Withhold the building permit	◐				●	●	◐	●	✕			○	●	●	✕
Withhold the utilization permit						●		●	✕		●				
Impose fine / active control	●	●	●	○	●		●				●				✕
Impose fine/ passive control					●					○					
Issuing building certificates; existing buildings															
Withhold the sale of the building							◐				◐				
Withhold the renting out of the building							✕				◐				
Impose fine / active control		●				●					●				
Impose fine/ passive control					●					✕			●		
Accreditation of assessors															
Withdraw the assesors accreditation		●	✕	●		●	○		✕		●		●	◐	

● applied
◐ partly applied
○ unspecified application
✕ intended application

Remarks per country:

Belgium (Brussels)	The operational details for the control of compliance with the requirements for new buildings are still under development. The procedures for the certification of existing buildings have not been decided/published yet.
	The withholding of the building permit applies only to some elements, not the full energy performance.
Belgium (Flanders)	Through a central electronic registration an active control is executed combined with an administrative fine in case of non-compliance
Belgium (Wallonia)	The operational details for the control of compliance with the requirements for new buildings are still under development. The procedures for the certification of existing buildings have not been decided/published yet.
Czech Republic	The control system is not specified
Germany	The compliance check varies in intensity depending on the federal state
Denmark	The compliance check varies in intensity depending on the local authorities
	Through a central electronic registration an active control is executed
France	For new buildings and major renovation, the owner signs commitment to comply with the regulations. The authorities can decide to control and there is a financial penalty in case of non-compliance, but this is only in force for new buildings.
	From the information available it is not clear whether the certification of the assessor can be withdrawn
	In case of sales the lawyer verifies the disposal of a certificate, the sanctions are not clear. For renting out control is not always available
Finland	In practice energy regulations are rarely applied to renovations although legislation is available
Greece	The plotted approach the intention of Greece to set-up the compliance and control scheme
Hungary	It is not clear whether control on the certification of existing buildings and the compliance with the requirements is actively executed
Italy	Controls can be done by Municipalities for 5 years after certificate issue, even on request of buyers, owner or renter
	In case of sale of existing building the seller can avoid the energy certification, declaring that his building is in the lowest class (G) and that its energy consumptions are very high. The sell or rent act can be declared null in absence of Energy certificate upon request of buyer and renter
	In Italy until now there is no certification of assessors: sanctions are established by the professional associations (engineers, architects): withdrawal from Chartered Associations of Architects or Engineers – lost of rights for design and supervise construction
Norway	Limited specification available
Netherlands	Issuing a certificate in case of sales and renting out can be forced based on the civil code, which is complex and unpractical
Poland	The only sanction of non-compliance with the requirements is the loss of rights of the responsible architect or engineer through Civil Court
	The certificate for existing buildings is not required unless the involved parties express the will to have a certificate
Spain	Limited specification available

6 > Discussion on the compliance and control schemes

The full implementation of the EPBD is hardly and in some countries not yet completely finalized. Implementing the EPBD is a huge task and it is an illusion to assume that the EPBD is implemented in the most effective way right from the beginning. Nevertheless parts of the EPBD like setting energy performance requirements for new buildings are already covered by existing legislation in some Member States. Other parts of the EPBD like energy certification of existing dwellings are quite new. Through implementation, evaluation and adaptation lessons learned may lead towards optimization of the approach. At this moment it is too early to generate a balanced judgement about the effectiveness of a compliance and control approach. Let alone the dependency from the legislative, cultural and political situation in a Member State. Nevertheless in this stage it is worthwhile to present the actual situation, not because of the balanced judgements that can be derived but because of the need in the Member States to get an overview of the various approaches applied of the Member States as a spectrum of possibilities. For the EPBD objectives of setting energy performance requirements, issuing energy performance certificates for existing buildings and quality control on the assessors observations derived from the table in chapter 4 are discussed.

Setting requirements for new buildings and major renovation

Probably the most imposing sanction is to obstruct the process of realization or utilization of new or majorly renovated buildings by withholding the building or utilization permit. The effectiveness of this approach strongly depends on the type and scope of control. Three major aspects of control can be distinguished to assure a solid implementation.

1. Check the presence of an energy performance indicator showing that the requirements are met.
2. Control the quality of the assessment of the energy performance indicator. This is of great importance to really reach the policy targets aimed for by setting requirements. When this quality is not integrated in the control scheme, the market might escape from the requirements by providing the authorities a fictional indicator.
3. Assure that the building is realized according to the plans.

The first activity is of course the basic action necessary to control compliance with the regulations. The second and the third action require more expertise and effort from the controlling body; a random check strategy is often applied to cover these last two issues. The fact that the building permit complies with the regulations is no assurance that eventually the building does. A utilization permit can provide the opportunity to check whether the building is realized according to the plans.

A majority of the surveyed Member States apply the approach of withholding the permit in case of requirements for new buildings and major renovation. Some countries have an additional utilization permit. One of the countries focuses on the utilization permit only. In some countries this approach is combined with imposing a fine or prosecution. A minority of countries allow the permit to be issued and only impose a fine or prosecution combined with an active control.

The differences of the approaches will most likely be explained by the legal and regulatory schemes already in force. The most rational approach is to fit into the existing procedures. This, in general, provides a better perspective for market acceptance and compliance.

The decision to control by means of imposing a fine or even prosecution and the balance between severity of the penalty in combination with the intensity and frequency of the control is related to cultural and political values in a country. Member States were the citizens have a strong community focus the control intensities and fines can be on a lower level than in countries were the people value autonomy highly.

Issuing certificates for existing buildings when sold or rented out

Regarding the enforcement of certification of existing buildings by obstructing the sales or renting out of the building can be an effective sanction.

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Addendum:
At the time of publication of this paper there has been a political agreement on the recast of the EPBD.

Nevertheless there are only two countries that apply this approach. Most countries choose to impose fines or prosecution in case of non-compliance with the legislation in energy certification in the existing building stock. They don't choose to obstruct the process of selling or renting out. Presumably the obstruction is considered to be a disproportional penalty for just an informative certificate. Most Member States involved in this survey apply a control strategy of imposing fines or prosecution when the certificate is missing. There is a wide variety of approaches. Selling or renting out is a less formalized action than realizing a new building or renovation without the involvement of authorities. It is therefore difficult to define a point of action for control. A variety of solutions is detected in the survey.

One possibility is to enforce a certificate of good quality by the buyer or the tenant through civil court. Although this is juridical conclusive it might be too much of a barrier for the consumer to enforce the issuing of certificates for existing buildings.

In case of central registration of certificates there might be an opportunity to detect whether a certificate was provided by the seller. Another option is to oblige the solicitor formalizing the sales of a building to report the lack of a certificate to a controlling body. The selling will not be obstructed, but the control authority can impose a penalty.

The process of renting out buildings is even less formal than selling buildings. Enforcing the issuing of certificates is more troublesome than in the case of selling a building. An active control is hard to execute and a more passive control relying on the initiative of the tenant is more likely. It is clear that in this situation the influence of cultural values and the legal context plays an important role in the development of the enforcement. Again a balanced approach regarding the severity of the penalty and the intensity of the control is crucial for the effectiveness.

Quality of the experts executing the certification of buildings

In some Member States the qualification of the experts is prescribed. Other countries have chosen for an accreditation or certification of the experts. In most of the surveyed Member States the accreditation will be withdrawn when an expert is incapable of performing his task. This quality control is effective when a clear understanding of the quality of the certificate is provided and proper audits are carried out frequently.

Some Member States choose to organize the accreditation of experts through governmental bodies; other countries leave it to the market.

Here, cultural aspects are affecting the approach. In case the focus of the population is on consensus Member States can rely on market actors for parts of the implementation of national policies. In order to achieve this co-operation communication with the market is essential. By applying this approach market actors are stimulated to organize themselves as counter part of the government. In those countries compliance and control can partly be taken care of by the market. When this climate of consultation is not embedded in the culture, solutions should not be based on this co-operation.

Experiences in the participating Member States

Some Member Sates reported in the survey their impressions on the EPBD implementation in their country regarding compliance and control. These experiences are generalized and presented point by point.

- A **good quality** of the national implementation of the EPBD (schemes, tools, training, information to the market and the public) justifies a **sound enforcement** by control and penalties. Good and controlled

quality of the building certificates provide confidence in the energy performance expressed and creates awareness on the energy issue.
- In case there are **weak parts** in the national instrumentation of the EPBD a sound enforcement approach on these issues is less acceptable.
- Compliance and control is more **transparent and easier to execute** when the implemented tools, schemes and regulations are more explicitly determined.

A more **uniform implementation** approach enables a more uniform enforcement and creates a better level playing field for the market. A **centralized approach** with one data base and one assessment method is one of the options to provide uniformity.
- Prescribing a **standard assessment method** for the building certification will simplify the quality control.
- **Regional differences** in implementation within a country may complicate enforcement and diminish the level playing field.
- Making the data of the building stock generated by the certification of buildings available provides the opportunity to evaluate and **attune the EPBD instrumentation and the control schemes** and create more efficiency and impact.
- In the case of calculated rating, there might be a **tension** between the drive to **simplify the assessment method** and the need to include the all necessary energy measures in the methodology. Quality control regarding the use of very advanced methods typically is more complex than for simple methods. Allowing adaptations to a simple method to take into account advanced measures for specific buildings complicates the control. A well-considered approach is necessary.
- Especially regarding **major renovation** the enforcement will benefit from a unambiguous definition of major renovation. This definition can be assessed nationally to fit the local context.

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7 > References

1. Schwartz S. H. (2006). A theory of cultural value orientations: Explication and applications. *Comparative sociology*, 5, 2-3, 137-182.
2. Dietz, T., Fitzegard, A., Shwom, R. (2005). Environmental values. *Annual review environmental research*, 30, 335-372.
3. Falkner, G., Hartlapp, M., Treib, O. (2007). Worlds of compliance: Why leading approaches to European Union implementation are only 'sometimes-true theories. *European Journal of Political Research,* 46, 395-416.
4. Falkner, G., Treib, O. (2008). Three Worlds of Compliance or Four? The EU-15 Compared to New Member States. *JCMS*, 46, 293–313.
5. Toshkov, D. (2007). In search of the worlds of compliance: culture and transposition performance in the European Union. *Journal of European Public Policy,* 14, 933-959.

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More information can be found at the ASIEPI project website: *www.asiepi.eu*

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Evaluation of compliance and control in different member states

The EPBD only imposes MS to set requirements without any specification about the severity of the requirements, nor about the measures to be taken regarding the control on implementation. As such, MS can fulfil the requirements of articles 4 to 6 without increasing the existing levels of requirement and without carrying out any kind of control.

Requirement levels are an important instrument to improve the energy efficiency of the building stock, but it is definitely not enough. With no compliance, the energy efficiency of the building stock will not improve.

In the framework of the ASIEPI project, funded by the Community's Intelligent Energy Europe programme, a study has been set up to collect information on compliance and control of energy performance legislation in the Member States. This paper presents the synthesis results.

1 > How is compliance of the EP requirements for buildings handled in MS?

To achieve compliance with the EP-requirements, the responsibilities of the various actors are defined in the EPB-regulations of each country. While some variations exist the procedures are similar. It varies from the simple check of completeness of documents to a random check at the construction site or both of them.

In general, controls are handled in the following way. They are performed by state or federal employees who are allowed to visit any building during the construction or after its termination. Control campaigns are systematic in Danemark, Finland, Netherlands, Belgium (Flanders) and Norway. It is based on Analysis of plans, specifications, or/and calculations. In Norway and Belgium (Flanders), energy performance declaration are generally submitted and checked electronically. In Belgium (Flanders), complementary to the systemetic control, autorities execute a second control based on random.

In France, the control is annual. A sample of operations is extracted with representative criteria and several regulations can be controlled including EP regulation. Generally, the control is based on :

- Analysis of plans, specifications, calculations
- Visit on site to check insulation
- Visit at commissioning

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When control has taken place, the building owner, designer or EPB responsible must be able to prove that his building complies with the regulation through supply of calculation notes and written proofs.

In Norway, Permit applications are generally submitted and administrated electronically. The check is made automaticly.

In Greece, the Energy Performance Regulation for Buildings is going to be implemented during 2009. The checks of compliance of new buildings with the energy requirements will be performed by the energy consultants who also issue the energy certificate. The energy experts group, responsible also for compliance checks, will be consisted by a large number of engineers or experts from other scientific fields related to energy aspects that will carry out the audits and will issue the certification.

In Spain, Most of the 17 regions are working in the development of the administrative procedures, for registry, control and inspection.

In Poland, there is no any special administration procedure to check the compliance with EP requirements.

Non-compliance with construction regulation is an offence with financial penalties : 240 euro/GJ for the energy performance and 60€/W/K for thermal insulation in Belgium, Up to 45.000€ in France, between 5.000 and 50.000 € in Germany, fine calculated on the basis of economic income of the professional in Italy or pecuniary fine in Greece against the responsible. Controllers have the duty to write down a report when they record a breach to require that the owner undertakes remedial actions to comply with the regulation. In general, problems are solved during the informal procedure.

In Denmark and Finland, if the building does not comply with the energy performance requirements it has to be adjusted. The building can be put to a prohibition of use as an extreme measure, but these kinds of measures are rare. The observed incompliance is normally corrected during the implementation phase.

In Netherlands, sanctions in case of non-compliance with EP-requirements can be imposed by the local authorities. In an early stage of the building process they can refuse the building permit. Once the building is started they can stop the construction process until the omissions are solved. Once the construction is finished the local authority can forbid the occupation of the building. Stopping the construction process happens in practice, but because of the large economical consequences it is seen as a severe sanction and therefore not used regularly. Forbidding occupation is even more severe and is nearly ever done.

In Norway, the most common sanction is a fine together with enforced remedial work, or at worst imprisonment. If the planning-&-building authorities find that the offence is of trifling significance, they may refrain completely from subjecting it to sanctions.

In Czech Republic, the Law is not clear about whether the building will have to be subsequently brought into conformity with the requirements of the Act, or not.

In Spain, different decrees and laws state penalties going from economic fines to activity suspensions.

In Poland, the only sanctions caused by non-compliance of EP requirements can be withdrawal from Chartered Associations of Architects or Engineers –

lost of rights for design and supervise construction or obligation to repay incurred losses of building owner according to the sentence issued by Civil Court.

2 > How is compliance of the EP certification process handled in MS?

In Belgium, the certification procedures and the status of the legislation vary from one Region to another. For new buildings, the EP-certificate is based on the EPB-declaration and is established at the same time as the EPB-declaration. If a control shows that the EPB-declaration is not correct, the EP-certificate is automatically cancelled. The control of the EP-certificate for new buildings is therefore based on the control of the EPB-declaration.

For existing buildings, the control concerns the energy experts allowed to issue the certificate, as well as the certificate itself. The experts must have followed a recognized training. The quality of the certificates is randomly checked. If one or more problems are identified with respect to a certificate, it is cancelled. If the controls show that a particular expert is not competent enough, his license can be abrogated.

In Denmark, the Danish Energy Agency is responsible for the scheme. The daily operation of the scheme is delegated to a secretariat also operating the other schemes related to the EPBD. From April 2008 it became possible to appoint a company official to issue the certificates, thus permitting companies to appoint their own consultants. The companies carry out their own quality checks according to DS/EN ISO 9001. The Danish Energy Agency carries out a market surveillance of the companies. These quality checks are made regularly, but also when there are complaints from clients, out-of-range values, etc. They also check the energy consultants' independence and qualifications.

There are possibilities of penalties if certification is omitted.

In France and Czeck Republic, the Ministry is responsible for this task. It authorizes energy experts for making the certification scheme, keeps the list of authorized experts and annually collects experts' records (number of EPCs, energy saving potential, etc).

In Finland, The quality control procedure of the EP certification is not regulated by the legislation, but the legislation allows the Ministry of the Environment to gather relevant information about the certificates and prices of certificates from the qualified experts. Qualified experts have to keep an archive of the certificates they have issued for 15 years.

In Italy, the selling/renting act must be accompanied by the energy certification. The documentation must be presented with all the relevant project documents. The municipality approves the end of the works only if the certificate/attestation is supplied.

If no compliance, there is a penalty system involving all the actors involved in the certification process, with administrative procedures and economic fees as described above.

In Netherlands, buildings built can get an exemption: the permit is equivalent with the certificate. There are no sanctions when no EP certificate is made, however the buyer can make a demand that a certificate is made based on the civil code.

The quality control scheme comprises the double check on the site executed by the accredited body (this is done by random checks).

In Poland, only new buildings are subject of certification. Designation of building into operation requires presentation of certificate. Certificate itself is not checked by authorities as its compliance with requirements is the responsibility of the expert. Concluding, there is no any special administration procedure to check the compliance of EP certification process.

In Germany, Compliance with EP certification for new buildings and buildings undergoing major renovations is in the hands of the federal states. There is no authority that checks the EP certificates for existing public buildings or buildings that are sold or rent. Here the responsibility is with the building owner as defined in the German energy decree.

3 > Are there incentive policies in MS contributing to respect of the regulations?

In general there are no incentives for the mere compliance with the EPBD. Incentives are only offered for buildings that go beyond the minimum requirements in France, Belgium, Czech Republic, Finland, Italy, Netherlands, Poland, Germany, Spain, Norway and Greece. These incentives include subsidies, zero interest loans, fiscal deductions, etc. Most of these economic supports for energy efficiency are focused on particular technologies (heat pump, insulation of walls or roof, photovoltaic panels, etc.). But in some regions of those countries, the subsidy allocated is based on the overall energy performance of the building and not on the particular systems.

In Denmark, there is no financial support for energy saving measures. The political climate has not been in favour of financial support; however it is currently on the political agenda and negotiations are ongoing and it seems that they will be successful.

4 > Conclusions

Compliance and control is done very differently in MS. In general, control campaigns are systematic or annual and the authorities have the possibilities to execute a random controls to verify that all rules are complied.

The reasons of no systematic check are the lack of expertise and very few funds allocated to make controls. To increase professionals and public awarness, the penalities must be remebere on the energy performance declaration and energy performance certificat. In addition, as certificates must be provided for most of building, energy experts who issue them can check the compliance. In this case a specific training is needed.

Regarding the incentives, there are no incentives for compliance with the EPBD. Existing financial supports concern energy saving measures in MS except in Denmark. This mechanism represents a positive instrument to improve the efficiency of the building and has indirectly a good effect on compliance with the rules of regulation.

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Original text language: English

5 > References

1. The Czech Republic: Impact, compliance and control of legislation - P166 (*http://www.buildup.eu/publications/7001*, *http://www.asiepi.eu/information-papers.html*)
2. Finland: Impact, compliance and control of legislation – P167 (*http://www.buildup.eu/publications/7042*, *http://www.asiepi.eu/information-papers.html*)
3. Italy: Impact, compliance and control of legislation – P168 (*http://www.buildup.eu/publications/7043*, *http://www.asiepi.eu/information-papers.html*)
4. Netherlands: Impact, compliance and control of legislation – P 169 (*http://www.buildup.eu/publications/7059*, *http://www.asiepi.eu/information-papers.html*)
5. Norway: Impact, compliance and control of legislation – P170 (*http://www.buildup.eu/publications/7044*, *http://www.asiepi.eu/information-papers.html*)
6. Poland: Impact, compliance and control of legislation – P171 (*http://www.buildup.eu/publications/7045*, *http://www.asiepi.eu/information-papers.html*)
7. Spain: Impact, compliance and control of legislation – P172 (*http://www.buildup.eu/publications/7050*, *http://www.asiepi.eu/information-papers.html*)
8. Greece: Impact, compliance and control of legislation – P173 (*http://www.buildup.eu/publications/7051*, *http://www.asiepi.eu/information-papers.html*)
9. Belgium: Impact, compliance and control of legislation – P174 (*http://www.buildup.eu/publications/7046*, *http://www.asiepi.eu/information-papers.html*)
10. Denmark: Impact, compliance and control of legislation – P175 (*http://www.buildup.eu/publications/7047*, *http://www.asiepi.eu/information-papers.html*)
11. France: Impact, compliance and control of legislation – P176 (*http://www.buildup.eu/publications/7048*, *http://www.asiepi.eu/information-papers.html*)
12. Germany: Impact, compliance and control of legislation – P177 (*http://www.buildup.eu/publications/7049*, *http://www.asiepi.eu/information-papers.html*)

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Evaluation of the impact of national EPBD implementation in MS

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1 > Introduction

The Energy Performance of Buildings Directive (EPBD) only imposes Member States to set energy performance requirements, without any specification about their severity. As such, MS can fulfil the provisions of articles 4 to 6 of the EPBD without increasing the pre-existing levels of the energy performance requirements. This of course would mean failure to achieve the main objective of the Directive, which is to ensure, through its implementation, an important additional reduction of the energy use of buildings.

This paper aims to obtain a good overview how the EPBD implementation has changed (or is changing) the national requirements in terms of energy efficiency and indoor climate and to describe what has been the impact (if any) of the EPBD implementation on the severity of those requirements. It aims to summarise and compare if there has been a widening of the existing types of requirements in the different MS (e.g. more severe requirements, widening of the range of buildings covered by the regulations, more requirements, requirements for renovations…) and tries to conclude whether the implementation of the EPBD already has succeeded to reduce the energy use of the building stock in Europe.

The paper is part of a study carried out among 12 countries (Belgium, Czech Republic, Denmark, Finland, France, Germany, Italy, The Netherlands, Norway, Poland, Spain and Greece) in the framework of the project ASIEPI, funded by the Community's Intelligent Energy Europe programme.

2 > Impact of the EPBD implementation on the national requirements

Energy performance requirements and energy certification in the MS before the EPBD

The majority of the questioned MS had some type of energy specifications incorporated into their national building or other regulations before the introduction of the EPBD.

Almost all of the investigated countries had indirect specifications or regulations referring only to the restriction of heat losses (U-values, minimum levels of insulation) and minimum ventilation rates. For these countries the implementation of the EPBD meant a complete revision of their national legislation and the imposition of new relative regulations, which set for the first time minimum energy performance requirements and adopt energy assessment and certification of buildings.

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A number of countries however already had both EP requirements, as well as a well-structured certification scheme in place (mandatory or voluntary), long before the introduction of the new Directive. Those were Denmark, France, Germany, The Netherlands and the Czech Republic. For those countries, the implementation of the EPBD provided an opportunity to reconsider their national regulations, expand their coverage and application and tighten the requirements. As an example, in The Netherlands, there was already a mandatory certification system in place for new buildings since 1995, but only a voluntary system for existing buildings. With the implementation of the EPBD, certification became obligatory for existing buildings as well.

Impact of the implementation of the EPBD on the national methodology, the national requirements and schemes

In general, the implementation of the EPBD forced MS to update their national regulations in order to apply a methodology for the calculation of the energy performance of buildings, to meet (more strict) energy performance requirements and to introduce energy certification. Even countries which already had EP requirements and a clear and strict certification scheme in place, they were forced to update their method to be in line with the EPBD and the CEN standards.

The new Czech calculation procedure is based on published CEN standards. Norway improved the national EP calculation standard (NS 3031) to be in line with ISO 13790 and Germany developed a new national calculation method for non-residential buildings that is fully CEN compatible.

In most cases the existing EP requirements became stricter (e.g. lower limits for energy consumption) than before the EPBD. Denmark and France now further tightened the existing energy performance requirements in their building regulations. However, there are a few exceptions to this rule, countries, whose requirements were not affected by the implementation of the EPBD (e.g. Germany, at least for residential buildings and the Czech Republic), while in one case (Poland), specific requirements for heating paradoxically became looser after implementation of the EPBD. All in all, the average tightening of requirements through the EPBD over Europe varies from 15% in the less positive scenarios, up to 30% in the most positive ones (e.g. Finland).

In many cases, the pre-existing, direct or indirect, requirements were extended to include additional parameters; e.g. in Denmark, the new calculation method now includes thermal bridges, solar gains, natural ventilation, heat recovery, air conditioning, lighting (for large buildings), boiler and heat pump efficiency; in Belgium, requirements were complemented to include space heating and DHW consumptions, auxiliary energy consumption, cooling consumption, but also energy production through PV cells or a cogeneration installation; and in Norway, the new EP calculation standard now includes cooling, DHW, lighting, fans & pumps, but uses some fixed input parameters including internal heat gains (equipment, people), DHW, operating hours, set-point temperatures for heating & cooling and default lighting energy.

An important addition to the existing requirements Europe-wide is shown to be the introduction of summer requirements, often for the first time, even in Northern climates such as Finland and Norway.

Quite a number of countries (like Greece, Italy, Poland, Belgium, Finland, Norway and Spain) first introduced energy certification, as a result of the EPBD. So was as well the Renewable Energy Sources feasibility study, applicable mostly for buildings >1,000 m^2, in the Czech Republic, Greece but also in France.

In many cases the existing methodology found a broader application. The pre-existing method has been extended, or is currently being extended, for example to include additional building types. The German certification methodology set in 2002 changed to apply as well in case of sale or renting of existing buildings. In other examples this extention of application goes beyond the strict scope of the current EPBD. This is the case for example in France, where the existing method already became applicable for existing buildings as well. In The Netherlands, two different existing methodologies are now being combined into a single new one that will cover both existing, as well as new buildings.

Specifications stricter than imposed by the EPBD?

Most MS just meet the specifications set in the EPBD. However, some interesting approaches go beyond the necessary EPBD specifications and set additional rules to ensure high energy performance.

In Denmark for example, all cost-effective energy saving measures are obligatory in the case of major renovation. Furthermore it is required that some individual, profitable measures (like insulation of external walls when changing the weather shield, insulation of attic and roof when changing the roof, a replacement of the boiler or heat supply) have to fulfil the requirements, regardless of the size of the renovation. Public authorities are obliged to implement energy-saving measures with a pay-back time of less than five years as described in the energy certificate of the buildings; this is a stricter rule than the one implied by the EPBD. And finally for Denmark, the lifetime of the certificate is 5 instead of 10 years.

In France, compliance with the requirements and certification is also valid for renovation of small buildings (< 1000 m^2), which is not required by the EPBD. Additionally, feasibility studies on RES are required as well for buildings over 1.000 m^2 in case of important energy renovation, when EPDB only requires these studies for new buildings.

Germany also has no 1,000 m^2 threshold for buildings that undergo a major renovation. Furthermore, Germany has stipulated a minimum use of renewable energy for all new buildings, while in some federal states the use of renewable energy is also required for major renovations of existing buildings.

The threshold of 1,000 m^2 is also overcome in Poland, at least in theory. However, since execution of the certificate is required only if, after construction, the building needs to get a permit for operation, this does not include renovation, not even major. Additionally, Polish requirements are less strict than the EPBD as they only apply to new buildings (no rent or sale).

A totally different approach is the one used in Finland and Norway, where the legislation allows the local building supervision authorities to decide whether the building regulations will be applied to the renovation or not. The problem with this approach is that local authorities tend to be lenient, giving dispensation too often.

Certification scheme

Many of the questioned countries, among which are Belgium, Finland, Poland, Spain, Italy and Greece, first introduced a certification scheme in their national regulation frame, as a result of the EPBD implementation. Denmark, the Czech Republic, France, Germany and The Netherlands already had a certification scheme in place before the EPBD. With its implementation, changes may have occurred to the existing certification schemes. In Denmark, the certification was originally based on the measured consumption (operational rating) for buildings > 1,5000 m^2, but after the implementation of the new Directive, all certificates have to be calculated (asset rating). In the Netherlands the certification scheme became mandatory, the calculation method slightly changed and an A to F rating was introduced. Germany introduced certification of existing buildings for the first time and in France, the existing method became applicable for existing buildings as well.

In the Czech Republic, and possibly also in other countries where certification is applied only to new and renovated buildings and the average age of the building stock is relatively high, all issued certificates are category C and above, so the classes "D" to "G" remain entirely unused for buildings that are assessed in terms of energy performance as poor and therefore requiring the implementation of saving measures. In the case of Poland, possible errors and misleading methods in practice downgrade the energy certificate to just a piece of paper required by law that does not provide much useful information to the building owner.

Indoor climate

Prior to implementation of the EPBD, all Member States (except for Italy) already had incorporated some requirements concerning indoor climate to their national legislation. Those mainly focused on ventilation levels and heating. The implementation of the EPBD, did not totally alter those.

However, with its implementation, many MS first formally introduced in their national regulation aspects related to summer comfort (avoiding the risk of overheating and reducing the cooling loads). This was specifically the case for Belgium, Finland, The Netherlands, Norway and Greece. A few other countries, among which is France, used the EPBD as an opportunity in order to further specify existing requirements related to summer comfort (defining indoor temperatures for unconditioned buildings, changing the ventilation rate and the air tightness level). Germany had a requirement for the prevention of overheating already in place, which is based on a limitation of the solar gain factor.

The use of Renewable Energy Sources (RES)

In all Member States, the use of RES has been incorporated into the energy efficiency of buildings and the overall calculation procedure.

A RES feasibility study has been first introduced and is obligatory for new buildings over 1,000m^2 in almost all the investigated countries, including the Czech Republic, France and Greece.

Although most countries' policies are to introduce more RES, many Member States have no specific regulation that makes the use of RES obligatory for buildings. Exceptions are Germany, Italy, Spain, Norway, The Walloon region of Belgium and Finland. In Germany, the law imposes a minimum use of renewable energy for all new buildings. The ratio is dependent from the type of renewable energy (e.g. 15% solar thermal, 30% biogas, 50% heat recovery, biomass and biofuel, geothermal and waste heat). One federal state requires as well as that renewable energies are used for existing buildings for which the heating system is exchanged. In Italy, it is required that 50% of domestic hot water (DHW) comes from solar thermal systems. The percentage decreases to 20% in the historical city centres. This rule can be avoided if the impossibility of such an installation is accurately described in a technical report. This latter aspect is crucial as it avoids the installation of solar systems in many cases. Also, the installation of photovoltaic (PV) systems for at least 1 kWp minimum per dwelling is mandatory. In Spain solar DHW is obligatory, as is the use of PV's for non-residential buildings. Norway imposes a requirement that ≥40% of a building's net energy demand shall be supplied by RES (not electricity or fossil fuels). In the Walloon region of Belgium, the installation of solar thermal systems for domestic hot water or any system that saves an equivalent amount of energy will be mandatory for existing buildings in the case of large renovation and for new buildings. Finally, the current status in the Finnish building stock is that renewable energy sources (in specific wood) are mainly used in the single family houses.

In some countries (France, Poland, Germany and Greece among others) there are individual incentives to promote the use of RES in the building sector. These incentives mainly involve tax incentives or increased tariffs for the energy fed to the grid. In Germany, for example, the PV-production was accelerated by the law, because it was ensured that renewable energy can be fed into the grid at rather high tariffs. The same principle is valid also for Greece where additionally, the installation of photovoltaics in buildings is reinforced by a simplification of the administrative burden.

Energy auditors

Countries that already had a certification scheme in place prior to EPBD implementation, had as well a group of experts responsible for carrying out the energy audits. The implementation of the EPBD meant in most cases changes to the national requirements, but not to the qualifications of the energy experts. The selection criteria remained mostly the same, including engineers, architects and experts from other relevant fields. A training session has been implemented in some countries for keeping experts up-to-date.

In many cases energy assessors and system inspectors are brought under the same structure and have to fulfil the same requirements and qualifications. However, some countries, including for example France, still do not have a regulation concerning inspectors in place. At the other hand, many already established voluntary regimes now become mandatory, as is for example the case in Norway. It is interesting that in Germany, the existing group of experts for the assessment of new buildings remained unaltered, while the criteria have been enlarged for the new group of experts assigned with the assessment of existing, or non-residential buildings.

On the other hand, countries that did not have a certification scheme before, are now defining their experts groups and qualification criteria, in order to comply with the recommendations of the EPBD.

3 > Impact of the EPBD implementation on the energy performance of buildings and the building market

When looking at the building market in the EU, there seems to be a clear shift towards more energy efficient constructions and introduction of better performing products. However, such changes can not be attributed solely to the implementation of the EPBD, as they are much more affected by the regional, seasonal, social and general economic situation. Therefore, the impact of the EPBD on the energy performance of buildings, or the building prices is not yet really quantifiable.

Energy performance of buildings

Setting aside whether the result is directly, or not, related to the implementation of the EPBD, the general trend shows a clear improvement in the energy efficiency of buildings in the EU.

Specifically, the Danish energy consumption of households is proven to have stayed rather constant over the years, despite their continuously growing floor area. The energy consumption per m^2 is considered to be decreasing due to better insulation and boiler efficiencies.

Also Italy shows a positive trend in the energy consumption reduction, even if the intensity is modest. This reduction is owed not so much to the new energy policy, than to the reduction in the heating energy consumption in the past years.

In Norway, the energy consumption per m^2 has decreased, as has consumption per dwelling and per capita. This improvement in energy-efficiency is considered to be the result of a combination of factors, including higher energy costs, better focus on energy conservation, better insulation and more efficient equipment. It is too early to say what impact the EPBD has had on the energy consumption of the building stock as a whole. However, the few new buildings that are being constructed under the new EPBD regulations in Norway are more energy-efficient (estimated approx. 25%) than older buildings, built under the previous building regulations.

The German building stock has not clearly become more energy efficient yet, however, energy efficiency has reached a higher level of visibility with certificates also for existing buildings and especially for public buildings. The EPBD implementation did not have an influence on the energy performance of the German building stock if we regard strictly the energy performance requirements.

Polish energy requirements, on the other hand, are less strict than before the implementation of the EPBD, and as a result the performance of the Polish buildings stock it not expected to be positively influenced.

Market overview

So far, there is no clear evidence available whether, and in what way, building prices are affected by the implementation of the new Directive. As mentioned earlier, also the changes in the building prices, can not be directly appointed to the implementation of the EPBD, as these may as well be primarily affected by other parameters like season, social and general economic situation.

A recent study of rising construction costs in Finland, did not prove a clear correlation with energy efficiency, but rather with overall social improvements of buildings. Also, in Germany there is no measurable influence of the EPBD implementation on the building market and prices. However, in cases where an increase in building prices due to improved energy efficiency is expected (e.g. France) the average expected price increase (here 2%) has to be compared against the energy savings (that are estimated to reach 15%). In Denmark the price for a new building compared to a building built according to the previous building regulation is calculated to be approx 15-30 euros higher per m^2. In the Netherlands, it seems that having a “green” label has a small positive effect on the transaction price and on the period of time that a house remains unsold, compared to having a “red” label.

In general it could be anticipated that the owners of better energy performing buildings will be able to demand higher prices for them, as their performance means lower running costs and conversely, owners of poorly performing buildings will have to lower prices, or invest in improving their performance, in order to make them attractive.

In Poland, as new requirements are less demanding than the old ones and due to overall economy crisis, even the opposite could be expected: that new constructed buildings should be cheaper than before.

The effect of the EPBD on the building market therefore mainly focuses on the development of new building products and innovative techniques. Thus, the higher prices concern mainly the new-technology products and not the prices of buildings themselves. Products and techniques that already gained market ground through the EPBD implementation are condensing boilers, improved insulation and glazing, heat pumps, mechanical ventilation and heat recovery systems, DC fans, improved lighting systems and renewables (like solar thermal collectors, photovoltaic cells and others). Also, new techniques have been introduced, e.g. heat recovery systems of shower water and demand driven ventilation systems, cool paints, etc.

It is interesting to mention that in a couple of countries like the Netherlands and Germany, with every step of reducing the energy performance requirement level, the procedure is to perform a study on cost-effectiveness. By announcing the reduction of the EP level far in advance, the industry has time to adapt and develop improved and innovative systems. The industry uses the EP regulations as a PR instrument for their improved products.

4 > Conclusions

Despite the significant variation in EPBD implementation and experiences, the current analysis shows some clear tendencies related to impact.

There are different fields that have been influenced through EPBD implementation and so the tendencies are analysed in terms of changes in:
- legislation
- requirements
- energy consumption of the building stock
- building market and prices
- public awareness

All countries used the opportunity to change their legislation: either to impose EP requirements and/or certification for the first time, or to re-evaluate their existing ones. It is interesting to note that countries that already had requirements in the past, tend to make them even stricter. A pre-existing methodology often is extended to apply to additional building types, inserting obligations for the use of renewables and going beyond the exact obligations imposed by the EPBD. Conversely, countries that are imposing energy requirements and certification for the first time, tend to be more conventional and uninventive for the time being.

Changes in the building energy consumption can not be easily attributed to the EPBD alone. The actual impact on the energy performance of the building stock is not yet clearly estimated, although there are some countries with success stories showing a positive change in the energy performance of the new building stock due to the EPBD related regulations.

At the same time, the building market is clearly affected by the implementation of the EPBD, especially by means of visibility and introduction of new and improved building products and technologies. There are success stories regarding the market uptake of innovative systems, wherein the EPBD regulations have had a catalysing effect. However, the specific effect of the EPBD on the building prices is again difficult to isolate.

Clearly affected is the public awareness, which shows an increasing tendency towards more efficient constructions and systems but also towards sensible use of energy.

All in all it is expected that the recast of the Directive will further build on the tendencies already set by the EPBD, therefore making it possible to meet the specific objectives.

Also measures not included in the original EPBD will be seriously considered, such as stricter control of refurbishment, forewarning of staged tightening of energy regulations up to at least 2020, white certificates, etc. Such measures have already been implemented in select countries.

5 > References

1. The Czech Republic: Impact, compliance and control of legislation - P166 (*http://www.buildup.eu/publications/7001, http://www.asiepi.eu/information-papers.html*)
2. Finland: Impact, compliance and control of legislation – P167 (*http://www.buildup.eu/publications/7042, http://www.asiepi.eu/information-papers.html*)
3. Italy: Impact, compliance and control of legislation – P168 (*http://www.buildup.eu/publications/7043, http://www.asiepi.eu/information-papers.html*)
4. Netherlands: Impact, compliance and control of legislation – P 169 (*http://www.buildup.eu/publications/7059, http://www.asiepi.eu/information-papers.html*)
5. Norway: Impact, compliance and control of legislation – P170 (*http://www.buildup.eu/publications/7044, http://www.asiepi.eu/information-papers.html*)
6. Poland: Impact, compliance and control of legislation – P171 (*http://www.buildup.eu/publications/7045, http://www.asiepi.eu/information-papers.html*)
7. Spain: Impact, compliance and control of legislation – P172 (*http://www.buildup.eu/publications/7050, http://www.asiepi.eu/information-papers.html*)
8. Greece: Impact, compliance and control of legislation – P173 (*http://www.buildup.eu/publications/7051, http://www.asiepi.eu/information-papers.html*)
9. Belgium: Impact, compliance and control of legislation – P174 (*http://www.buildup.eu/publications/7046, http://www.asiepi.eu/information-papers.html*)
10. Denmark: Impact, compliance and control of legislation – P175 (*http://www.buildup.eu/publications/7047, http://www.asiepi.eu/information-papers.html*)
11. France: Impact, compliance and control of legislation – P176 (*http://www.buildup.eu/publications/7048, http://www.asiepi.eu/information-papers.html*)
12. Germany: Impact, compliance and control of legislation – P177 (*http://www.buildup.eu/publications/7049, http://www.asiepi.eu/information-papers.html*)
13. Energy savings in buildings: Assessment and Improvement of Legislative impact – Observations and recommendations regarding impact, compliance and control issues with regard to the proposed recast of the REPBD (*http://www.buildup.eu/publications/6065*)
14. Summer comfort and cooling: calculation methods and requirements – P163 (*www.asiepi.eu, www.buildup.eu*)

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Barriers and good practice examples identified during early implementation of the EPBD

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During the transposition and early stages of implementation of the EPB Directive into national practices, several issues appeared either as barriers, or as points for discussion. This paper, which is part of a study in the framework of the ASIEPI project funded by the Community's Intelligent Energy Europe programme, aims to analyse the most common, or most critical of these discussion points for the implementation of the EPBD, in order to provide possible solutions and good practice examples for other countries.

1 > Introduction

Although the EPBD allows for quite some freedom in national requirements and even though the national boundary conditions (legal frameworks, cultural differences, climate etc.) may differ a lot from country to country, in practice it is proving that most countries have experienced, or are still experiencing similar challenges in implementation.

This paper summarises a selection of some of the most common or most critical discussions and barriers for implementation of the EPBD and the solutions taken to resolve those in individual MS. The study is restricted to a specific set of such barriers or discussion points, since the actual list of issues in question may in fact have been quite long. The investigated issues concern:

- How countries are handling certification in the case of apartment buildings
- Whether control systems are taken into account in the standard calculation methods
- Whether energy saving measures that are under discussion in specific countries in terms of e.g. questioned efficiencies, or health and safety reasons, exist
- Whether energy efficiency technologies, such as mechanical ventilation with heat recovery, are common even against indoor quality
- Whether the results of a national method in one country are accepted in another country
- How the gap between theory and practice is being bridged
- How conflicting interests from national regulations are being dealt with
- Whether summer comfort is being promoted to the detriment of energy efficiency

The analysis is based on internal discussions and the unofficial answers provided by the partners involved in the ASIEPI project on a simple internal questionnaire. The study is carried out during the summer of 2009 among

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13 countries (Belgium, Czech Republic, Denmark, Finland, France, Germany, Hungary, Italy, The Netherlands, Norway, Poland, Spain and Greece). The information provided is mostly based on personal experiences of the partners involved in the project and therefore does not necessarily reflect the official position.

2 > Certification in case of apartment buildings

One of the issues that all MS had to resolve prior to implementation of the EPBD was the handling of certification for apartment buildings. The Directive leaves space for different approaches to this type of certification. Two are the most obvious options: a) to certify the building as a whole, or b) to certify each individual flat separately.

Clearly there are pros and cons for both options. Certification of the building as a whole is more economic and of course more evident where a central heating system without separate metering exists. However certification per apartment gives a better overview of the actual consumption and thus of the potential for energy savings.

In practice different combinations of the two options seem possible and effective. MS have dealt with the issue of certification of apartment buidlings in various ways. Four of the examined countries always assess the building as a whole, while 2 countries always assess just the individual apartments. In the remaining 5 countries, both options are possible under specific circumstances, either in parallel, or separately, e.g.:

- There is one certificate for the whole building, but one or more additional pages are used to describe the individual apartment;
- The whole building certificate may be obligatory, but the owner has the possibility to issue additionally a certificate for the individual apartment;
- Either the building as a whole, or the individual apartments can be certified;
- When the systems are collective, certification is per building, while in case of individual systems, certification is valid only per individual apartment.

Clearly, the specifications of apartment buildings are different in different countries and also different types of ownerships can have a substantial impact on the choice of the right approach. In general there is no one good approach which fits all needs [1].

Generally seen, with the exception of the 2 counries that always assess the individual apartments, when there is a collective installation system in the apartments building, the assessment will mostly be on building basis. Then the individual apartment's energy performance may either be considered the same for all individual apartments (same certificate for all the individual apartments), or be calculated based on the total real, or calculated, consumption in proportion to rental charges repartition rates of the apartment. Both ways, the apartments' energy certificate cannot represent the actual performance of the apartment. Upon certain conditions, the issue of a separate (additional)certificate for the individual apartment is possible, so that the actual situation is described. This not only better represents the actual potential for energy savings, it also helps understand user behaviour and trigger the owners awareness. Of course this usually goes together with a slight increase in costs for energy certification.

More information on the different approaches of certifications of apartment buildings can be found in [6,7].

3 > Control systems

All questionned countries do, to some lesser or greater extent, take into consideration in their standard calculation method control types. The mentioned types, in order of popularity are:

- Lighting (day- or artificial);
- Heating (thermostatic valves, pumps, night set back, week-end interruption, manual control);
- Ventilation (occupancy based, CO2, hybrid);
- Cooling;
- Humidity.

The way such controls are taken into consideration is mostly by default coefficients and (control and/or utilisation) efficiency of the system.

In one country the national EP calculation method normally prescribes a fixed value for the lighting load but a 20% lower value in case of advanced lighting control. In the same country, the efficiency of the energy delivery system is accounted for, but only in the energy label (which is based on *delivered energy*), not in permit applications for new buildings (based on *net energy demand*). This means that builders are more likely to invest in a well-insulted thermal envelope instead of efficient and delivery systems and control types (which have a shorter service life than the building).

In some countries, the Principle of Equivalence can be used to evaluate the performances of such control systems [2]. This basically means that a study is conducted to document the performance (e.g. efficiency) of a product, and this performance data can be used in energy performance calculations of buildings using that product (see also §6, below).

Finally, some control systems that are manually steered, are not always taken into account, as the human behavior is considered too difficult to predict.

4 > Questioned technologies

Various, especially innovative, systems are under discussion because the methods used to prove their energy efficiency are still questioned. It is difficult in practice to evaluate the complex assumptions and physics used in the various calculation methodologies, which are often ambigious.

One example is the discussion about how to calculate preheating from ground heat pumps. Another discussion is the calculation of the efficiency of the air-to-air heat pumps in relation to the actual outside air-temperature. In the case of high efficiency heat recovery from ventilation, the question is whether efficiencies reached under test conditions will also occur in practice, as true efficiencies are in certain cases found to be up to 10% less than manufacturer documentation.

Countries deal with such matters through the development of standardised calculation and occupants' behaviour methodologies. It means that average values of efficiencies of the appliances are entered into the calculation.

In addition to efficiency issues, other measures are questionned in terms of health and safety reasons. Balanced ventilation is under discussion in some countries because of presumed health risks (but not in the Nordic countries, which have long experience with mechanical ventilation). The main problem here is that people often keep the ventilation rate low, even when a high rate is needed for health reasons, due to ignorance, or noise problems with the fan. HVAC installations should be applied in a way assuring achievements of assumed environment quality in the compartment along with rational use of energy for heating, cooling and electrical supply.

Similar issues seem to appear in almost all countries.

5 > Energy efficiency in relation to indoor climate

As a result of the EPBD requirements for the improvement of the energy performance of buildings, some new concepts and technologies have been introduced that are sometimes questionned in terms of indoor air quality. A clear example of this is building air-tightness. Mechanical ventilation with heat recovery is becoming more widespread, and is already well established in the coldest climates. It is assumed that also here some countries could question the influence of this technology on the indoor environment.

Indeed, mechanical ventilation (both supply and exhaust) with heat recovery is quite common in new or renovated, non residential and large buildings and in particular for low energy buildings. But even in cases where it is not yet common (like residential buildings), mechanical ventilation and heat recovery are steadily gaining a lot of ground.

The reason behind this is improved energy performance, especially in terms of heating, and in terms of compliance with the regulations. In most situations, regulations demand a minimum exhaust air heat recovery efficiency of the ventilation system. Cost efficiency is supporting the implementation of the technology in question, although a number of countries are arguing the benefits on indoor quality.

It is interesting to mention that 3 of the questionned countries, all of which have warmer climates, claim that mechanical ventilation and heat recovery is not yet quite common. In these cases, mechanical ventilation is required only if natural ventilation is not sufficient enough, and heat recovery is mandatory mainly when the required air volume is greater than a given value.Also the concept of airtightness has only recently been introduced.

6 > Determining system/product efficiency

When determining the energy performance (e.g. efficiency) of a new energy-saving technology or system, countries normally follow their own specific legal framework, certified methodologies and laboratories. The question is whether it is evident for one country to accept the results of such a study performed according to another EU country’s legal principles.

In the majority of countries, only CE/EN certified systems and technologies and test methods are accepted, so if the CEN method is followed for determination of the technical performance, then no additional measurements will be needed. At least two of the questionned countries accept the data of any certified European quality control institute or laboratory. However, in certain cases it is important to follow the local procedures, as the assumptions made often reflect very specific local conditions.

7 > Theory versus practice

It is well known that there can be a big gap between the functioning of a system on paper and in practice, or between the energy performance of a building as a whole or a building component, in theory and in practice. There can be many reasons for this: things can go wrong during the design, the installation, the fine-tuning and/or use of the system, and calculations are performed under ideal, standardised design conditions, etc.

The experiences with this issue between the 13 questionned countries do not vary much; all 13 countries seem to be aware of such discrepancies among asset and operational rating. The question is, how to deal with this fact in order to reduce the gaps in performance.

The study shows that in fact 8 out of the 12 countries who answered this question in detail do not have specific rules to adjust those discrepancies to. The ideal situation, which in rare cases is required also by building law, is to perform commissioning after the installation of a new system, or after construction. It is also advisable to do this when the building use is changed, or even after some years of use. Continuous commissioning by long-term monitoring and evaluation is the best option and is expected to be applied more and more often.

However, in most countries, it is the responsibility of the inspectors to identify if systems are not working properly, or efficiently and to report such discrepancies and propose saving measures in the EPC report. Similarly, the principal system designer or building designer is responsible to the building supervision authorities for carrying out his duties in an appropriate manner during the building project's design and construction phase. For this reason, both the building and system designer, as well as the inspector, should be highly qualified and sometimes even need specialist expertise.

Real life examples show that installers are not always sufficiently trained to install these complex systems correctly and/or adjust the systems correctly to the building use or building as a whole. As Europe wide EP requirements are becoming more and more severe, systems are expected to become more and more complex.

An additional problem is that various companies/installers are responsible for various parts of the system, but no one is responsible for the total system. In fact there will often be situations where the systems are so complicated that malfunction is noticed only in the commissioning phase, and failure has to be corrected afterwards.

It is of common expectation that the normal quality assurance of the construction works should take into consideration consistence with the overall design. In one country, specific certification procedures for individual craftmenships exist for specialised consultancy firms. Another country is introducing programs to evaluate specific buildings performances, the experiences of which are used to prepare the future regulation. Yet another approach is adoption of advanced monitoring and BEMS systems to control energy consumption.

Recently, initiatives that try to solve these problems by trying to formulate criteria for guaranteeing the performance of the total system/building in practice are under development.

A small number of countries aim to reduce the problem by introducing actual energy consumption against design consumption.

8 > Conflicting interests

During the initiative implementation of the EPBD, some countries faced the problem of conflicting national regulations that prohibit specific energy efficiency measures from being uptaken. One example is biomass burners, which are not allowed by law in some regions or countries, although in terms of energy efficiency they are considered better. Another example is the fact that retrofitting external insulation may conflict with the building regulations related to minimum distance to the land border.

Other examples of conflicting regulations in relation to the national EPBD law may also exist.

This study has shown that there are indeed countries that face such problems. Only 5 out of the 13 questionned countries seem not to have such conflicts. In the remainder, some kind of conflict may or does exist. The examples mentioned earlier are the two most typical examples of such conflicting interests among national laws.

The conflict of laws in the case of additional external insultion seems to appear in at least 5 of the questionned countries. However, in some situations the issue is solved either through relaxation of the building codes for external insulation in the case of renovations, or through the building authorities. In some cases, urban rules have been, or are being revised to favor energy performance, providing for example the possibility to increase the ratio of land built subjected to energy performance requirements.

An interesting approach is that, where an exception to the minimum distance to land border is possible, if the building adopts external insulated layer and presents a U-value lower than 10% than what is foreseen by national requirements; a bonus (an average of 10%) in terms of authorised volume for buildings with high energy performance.

A similar example is that of the simplification of the installation procedure of a solar system (PV or heating collector) so that such systems can be installed with less bureaucracy.

Another type of conflict mentioned is that of certain units (e.g. ventilation), systems (burners, heating) or materials (wood on facades), which may conflict with the national fire safety regulations in buildings, or other formal documents. Often, in such cases of conflicting interest, the environmental rights prevail only for security or safety reasons.

In one of these cases, banning some of the conflicting rules that would systematically prevent the use of such systems or materials, may occur. Also, the national law may take into account many aspects of the buildings regulations in exception to the regional or municipality regulations.

Finally, as proven in all countries, Historical Monuments protected by Law are excluded from the minimal energy requirements set by national EPBD law, so that in such buildings, renovation and works on envelope cannot respect the EP regulation, while RES may not be installed at all. The same exception is mentioned in one country where the EP requirements are contradictory with intrinsic qualities of the building (old buildings with particular hygrothermic transport in walls).

9 > Summer comfort and energy efficiency

Guaranteeing summer comfort and cooling in buildings is a growing challenge for most European countries. Nevertheless, calculation methodologies for assessing summer comfort and requirements for cooling are not yet advanced. The current EPBD regulations may in some cases give the impression that summer cooling is required, although there are plenty of other techniques to prevent overheating, without using energy for cooling. There are a few examples of countries whose EPB requirements are relaxed if cooling is applied, therefore allowing extra space for cooling energy use [3]. In this study we investigated whether this indeed is an issue in EU countries and how it has been dealt with until the time of the survey.

Scandinavian countries were not thought to have an overheating problem until recently, when tightening of the thermal isulation requirements increased the risk of summertime overheating.

In a few Northern and Central European countries, cooling is becoming an issue (mostly in larger administrative buildings with high occupancy, because of greater density of internal heat gains) and minimum energy requirements are not yet tight enough to promote less energy need or passive cooling design.

In the other countries cooling is an issue on a broader scale, covering both residential and non-residential buildings. Many countries choose and make obligatory the alternative cooling techniques and good building design above the use of mechanical cooling and air-conditioning systems to avoid overheating, however, detailed restrictions in regulation, relevant for example to system efificiencies during peak and part loads, limitation of cooling loads for different climatic zones and other, are not always in place.

Fortunately there are good exemptions to this, where for example limiting g-values, or maximum solar gain factors are introduced, or where for buildings with low internal gains, no allowance is given for mechanical cooling in the kWh/m^{2}a limit, therefore being possible to fullfill the requirements only through the buildings performance and high efficiency of service systems.

An interesting approach is that of penalising air conditioning use through the calculation method, which allows for same space for consumption, whether there is an air-conditioning system or not. At the same time this methodology is taking into account certain alternative cooling techniques, like e.g. night ventilation, and introduces minimum summer comfort requirements through solar window factors.

A similar approach is the prescription of the use of a very low room temperature set-point, if mechanical cooling is to be installed. This is intended to dissuade the use of mechanical cooling by giving it a high energy penalty. However, experience has shown that this rule has limited effect as it does not apply to central cooling in the air handling unit. As a result, the regulation has been tightned further with limits on glazing g-factor to ensure both good building design. Additionally one could set limits on the temperature set-point for central cooling systems as well.

Again a different approach was to expand the EP calculation to include the calculation of energy use for summer comfort. With this approach, passive cooling measures have an effect on the EP level of the house, even though no cooling system is present, because a fictive cooling system with specific efficiency is assumed. The idea behind this approach is the reasonable thought that, when overheating is a problem, occupants will buy such a system. Reducing the cooling need of the house will reduce the energy use of this portable system once it is bought, or (even better) limit the need of buying such a system.

In Southern European countries summer comfort is a major issue of concern and it is already very difficult to find buildings without air conditioning. Because in many such cases mechanical cooling can be avoided, careful desing and the use of alternative or passive cooling techniques should prevail above the use of cooling. It is therefore quite important to ensure that alternative cooling techniques are somehow integrated into the calculation methods and cooling loads are limited by law. Alternatively, if no cooling system exists, the minimum requirements can refer to an overheating indicator, the limit value of which is to demonstrate that no cooling will be necessary.

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Member states should be encouraged to apply passive requirements reffering to building design or elements that reflect the specific national building traditions and climate conditions. This means they cannot be fixed uniformly across Europe. [4,5]

10 > Conclusions

It is clear that EU MS have been, and still are, facing similar issues with the implementation of the EPBD. The actual list of issues that have arisen for discussion during the first stages of implementation is of course not restrictive. However, some of the most common ones are discussed in this paper in order to share experiences and knowledge. We have seen that for each barrier faced, several approaches are possible. There is no uniform solution that fits all the needs. Some of the examples given in this paper show how technology and regulations should serve a combination of specific (country or building related) needs (in terms of energy efficiency, indoor climate, safety etc.) and not simply exist or be adopted inspite of them. It is therefore up to the countries to judge which approach best fits the national boundary conditions and best serves the objectives for a sustainable future.

11 > References

1. Detailed report on certification - CONCERTED ACTION - Supporting transposition and implementation of the Directive 2002/91/EC CA – EPBD (2005-2007)
2. Assessment of innovative systems in the context of EPBD regulations – P063 (*http://www.asiepi.eu/information-papers.html*, *http://www.buildup.eu/publications/1478*)
3. Summer comfort and cooling: calculation methods and requirements – P163 (soon available at *http://www.asiepi.eu/information-papers.html*, *www.buildup.eu)*
4. Requirements in EU Member States related to Summer Comfort and Energy Consumption for Cooling – P135 (*http://www.buildup.eu/publications/1171*)
5. Specific study in relation to the EPBD requirements in the EU Member States to summer comfort and energy consumption for cooling (EPBD Art. 4) - Fraunhover IBP.
6. IMPACT- Guidelines for Good Practice in Energy Performance Certification of Existing Buildings
7. IMPACT – Cross country evaluation of energy performance certification

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The Czech Republic: Impact, compliance and control of legislation

This paper aims to summarize how in the Czech Republic the implementation of the EPBD has changed the national EP requirements and has affected the building stock. It describes the national way of handling with EPBD compliance and control and identifies interesting approaches and possible bottlenecks.

1 > Impact of the EPBD on the national requirements

Energy assessment of buildings is not a new thing in the Czech Republic. Since 2001 there is a methodology for energy audits and certificates of building envelope in place. The energy audit (EA) is mandatory for all types of buildings with total energy consumption higher than 1,500 GJ per year. A part of the energy audit was also the energy certificate with a graphical scale, showing the thermal characteristics of the building envelope. Due to the energy auditing system a set of national requirements in terms of energy efficiency and indoor climate was adopted. Authorized energy auditors are the experts certified by the Ministry to conduct energy audits. Authorized energy auditors are registered on a List of Energy Auditors kept by the Ministry.

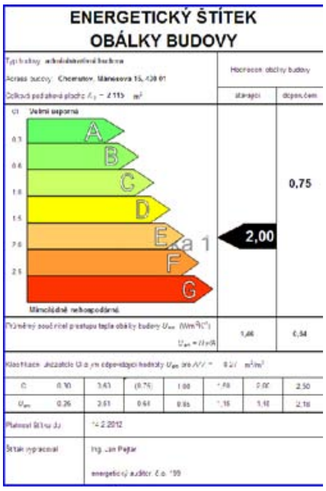
The EPC implementing regulation (published in 2007) of the Act (Energy Management Act incorporating EPB Directive – published in 2006) sets the minimum requirements for the energy performance of new buildings and existing buildings under major renovation.

EP requirements for new and existing buildings are the same; it means that there is no difference in energy performance aspects of new or refurbished buildings.

The EPC regulation has adopted a majority of valid national standards (mostly in the form of prEN ISO) and other requirements (regulations, decree of the government e.g. on thermal insulation of hot water pipes, boilers efficiency, indoor climate) by references to these standards and regulations.

Main regulations are:
- Regulation No. 148/2007 Coll. of the Ministry of Industry and Trade specifying the details of energy performance of buildings.
- Level of heat energy demand according to Czech standard ČSN 73 05 040-2/Z1: 2005

Both specify details of energy efficiency in buildings. The required values are obligatory for almost all new buildings. In case of existing buildings they are obligatory for larger refurbishments (e.g. if more than 25 % of the



Energy certificate of building envelope

Major renovation means alteration to a completed building, which involves more than 25% of the overall surface area of the building shell, or a change of the technical equipment of the building that causes energy effects whose overall impact on initial energy consumption is higher than 25% of the overall energy consumption of the building.

surface of a building is insulated, then the insulation must comply with the standard). The standard sets two levels of insulation – required and recommended. The required level is obligatory; the recommended level reflects the expected development in the future.

Following the development of the required U-values in the Czech Republic no impact of the EPBD is shown on strengthening the thermal characteristics of the buildings envelope (last update of U-values was prepared and published in 2005).

U-value (W/m^2K)	Since Jul 1964	Since Jan 1979	Since May 1994	Since Nov 2002	Since Jan 2006
Windows	-	3,700	2,900	1,800	1,700
Wall	1,467	0,894	0,461	0,380	0,380
Floor	1,369	1,091	1,034	0,600	0,450
Roof	0,900	0,508	0,316	0,300	0,240

- Regulation No. 150/2001 Coll. of the Ministry of Industry and Trade specifying the minimum efficiency of the utilization of energy in production, distribution and use of electric power and heat.

The regulation sets the minimum required efficiencies for electricity and heat production. In relation to the building sector the regulation covers all boilers with a heat capacity of over 200 kW. The specified efficiencies are obligatory for all new boilers.

The required minimal energy efficiency of the boilers (in %) is valid since 2001.

Thermal output of the boiler(s)	Coke	Hard Coal	Coal Pressed Fuel	Brown Coal - sorted	Brown Coal - unsorted	LFO	HFO	Natural Gas
up to 0,5 MW	69	68	67	66	62	80	-	85
0,51 - 3 MW	-	70	69	68	63	83	-	86
3,1 - 6 MW	-	75	-	72	65	84	81	87
6,1 - 20 MW	-	77	-	75	70	85	82	90
20,1 - 50 MW	-	80	-	-	77	87	85	92
above 50 MW	-	82	-	-	82	89	86	93

There are some new requirements directly connected with the EPBD implementation. The following requirements are considered as new features:

- Global minimum requirements on consumption for all types of buildings, expressed in kWh/m^2year of delivered energy;
- RES (renewable energy sources) and DH (district heating) feasibility studies for new buildings over 1000 m^2;
- Energy Performance Certificate (incorporating heating, cooling, DHW (domestic hot water)preparation, mechanical ventilation, lighting and auxiliary energy).

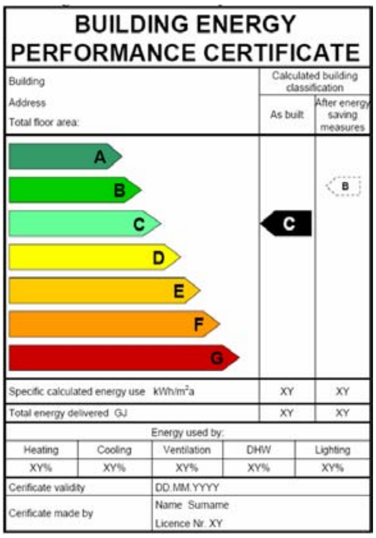
For the EP certificate the requirements are the same as stated in Article 7, no tighter or wider.

The EP certification is obligatory since 1st January 2009 for new buildings (larger than 50 m^2) and existing renovated buildings (larger than 1,000 m^2). Other buildings when rented or sold are provided with the energy performance certificate only if they are newly constructed or renovated.

Similarly, public buildings (larger than 1,000 m^2) must display the EP certificate in a prominent place visible to the public only in case of a new construction or a major renovation.

Materials	Block of flats	Family houses	Total
Baked matter and profilated bricks	47%	58%	52%
Stones, baked matter bricks	13%	33%	23%
Concrete panels	37%	1%	19%
Other materials	2%	9%	5%
Total	100%	100%	100%

The break down of residential buildings by the material of exterior walls.



These national modifications strongly influence the scope of the Directive in the Czech Republic. It applies therefore only to new buildings and to renovated buildings over 1,000 m^2 of total floor area. The inconsistent implementation of the Directive leaves energy classes "D" to "G" entirely unused. Those are the buildings, which are assessed in terms of energy performance as poor and therefore requiring the implementation of saving measures. This limitation means that basically only EPC with class A to C are currently produced in the Czech Republic.

The average age of the housing stock is relatively high. In the year 2001 an average age of the housing stock was 46.9 years. A serious problem is the neglected maintenance of the housing stock, due to a lack of maintenance over a protracted period of time, which has resulted in a decrease of the financial and utility value of structures of residential buildiongs. Specific problems exist in respect of prefabricated-panel buildings. Due to construction and design flaws and insufficient maintenance, these problems are exacerbated by the fact that buildings of this type account for close to one third of the housing stock.

Since the beginning of the 1950s new technologies for a new type of residential building construction are used: the panel houses, which had been built till the end of the 20th century. Thermal resistance of the outside walls was 1.2–1.5 m^2K/W (it represents an U-value of 0.83-0.67 W/m^2K).

Despite the fact that most of the blocks of flats built in the period 1970-1990 used concrete panels as material of exterior walls, the majority of the currently used housing was built using bricks.

Energy performance is expressed by the total annual delivered energy consumption, including heating, cooling, DHW preparation, mechanical ventilation, lighting and auxiliary energy needed for standardised building operation.

Primary energy and CO_2-emission are not assessed in the building energy certification. The discussion about primary energy coefficients was stopped at the beginning of the preparation of the EPBD implementation due to various interests of stakeholders (D-H companies, gas and electricity suppliers).

Table below shows energy classes (in kWh/m^2a) for different building types. Class “C” is a minimum EP requirement level for new and renovated existing buildings.

Building Type	A	B	C	D	E	F	G
Single-family Houses	< 51	51 - 97	**98 - 142**	143 - 191	192 - 240	241 - 286	> 286
Apartment Blocks	< 43	43 - 82	**83 - 120**	121 - 162	163 - 205	206 - 245	> 245
Hotels & Restaurants	< 102	102 - 200	**201 - 294**	295 - 389	390 - 488	489 - 590	> 590
Offices	< 62	62 - 123	**124 - 179**	180 - 236	237 - 293	294 - 345	> 345
Hospitals	< 109	109 - 210	**211 - 310**	311 - 415	416 - 520	521 - 625	> 625
Education Buildings	< 47	47 - 89	**90 - 130**	131 - 174	175 - 220	221 - 265	> 265
Sports Facilities	< 53	53 - 102	**103 - 145**	146 - 194	195 - 245	246 - 297	> 297
Wholesale & Retail Trade Services Buildings	< 67	67 - 121	**122-183**	184 - 241	242 - 300	301 - 362	> 362

The same methodology is used for all regions and all building types in the Czech Republic. The recommended calculation procedure is based on published CEN Standards and applicable Czech Technical Standards.

The price of the residential buildings or apartments is not affected by the EPBD implementation, but rather by overheated real estate market.

Overheated real estate market

Until the mid of 2008 a demand exceeded supply on the market for new residential buildings. This meant enormous increase of real estate prices and focus on quickly as possible construction. This did not help to improve quality of the dwellings and the energy performance.

Due to the financial crisis, this situation is changing. But so far the only effect is less construction activity, no noticeable shift towards different construction style (e.g. higher quality or low-energy).

Achieving the minimum EP requirement level should be possible by using standard building materials, as class "C" was determined in compliance with existing standards (introduced in 2006). The increase in prices should only be the result of the cost for processing the EP certificate. The document demonstrating compliance with the requirements for the energy performance of the building shall comprise an integral part of the documentation prerequisite to the planning permission for constructing a new, or renovating an existing building.

Experience with administrative or other types of buildings are currently not available due to the short validity of the Regulation, but generally there is no tightening of requirements on the energy performance of buildings.

The use of renewable energy sources is mentioned (for new buildings over 1000 m^2) in the general EPBD law. The law requires that they must be the results of the assessment of the technical, environmental and economic feasibility of the alternative heating systems, which are:

- decentralised energy supply systems based on renewable energy;
- combined heat and power;
- district or block central heating and cooling if applicable;
- heat pumps.

It is not explicitly stated that using RES is mandatory, even after positive result of the assessment.

Further regulations to use RES in the building sector are not introduced.

The energy produced from renewable sources in the building is deducted from the energy delivered to the building.

Minimum ventilation requirements for all building types were set by the national standards, regulations and Ministry orders long before the EPBD implementation. This guarantees reduction of the increase in pollutants concentrations in internal building environment. The demands on the necessary quantity of supply of fresh air and other demands on the method of ventilation of rooms are given in special regulations depending on the character of operation of the building, the technological requirements and the physical activity of persons (e.g. National standard and the Order of the Ministry specifying air change rate requirements for dwellings, administration buildings, swimming pools and saunas, for operation of schools and pre-school facilities; the Decree of the government on health protection sets requirements for catering services).

Experts for building certification and inspections are authorised by the Ministry of Industry and Trade. The application may be submitted only by a person who:

- has a an Energy auditor registration number or
- is registered as a Authorised architect or Authorised engineer and technician by the Czech chamber of certified engineers and technicians.

In the mid of 2009 there are about 280 authorised experts for EP certification in the Czech Republic.

2 > Compliance and control

Act 458/2000 Coll. - Law on Business Conditions and Public Administration in the Energy Sectors is known colloquially as the Energy Act. Although this is largely concerned with regulations in the energy sector, this Act also defines the responsibilities and powers of the State Energy Inspectorate

Zelená úsporám

Within the Kyoto Protocol, the Czech Republic pledged to cut carbon dioxide emissions by 8% from 1990 levels. The country has managed to cut the emissions by as much as 24%. According to the EU statistics the Czech Republic continues to be one of the worst climate polluters in Europe (table of GHG per capita put the Czech Republic in fourth place).

It is planned to sell a part of the Czech Republic's carbon credit units to Japan. The Czech Republic has 150 million units available, while Japan needs more than 1 billion units. The Czech Republic is also holding talks about the units' sale with the Netherlands, Spain, Austria, New Zealand and Belgium, which need around 10 million units. The profit might reach € 950 million depending on the market price.

(SEI). This Act gives SEI the right of initiative to instigate inspection proceedings to ensure compliance with the Acts and Decrees related to energy generation, distribution and consumption.

The State Energy Inspectorate has specific responsibilities for Quality Control of EPC and inspections according to the requirements of the Energy Management Act. The Quality Control of EPC is additionally cofinanced by the state budget, through the State Programme (programme for energy efficiency).

SEI has the right to award penalties for failure to comply with the Act.

Incentive policy

The Czech Republic has developed in the past few years a system of subsidies available for improvement of energy performance of buildings. The latest system is mostly concentrated on panel buildings and combines improvements of the static characteristics of such housing, with improvements of the energy characteristics.

In the residential sector the legislative/normative measures prevail, triggered by the introduction of the European Directives.

Investment subsidies in the framework of the Government Programme A (Ministry of Industry and Trade) and Government Programme B (Ministry of Environment) represent an important share. The part dealing with the residential sector supports the implementation of measures for reduction of the energy demand in apartment buildings, as well as the implementation of solar systems or heat pumps for space heating and DHW. As the subsidy budget for each Programme is limited, only part of the applications are granted. Selection is usually based on the time of application (the earlier the submission, the bigger chance for grant).

A new incentive programme was launched in March 2009 (based on the Green Investment Scheme, paid out of revenues from emission trading). The programme supports the introduction of renewable energy, thermal insulation of single family and multi family buildings and construction of passive houses. Eligible applicant for the subsidy is a private owner of family and multifamily houses, housing associations and association of owners and municipalities. For the four-year period a budget of EUR 950 million is available.

Certification market

The Ministry of Industry and Trade (MIT) is responsible for the certification scheme. The MIT authorises energy experts for certification schemes, keeps the list of authorised experts and annually collects experts' record (number of EPCs, energy saving potential, etc.).

Energy experts should be commercially insured for liability. If there are complaints on an experts' work, or if the expert does not process any audit or EPC for 5 years, he is deleted from the list of experts.

If, during the construction, or after the completion of a building, SEI finds out that the building doesn't comply with the EP requirements, the builder or the owner gets fined. By the law it is not clear whether the building will have to be subsequently brought into conformity with the requirements of the Act.

The organisational structure of SEI is divided into 11 regional branches with headquarter's in Prague. The total number of employees is about 160. SEI covers the whole power industry (electric power, heat and gas production

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and supply) with lasting considerable authority over both the suppliers and consumers side.

The State Energy Inspection employees are subjected to rules and in particular to independence and objectivity. The inspectors have to take a pledge in court and their personal responsibility can be charged.

The EP certificate/inspection may NOT be performed by a person who:
- holds a share in the company or co-operative that ordered the EPC;
- is a stakeholder in, or a member of the co-operative that ordered the EPC, or is a statutory body of, or a member of the statutory body of the entity that ordered the EPC, or is employed by, or has a similar relationship to the corporation that ordered the EPC;
- is someone close to those people who might be, due to their position, a natural or legal person to influence the energy auditor.

The Energy auditors (the qualification required is a university degree and 3 years technical experience, or a "High school" degree + 5 years experience) and Authorised engineers or architects undertaking a specific training course and passing an examination, are authorized by the Ministry.

Experts in building certification, inspectors of boilers and AC systems have to pass different examinations, but the same expert can be simultaneously authorised to perform more than one of these activities.

Relevant state authorities such a building construction offices and municipality departments dealing with EPCs are well informed and educated about new requirements forced by EPBD legislation through periodical courses for personnel.

3 > Copyright

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Finland: Impact, compliance and control of legislation

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Finland has adopted appropriate measures to implement the directive into national legislation. The new legislation and decrees came into force on 1 January 2008 [1]. The EPDB has led to -30% tightening of the national regulations concerning the new buildings. The accelerated regulation development is still needed for the renovations.

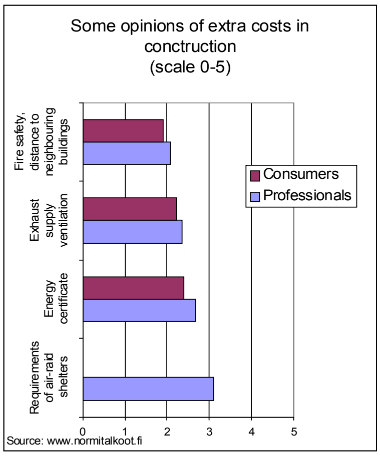
1 > Impact of the EPBD on the national requirements

Finland has set minimum requirements in the National Building Code for thermal insulation and ventilation of new buildings since 1976. The requirements have been changed several times in order to improve energy efficiency in buildings.

The changes have been made in 2003, when the level of the requirements was tightened by 25-30%, and in 2007, when the requirements were changed because of the implementation of the EPBD. The latest tightened (-30%) requirements were given on December 2008 and will come into force in the beginning of 2010.

The regulatory framework has traditionally controlled the thermal losses of buildings. The Minister of Housing has announced that in 2012 Finland will introduce a regulation based on overall energy consumption, where the energy sources will be taken into account (primary resource factor).

Regulations themselves compose no barrier for the energy efficiency. The expected impact of the EPBD can be modest in the short run because the current heating energy requirements are already quite strict and are applied mainly to new buildings. The accelerated regulation development is mainly needed for the overall energy calculation, for the renovations and for cutting down the increasing electricity use of appliances. The last topic is challenging because it is partly out of the administrative sector of the Ministry of the Environment.



The ranking of some extra cost in the Finnish construction
Source: www.normitalkoot.fi

Reference values for maximum heat loss	Year 1976	1978	1985	2003	2007	2010
Wall, U-value (W/m²,K)	0.40	0.29	0.28	0.25	0.24	0.17
Roof, U-value (W/m²,K)	0.35	0.23	0.22	0.16	0.15	0.09
Floor, U-value (W/m²,K)	0.40	0.40	0.36	0.25	0.24	0.16
Window, U-value (W/m²,K)	2.1	2.1	2.1	1.4	1.4	1.0
Door, U-value (W/m²,K)	0.7	0.7	0.7	1.4	1.4	1.0
Air-tightness, n50 (1/h)	6	6	6	4	4	2
The yearly exhaust air heat recovery efficiency	0 %	0 %	0 %	30 %	30 %	50 %
Thermal transmittance (W/K) [1]	***2017***	***1905***	***1879***	***1367***	***1353***	***917***
Change 1976 =100	*0 %*	*-6 %*	*-7 %*	*-32 %*	*-33 %*	*-55 %*
The EPDB-effect					*-1 %*	*-33 %*

[1]A typical 3-floor apartment house design in Finland

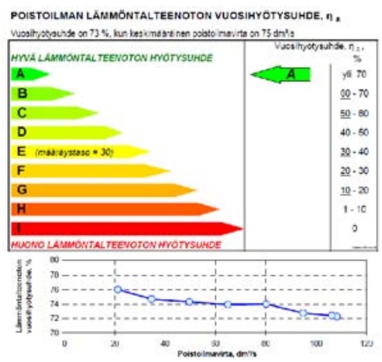
The indoor climate and ventilation of buildings has been a fundamental part of the Finnish regulatory framework. The guidelines of minimum ventilation rate by various building types and spaces have been used more than two decades in Finland. The EPDB did not change the current practice, but some emphasizing in the summer comfort can be seen.

In renovations, the National Building Code is applied in accordance with the Land Use and Building Act, Section 13: "*The regulations in the Building Code concern the construction of new buildings. Unless otherwise specifically prescribed by the regulations, they are applicable to renovation and alteration work only in so far as the type and extent of the measure and a possible change in use of the building or part thereof require*". The legislation allows the local building supervision authorities to decide whether the building regulations will be applied to the renovation or not. The current practice is that the energy regulations are rarely applied, but there is a market driven voluntary practice to increase the energy efficiency to some extent in the refurbishment of the building envelope.

The rising construction costs were studied recently in the context of the Finnish regulatory framework of buildings (www.normitalkoot.fi). The findings of the increasing costs were mainly caused by the regulations concerning the fire safety; the car parking; the air-raid shelters; the accessibility of the disabled people; and some activities of the public authorities during the construction process. The study still mentions that some people have felt the energy certificate to be an extra cost.

Since 1985 Finland's National Building Code has included guidelines for calculating the power and energy demand for the heating and cooling of buildings. These guidelines could be used for calculations for all building types. The calculation method was refined because of the implementation of the EPBD. It follows the main principles of EN13790. The new calculation method was published in the National Building Code in June 2007. The current calculation methodology does not contain primary energy calculation, but foreseen 2012 revision of the regulatory framework will introduce the overall energy calculation.

The current regulatory framework is energy source neutral in Finland. The regulations themselves do not promote or hinder using of a certain fuel in the building heating. The normal market mechanism (availability, fuel prices and investment costs) has taken care of the selection of the heating type. Some cities do promote a local district heating, because of its high total efficiency, especially, if the local power plants are type of a Combined Heating and Power.

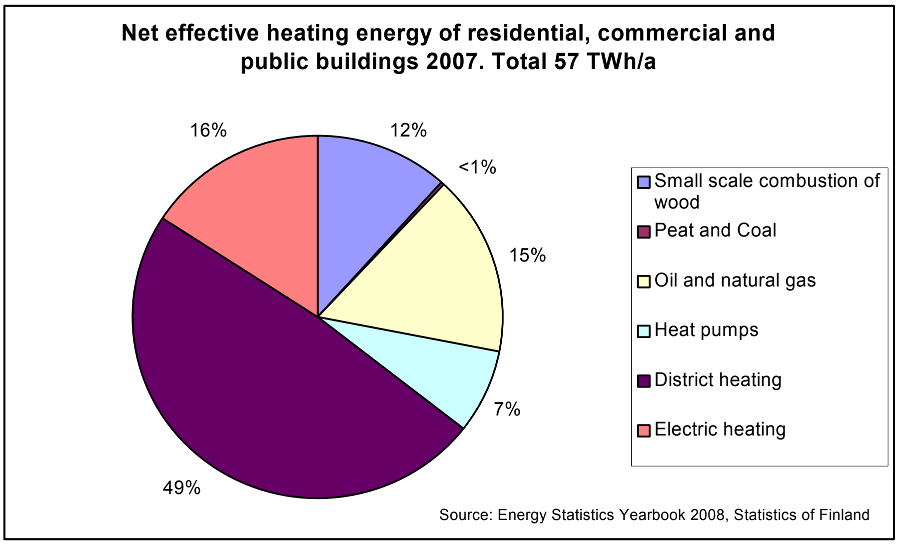


A snapshot of a heat recovery product data used in Finland. A voluntary certification (VTT Product Certificate), http://www.vtt.fi/service/exp/certification/index.jsp?lang=en

The current calculation method supports the following renewable energy forms:

- ventilation heat recovery
- heat pumps (ground source, exhaust air and air-to-water)
- biomass boilers (pellets, wood chips, chopped firewood)
- free cooling, night ventilation

Current status in the Finnish building stock is that renewable energy sources are mainly used in the single family houses (wood). Some larger scale district heating plants use also biomass, but its share is only 12% of the fuel consumption of the district heat and the combined heat and power in Finland. The increasing number of heat pumps (air-to-air, ground source, exhaust air) has been installed to heat the single family houses in the last decade. The share of the renewable energy forms (hydro, wind and wood fuels) in the Finnish electricity production is 25%.



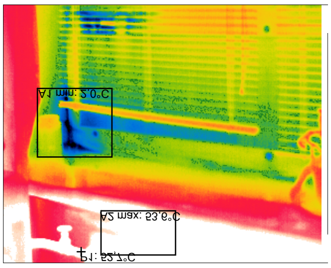
2 > Compliance and control[1]

EP REQUIREMENTS COMPLIANCE AND CONTROL

The main responsible person in the building process is the principal designer in Finland *[2]*. His/her duty is to ensure the sufficient quality and comprehensiveness of the designs for the building project. The principal designer is responsible to the building supervision authorities for carrying out his duties in an appropriate manner during the building project's design stage and during the construction work. The control framework is strong according to the law. The municipality grants a building permit when the design of the building presented by the principal designer complies with the Building Code and when the requirement for validity of the actors in the construction project is fulfilled. If the compliance is not met in the realisation phase, the building can be put to a prohibition of use as an extreme measure, but these kinds of measures are rare. The observed incompliance is normally corrected during the implementation phase.

Some subcomponents concerning the energy efficiency of the building are checked voluntarily by the construction company in the realisation phase. These checks (for example: a thermography, a pressure test) are part of the normal quality control of the construction work, but this depends

[1] Compliance means the fulfilment of EP requirements and EP certification process while control is the mechanism for checking the compliance.



mainly on the customer demand and the undertaking company. Some construction companies have better quality control than others. The control framework in the realisation phase is strong and the building supervision authorities may require third party expert opinion, if there is a doubt of the energy performance of a certain building component.

The requirements on maximum heat losses of the whole building (building envelope, ventilation and infiltration) contain detailed numbers to fulfil, but there are quite rare detailed (=numeral) requirements for the HVAC-systems in Finland. This means that in most cases the HVAC designer selects the detailed parts of the system solution in the design process from the catalogue of current design practice. The HVAC system details are rarely checked in the realisation phase, because of the lacking numbers to compare with. There are some exceptions concerning the HVAC-system efficiency:

- limiting guideline value max. 2.5 kW/m^3/s for the specific fan power of the ventilating system as a whole (electrical efficiency)
- limiting guideline value of thermal resistance of the pipe insulation is 1 m^{2}K/W
- limiting guideline value of thermal loss of the heat storage by the storage size
- boiler efficiency (oil, gas) must be compliant according to European Council directives 92/42 and 93/68 (Boiler Directive). The boiler has to be CE marked and its minimum efficiency requirement is a “One star”
- the minimum ductwork tightness class should be class B (classification in EN 12237)

Logo of the energy certification info campaign.

EP certification COMPLIANCE AND CONTROL

The quality control procedure of the EP certification is not regulated by the legislation, but the legislation allows the Ministry of the Environment to gather relevant information about the certificates and prices of certificates from the qualified experts. Qualified experts have to keep an archive of the certificates they have issued for 15 years. The local building supervision authority also has to keep an archive of the certificates issued for new buildings that have been issued a building permit. It is possible for the Ministry to access these archives to conduct periodic checks of the certificates. A national centralized database is under development for energy certificates. The system will be ready at the end of 2009.

Qualified experts for certification have the authority to issue so-called Separate Certificates. They must be architects, engineers or technicians with education in building, HVAC or electrical engineering. The professional examination can be replaced by at least three years’ experience in energy efficiency in the building sector. Qualified experts must pass an exam arranged by an accreditation body. The exam tests their knowledge of the certification legislation and the certification system itself. Attendance at training courses is not mandatory.

Qualified experts for certification will get an accreditation that is valid for 7 years. Qualified experts can act on an individual basis or can be integrated with public or private organizations. By March 2009, there were 360 qualified experts for energy certification. The Ministry of the Environment has designated two accreditation bodies, FISE Oy and Kiinteistöalan Koulutuskeskus (Kiinko) to approve qualified experts. Other professionals who can issue energy certificates (e.g. principal designers, property managers, chairpersons of housing company boards and energy auditors) do not need accreditation according to the Act on Energy Certification of Buildings.

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The construction professionals, energy auditors and qualified experts are typically skilled enough to issue a certificate. The chairpersons of housing company boards can be non-professional and also the independence is a question mark ending in some uncertainty of certificates issued by them.

There are several service providers issuing energy certificates and some sort of price balance has been found on the market in Finland. The price of the separate certificate of an old building begin from 250 € for a single-family houses and 500 € for an apartment building. The energy certificate of a single-family house for the building permit is close to 120 €.

The state supports energy efficiency improvements, low-CO2 investments and renewable use in heating systems with three ways:

- an incentive for housing companies (more than 3 apartments)
- an incentive of material costs for low income households (less than 3 apartments)
- a tax deduction for households purchasing services

The state budget allocates incentive for housing companies (10-15 %) funds of repairs of buildings and specifically targeted energy repairs; for example: changing the old heating system to district heating or to wood based boiler or to ground source heat pump; and installing a solar heating system or an outdoor air heat pump as an auxiliary heating system. The state also supports the low-income households with an optional up to 25% incentive of material costs of energy efficiency repairs.

There is a tax incentive for domestic employment of various service providers. A household may deduct 30 % of personal salary costs or 60 % of company provided services (but not of materials) in personal taxation. The deduction is applicable for acquisitions of labour (services) at home. This incentive can be allocated to energy improvement works, but the amount (annual maximum of 3000 €/person) can be small, if larger investments wanted to be started.

3 > References

1. Haakana Maarit. Implementation of the EPBD in Finland: Status and planning - August 2008. Information Paper 120. County review. 2008. *http://www.buildingsplatform.eu/epbd_publication/doc/P120_EN_Finland_Aug2008_p3200.pdf*
2. A2 NATIONAL BUILDING CODE OF FINLAND Building designers and plans A2 Regulations and guidelines 2002. *http://www.ymparisto.fi/download.asp?contentid=23440&lan=fi*

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Disclaimer: ASIEPI has received funding from the Community's Intelligent Energy Europe programme under the contract EIE/07/169/SI2.466278.

[European projects]

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31.12.2009

Italy: Impact, compliance and control of legislation

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This paper aims to summarise how in Italy the implementation of the EPBD has changed the national EP requirements and has influenced the building stock. It describes the national way of handling with EPBD compliance and control and tries to identify interesting approaches and possible bottlenecks. This document summarizes the situation at July 2009.

1 > Impact of the EPBD on the national requirements

The publication of EPBD had a strong impact on the energy policies in Italy. Even if a national framework existed before 2002, a new set of legislative measures was set up in order to comply with the EU framework.

The energy legalisation for the building sector started in Italy in 1976, as a consequences of the world oil crisis[1]. The main content of this law was the limitation of the building losses for transmission and ventilation to limit the heating system size, as function of the geometry of the building and the climatic conditions. It was mainly a power control method, without considering the energy efficiency of the building. These issues became more important in early 90´s with a new legislative measure [2] [3], introducing the energy performance of buildings according to the locality and the geometry of the building itself, also requirements on the energy system efficiencies were introduced. Figure shows the trend of energy use in the building sector, divided in residential and non-residential buildings. The first step of legislative framework was based on the evaluation of the building energy efficiency taking into account the heating energy use in the winter season [4].

DHW, cooling and energy use specifications were added in June 2009 [5]. No specific indications are given on the efficiency of the ventilation systems.

The law fixes minimum requirements for the primary energy consumption of the building (in kWh/m^2 in residential buildings and kWh/m^3 in not residential buildings). These requirements are fixed depending on geometry of the building and the climatic zone.

Minimum requirements for the thermal insulation level of the envelope components and for the energy systems are also fixed. To be noted that the actual law defines the insulation levels and the heating system efficiency which prevents from the calculation of the energy performance indicator.

The new minimum requirements led to tighter limits to be respected by new buildings, it is estimated that such reduction should be between 15 and 20% respect to the old calculation method. The actual law does not take into account indoor temperature issues.

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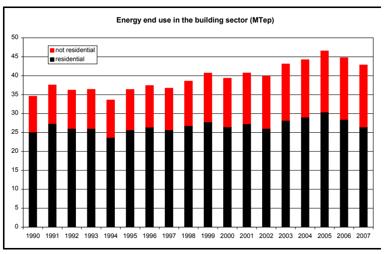

Figure 1: Energy end use in Italian buildings since 1990. Red: non residential, black: residential[6]

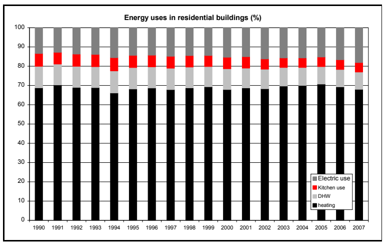

Figure 2: Percentage energy uses in the residential sector per typology of energy use.
Dark grey: Electricity
Red: Kitchen uses
Light grey: DHW
Black: Heating [6]

The data in figure 1 shows a positive trend in the energy consumption reduction, even if the intensity is modest. The results is mainly achieved by reduced heating consumption partly due to the new energy policy landscape and partly, probably, due to milder winters in the few past years.

To be noted that the building energy certification procedure has been defined with National Guidelines issued on June 26, 2009. The certificate must not be exposed in buildings and has a 10 years validity.

The legislative framework is in line with EPBD for what concerns existing buildings and the mandatory certification when selling or renting buildings.

The market is moving towards more efficient products, even if eco-labelling is not introduced in the country and the energy systems control did not change since the past energy regulations. The real market push to more efficient components is coming more from incentive schemes than by the EPBD implementation. Lot of funds were made available for end users to take renovation actions (new windows, envelope insulations, solar thermal systems, condensing boilers) and this measure is really moving the market, while the EPBD implementation is suffering from the long bureaucracy procedures. In the future it is very important to move towards reductions in other energy uses. As an example figure 2 illustrates how the electric uses share is increasing in these few past years.

Italian climatic zones

Because of this situation the influence of the energy certification on the building prices is practically null.

Concerning the use of renewable energies in building, the national decrees expressly state that the installation of solar systems for electric and thermal energy uses are mandatory. In particular it is required that the 50% of domestic hot water heating energy is from solar thermal systems. The percentage decreases to 20% in historical city centre. This rule can be exempted if the impossibility of such installations are accurately described in a technical report. This latter aspect is crucial to avoid the installation of solar systems in many cases. Also the PV system for at least 1 kWp minimum per dwellings is mandatory.

Concerning the primary energy conversion factor, the landscape is not well assessed. The fossil fuel conversion is 1, while the electric conversion factor is 9 MJ = 1 kWhelectric.

Conversion factors for renewable energies are still missing. Literature review values are taken by experts when dealing with solar, biomass, etc.

The actual decrees do not clarify the qualification requirements and independence of energy experts for certification process. This is expected to come in the forthcoming decree. Today the energy qualification document can be signed by a number of professionals, included the calculated results without specific experience in this sector.

It is important noting the national legislation allows the single regions to manage the energy policies, if they decide not to follow the national framework. This implies that while the national government is slowly proceeding his route, several regions already started working on a regional certification scheme. Local schemes are developed in several are: Lombardia Region, Ligura Region, Bozen Province among others. They have their methods and their accreditation scheme, situation uneasy if seen from a national point of view (i.e. If we will have 20 schemes, 1 per regions, in principle an expert should go through 20 accreditation schemes!)

2 > Compliance

Professional in charge for the EP calculation has the responsibility to verify that the requirements are met. The professional can be the supervisor of works or a third figure respect to the building construction company and the final customer.

There is a penalty system involving the professionals involved in the certification process, with administrative procedures and economic fees. In particular this will apply if:

- the EP requirements does not meet the minimum values as set in the legislative acts
- the EP requirements results to be not true.

In both cases the fee is calculated on the basis of the economic income paid to the professional.

Proper authorities (municipalities in most of the cases) can carry out all the needed control during th execution of the works or up to 5 years after the end of the works. What happen in general is that they have generally lack of expertise and moreover very few funds allocated to make controls on the proper execution of the work.

It is responsibility of the constructor to supply the certificate by a qualified professional to comply with the EP certification. The same applies for building renovations. In case of selling or renting, the responsibility relays on the building owner. The selling/renting act must accompanied by the energy certification. The documentation must be presented with all relevant project documents. The municipality approves the end of the works only if the energy certificate is supplied.

There is a penalty system involving all the actors involved in the certification process, with administrative procedures and economic fees. In particular, the works supervisor is responsible for:

- the correct execution of the work respect to the original design and approved variations and
- depositing the documentation to the proper office of the municipality; the constructor and the owner, responsible for the certification compliance;

If the supervisor does not respect these responsibilities, he will be fined with an amount proportional to his professional fee.

The professionals, in charge for control and maintenance of the energy systems, are in charge for the control and compliance of the procedures.

The building contractor and/or owners are responsible for the energy certification process, hence they will be fined if they will not comply with the procedures defined in the legislative acts.

3 > Control

Proper authorities (municipalities or other national or local authorities for public buildings) have generally lack of expertise and moreover very few funds and resources allocated to make controls on the proper execution of the work. This is a bottleneck the country experienced in the past decades, when no serious penalty and control actions were disposed in in the case of violated energy requirements.

At national level there is no qualification control: to be member of a professional board (engineers, architects and so on) is enough for issuing an energy certificate, but at regional level different procedures of qualification are foreseen. An auto-declaration of not being in position of conflict of interests is enough for proving the independence of the professional.

The certification market did not really start in Italy yet: the decree that regulates the matter has been delivered few weeks ago. The lack of procedures for experts has been another point that slowed down the process.

4 > Incentives

In this framework energy consultancy is a privilege for few large projects where, moreover, the attention towards the energy efficiency is moved by a general increased interest for the low-carbon strategies, more than by the national certification scheme.

Some incentive policies related to EBPD were applied during the last couple of year. It's foressen a 55% reduction in tax for some energy measures, related to the improvement of insulation of the building envelope, the heating system and the installation of solar thermal systems. The scheme is dedicated to the building renovation.

Other efficiencies measures are covered by the 36% reduced taxation scheme, which cover generic refurbishment measures, including some Other incentives can be found at regional level, they are related to different measures and the fund are assigned by dedicated tenders.

Certain techniques (mainly those involving cooling or lighting) have not yet been subsidized because the certification scheme did not cover the whole area, as designed in the EPBD. Other techniques will probably be subsidize in the future in consequence of recent enlargement to cooling and lighting loads certification procedures.

5 > References

1. Legge 373/76 “Norme per il contenimento del consumo energetico per usi termici degli edifici”
2. Legge 10/1991 "Norme in materia di uso razionale dell'energia, di risparmio energetico e di sviluppo delle fonti rinnovabili di energia".
3. DPR 412/93 “Regolamento recante norme per la progettazione, l'installazione, l'esercizio e la manutenzione degli impianti termici degli edifici ai fini del contenimento dei consumi di energia, in attuazione dell'art. 4, comma 4, della legge 9 gennaio 1991, n. 10.” Updated with DPR 551/99
4. DLgs 192/2005 "Attuazione della direttiva 2002/91/CE relativa al rendimento energetico nell'edilizia"; DLgs 311/2006 “"Disposizioni correttive ed integrative al decreto legislativo 19 agosto 2005, n. 192, recante attuazione della direttiva 2002/91/CE, relativa al rendimento energetico nell'edilizia"
5. DPR 59/09 “Regolamento di attuazione dell'articolo 4, comma 1, lettere a) e b), del decreto legislativo 19 agosto 2005, n. 192, concernente attuazione della direttiva 2002/91/CE sul rendimento energetico in edilizia.”
6. Rapporto Energia Ambiente 2008 - ENEA

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Netherlands: Impact, compliance and control of legislation

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This paper aims to summarise how in **the Netherlands** the implementation of the EPBD has changed the national EP requirements and has influenced the building stock. It describes the national way of handling with EPBD compliance and control and tries to identify interesting approaches and possible bottlenecks.

Throughout the paper the situation in the country is described on the following four subjects :

- Impact of the EPBD on the national requirements
- Compliance and control of both EP requirements and certification systems

1 > Impact of the EPBD on the national requirements

Before the implementation of the EPBD, the Netherlands already had an energy performance method and requirements in place. There also was some experience with a voluntary system for labelling the energy performance of existing buildings. In general terms the impact of the EPBD mainly lies with the labelling system for existing buildings which changed from voluntary to mandatory. For new buildings nothing directly changed on a global level, because the Netherlands already acted according to the EPBD.

Due to this history, it is not evident to distinguish if the Dutch situation is impacted by the EPBD implementation from what would have been there anyway. In the discussions below it is left aside whether the impact is directly due to the EPBD implementation or to national policies which were already in place. The Netherlands already planned to tighten their requirements. Without the EPBD the same effects would have occurred.

Impact on energy efficiency

The energy performance requirements have affected the energy efficiency level of new buildings. When in 1995 the first energy performance requirements were set, these levels represented more or less the levels of energy efficiency which were possible to realise with an acceptable increase of building cost. In the following period, the requirement levels were tightened every few years. Various studies [1, 2] show that these new levels indeed resulted in more energy efficient buildings, although no percentages are given.

Little is known about the impact of the certificate on the energy efficiency of the existing building stock. Few privately owned houses have a certificate. A sample survey of 100.000 house-transactions in the first 9 months of 2008 [3] shows that less than 20% of these houses have a certificate. 50% of these certified houses have a C or D label, 35% have a “green” (A, B or C) label, 39% a “red” label (E of worse). An interesting result of the study is that having a “green” label (A, B or C) has a positive effect (although small) on the transaction price and on the time a house is for sale compared to having a “red” label.

A large part of the housing stock in the Netherlands is owned by housing corporations. While privately owned houses that are rent or sold should have a certificate from January 2008, housing corporations who certified their whole building stock at once were exempted until January 2009. A far larger percentage of these houses have a certificate when they are rented out. Several housing corporations even base improvement plans on the information from the labels when they certify their whole building stock.

Impact on indoor climate

In the first years of the EP legislation in the Netherlands the focus was mainly on the energy use for heating, even though the method took into account other energy uses as well. To prevent this trend from leading to overheating in houses and to stimulate passive cooling measures, the energy use for summer comfort was introduced. With this introduction of the summer comfort module in the EP calculation, passive cooling measures have an effect on the EP level of the house, even though no cooling system is present. The problem of overheating is still an aspect of concern, but discussions in the Netherlands related to possible effects of EP legislation on indoor climate mainly focus on indoor air quality. No studies are known to the author which show this correlation, but with the further tightening of the EP requirements this is a growing aspect of concern.

Additional regulations

In addition to EP regulations, new buildings need to comply with minimum insulation regulations and minimum air tightness regulations. Concerning indoor climate there are regulations related to daylight and view as well as to minimum ventilation capacity. Generally seen, these additional energy efficiency regulations do not apply to existing buildings, but the additional indoor climate regulations related to ventilation and daylighting do (sometimes in an adjusted form).

Impact on energy measures

Many technical measures for better energy performance were introduced and implemented in buildings since the introduction of the EP regulation in the Netherlands in 1995. The main trend has been product improvement [4]. Some examples of this are improvement of thermal insulation (floors, facades, roofs as well as windows), improvement of efficiency of condensing boilers, improvement of efficiency of heat recovery systems of ventilation, change from AC to DC fans, improvement of lighting systems so that less installed power is needed, etc. But also new techniques have been introduced, e.g. heat recovery systems of shower water and demand driven ventilation systems. Due to the implementation, also the skills to apply these techniques were improved. However, these effects are not solely related to the introduction of the EPBD.

Impact on building prices and building products.

With every step of reducing the energy performance level the procedure in the Netherlands has always been to perform a study on cost-effectiveness and to tighten the EP level to a cost-effective level. By announcing the reduction of the EP level far in advance, the industry has time to adapt and develop improved and innovative systems. Industry uses the EP regulations as a PR instrument for their improved products.

Renewable energy

The use of renewable energy sources is an integral part of the energy performance method (solar collectors, photo voltaic systems, heat pumps). There are no additional regulations which make the use of renewable energy obligatory in some situation.

2 > Compliance and control[1]

EP requirements

When planning a new building, a building permit is only provided when an EP calculation proves the EP requirement for the building type in question is reached. No certificate or training is needed to provide this calculation. The local authority has the responsibility to check if the calculation is correct. All parties taking part in the building process have the responsibility to build according to the building permit. The local authorities have the right to check this (at design stages on paper and in practice on the construction site).

As argued before, it is clear that the lower energy performance levels have had a positive effect on the energy efficiency of buildings [1, 2]. On the other hand there is doubt about the level of compliance to the EP regulations [e.g. 5]: for all new buildings an EP calculation is made and the calculation result will always meet the EP requirement (otherwise no Building Permit will be given), but it is unknown to what extent the calculated value will be totally correct and all energy saving measures used in the calculation will be implemented as such in practice.

Sanctions in case of non-compliance with EP-requirements can be imposed by the local authorities. In an early stage of the building process they can refuse the building permit. Once the construction is started they can stop the construction process until the omissions are solved. Once the construction is finished the local authority can forbid the occupation of the building. Stopping the construction process happens in practice, but because of the large economical consequences it is seen as a severe sanction and therefore not used regularly. Forbidding occupation is even more severe and is nearly ever done.

The amount of knowledge needed to check compliance in practice is large, often too large for the local authorities to do a proper control, especially where it concerns knowledge related to systems. And even if this knowledge is present, the capacity is lacking to do a severe check. Several instruments have been developed to help local authorities with this process [6]. An interview with inspectors of the local authorities of cities with more than average expertise shows that even in their cities the lack of capacity, knowledge and possibility for sanctions are a large problem [7].

EP certification

Advisors who provide the EP certificate need to be certified. Accredited Bodies control these advisors by checking their EP certificates on a random check basis.

The regulations oblige that all buildings which are build, rented or sold have a certificate. Buildings which are build can (and almost always will) get an exemption: the permit is equivalent with the certificate. In practice, houses which are rented or sold often lack the certificate, especially in the private market (see paragraph 2 of this paper).

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[1] Compliance means the fulfilment of EP requirements and EP certification process while control is the mechanism for checking the compliance.

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There are no sanctions when no EP certificate is made, however the buyer can make a demand that a certificate is made based on the civil code.

The quality control scheme comprises the double check on the site executed by the accredited body (this is done by random checks).

At this moment there are a few hundred certified companies which can give an energy certificate. They range from consultancy companies (construction, building physics, systems), construction firms, real estate agents, housing corporations to electricity companies. They range from one-man companies to large firms [8].

3 > Incentives

When the certificate was introduced, there were no additional incentive policies, but these are being introduced now:

- Tax reductions are possible when investments on energy savings are made, e.g. via green mortgages.
- Lower VAT on labour costs for applying insulation (existing houses).
- Subsidies for installing solar collectors, heat pumps or microCHP (existing houses).
- "Meer met minder (More with less)" incentives premium based on the extent of improvement of the energy certificate (few hundred EUR, existing houses).
- In order to repair the split incentives in the rental sector (the owner has to do the investment, while the renter has the benefit of the lower energy bill) the maximum rent an owner is allowed to ask for a house will be coupled to the energy label.

4 > References

1. Uitzinger, J. (2004). "Analyse EPC en energieverbruik bij woningen (Analysis of Energy Performance Cooeficient and energy use of houses)", Rapport IVAM. In Dutch.
2. Jeeninga, H., Uyterlinde, M. and Uitzinger, J. (2001). "Energieverbruik van energiezuinige woningen (Energy use of energy efficiënt houses)", Rapport ECN-C-01-072. In Dutch.
3. Brounen, D. Kok, N., and Menne, J. (2009). "Energy Performance Certification in the housing market. Implementation and valuation in the European Union."University of Maastricht, University of Tilburg, European Centre for Corporative Engagement.
4. Beerepoot, M. (2007). "Energieprestatiebeleid. Weinig innovatie in de woningbouw (Energy performance policy. Not much innovation in house-building)", *TVVL Magazine, 36*, p 36-40. In Dutch.
5. Visscher, H.J. (2008). Inaugural lecture "Woningkwaliteit onder controle (Housing quality under control?" Summary: http://www.tudelft.nl/live/pagina.jsp?id=ae9f9dc5-ab99-491a-a326-ece188ba48db&lang=en
6. http://www.senternovem.nl/epn/handhaving/index.asp In Dutch.
7. EnergieGids.NL, "Controle epc niet waterdicht (control of ep not watertight)". In Dutch.
8. http://www.vrom.nl/pagina.html?id=34304 "Find a consultant", in Dutch

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More information can be found at the ASIEPI project website: *www.asiepi.eu*

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Fig.1

Fig.2: *Traditional buildings*

Norway: Impact, compliance and control of EPBD legislation

This paper explains how the EU Energy Performance of Buildings Directive (EPBD) has changed the national Energy Performance (EP) requirements and influenced building practices in Norway. Furthermore, it describes the national way of dealing with EPBD compliance and control and identifies interesting approaches and possible bottlenecks.

1 > IMPLEMENATION STATUS, 2010

Although Norway is not an EU Member State (MS), it is implementing the EPBD because Norway is part of the European Economic Area (EEA). The status of national implementation of the different elements of EBPD, are described below:

- ***EP calculation standard***: A revised national standard for building EP calculations was published, NS 3031:2007[1], with a minor revision due in 2010. It is based on ISO 13790. At the same time a new standard for building area & volume calculation was published, NS 3940:2007[2].
- ***Building regulations***: Revised EP regulations[3] for new buildings and major renovations were issued 2007-02-01 with a 2.5 year transition period. They will be further tightened in July 2010.
- ***Energy Act***: The revised national Energy Act[4], including energy labelling and inspection schemes, came into force 2010. Detailed regulations for certification & inspection are implemented.
- ***Certification***: The labelling scheme is already operative, but will not be obligatory for all buildings before July 2010. There are two different schemes for (a) houses, and (b) all other buildings. Scheme (a) permits self-assessment, whereas (b) is open for qualified users.
- ***Inspection***: The inspection scheme is operative and in full accordance with EPBD Article 8, extended to include ventilation systems. Existing buildings shall be inspected within 2 years.

2 > IMPLEMENTATION OF EPBD BUILDING REGULATIONS

2.1 EP calculation software

Improvements to the national EP calculation standard: In 2007, the national EP calculation method (NS 3031) was greatly improved by harmonizing it with ISO 13790. Whilst the previous version calculated only annual space heating demand, the revised version can calculate energy use at any stage in the energy supply chain (see Fig.3), i.e. net energy demand, delivered energy (bought energy), primary energy, or GHG emissions. You may use any software that conforms to NS 3031, or that is verified with EN 15265. This means that a lot of well-established software may still be used (e.g. ESP-r, EnergyPlus, VIP+) in addition to new home-grown user-friendly software that has been developed based on NS 3031, most notably the free web-based Energy Certification software, and also some stand-alone applications (e.g. 'SIMIEN', or a spreadsheet by SINTEF).

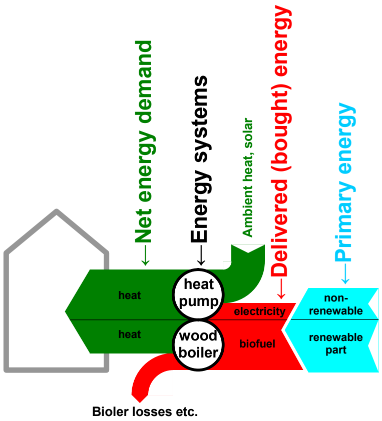


Fig.3: *Illustration of net & delivered energy, and primary energy type*

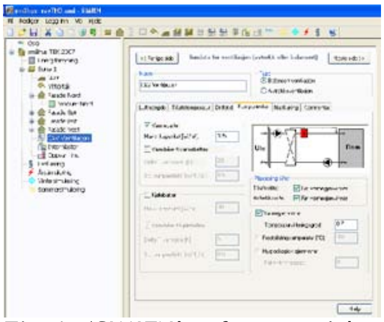


Fig.4: *'SIMIEN' software with dynamic hourly energy calculations according to NS 3031*

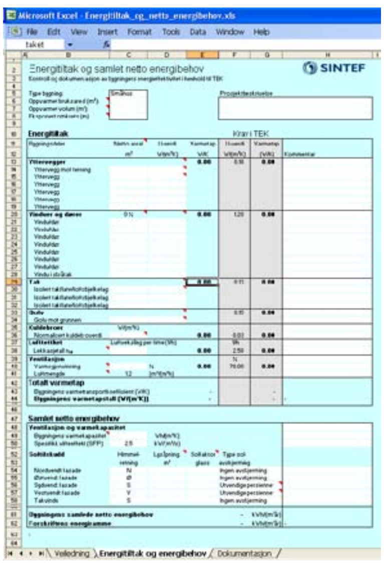


Fig.5: *Simple one-page spreadsheet from SINTEF according to NS 3031.*

Some special features of the revised EP calculation standard:

- The standard has general applicability, so can be used for building permit applications, energy labelling, indoor climate prediction, etc. The same input data can be used in calculations for both permits and labelling.
- For all buildings with AC-equipment, and all buildings of certain types (offices, retail, hospitals, universities) the EP calculation must be hourly dynamic instead of quasi-steady monthly.
- The new standard is published with a climate data file of hourly data from Oslo. This climate data must be used in EP calculations for building permits and energy labels throughout the country. This aids standardization of construction. However, future tightening of the building regulations will necessitate more climate zones. Naturally, the user is should use other hourly climate data in simulations of indoor climate, wherever the local climate differs from Oslo.
- In the case of EP calculations for building permits or labelling, some input data is 'fixed'. These are mostly parameters related to occupant behaviour: internal heat gains (equipment, people), hot water use, operating hours, and set-point temperatures for heating & cooling.
- Some other input data has 'default' values that the software user must use if they have no documentation. This includes for example: thermal bridges, lighting energy, minimum ventilation rates, and a long list of energy system efficiencies (e.g. boilers & heat pumps). The values can of course be changed if the user has specific documentation. The requirement for documentation is quite relaxed in practice.

  Incidentally, if the building has automatic controls, the default lighting load may be reduced by 20 % *without* documentation of lighting performance. Similarly, in the case of DCV-VAV (demand-controlled ventilation with variable air volume), the design ventilation rates may be reduced by 20 % *without* documentation of true average flow rate.
- The EP calculation method prescribes the use of a very low set-point room temperature (22°C) if room cooling is to be installed. This artificially low set-point is meant to discourage installation of mechanical cooling by giving it a high energy penalty. However, there is a loophole in the case of central ventilation cooling, for which the set-point temperature is not limited by the EP calculation standard.
- Buildings that receive high solar gains must be zoned in the EP calculation. This ensures more accurate calculation of cooling demand and indoor climate.

2.2 Changes to the building regulations

The building regulations were tightened in 2007, and there will be slight changes in 2010 [3].

Simple yet flexible approach: Both the previous (1997) and new (2007/2010) regulations give two alternatives for checking compliance with the EP requirements for building permits, there are:

- (**a**) A simple checklist of prescriptive energy-efficiency measures, such as U-values. The benefit of this simple approach is that it does not involve any calculations, and is immediately understandable to laymen. To get a permit for a new building that does not comply with the whole checklist, one must have compensatory energy measures, and follow alternative (b):
- (**b**) Conduct EP calculations using software that complies with standard NS 3031. Calculated energy consumption shall not exceed maximum limits [(kWh/m²)/yr] defined for different building categories.

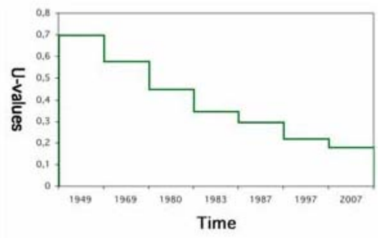


Fig.6: *Progressive tightening of wall U-value requirements in Norway since 1949. [source: NVE]*

Fig.7: *Holiday homes <150 m^2 and all log houses have more lenient U-value requirements, but are otherwise exempted from the EP requirements*

The two alternative approaches above are compatible, i.e. a building that complies exactly with checklist (a) will have approximately the same calculated energy use [(kWh/m^2)/yr] as the maximum limit set in alternative (b) for each building category. There is of course a deviation due to building geometry. There are also minimum requirements (e.g. maximum U-values and airtightness) that must be satisfied in all cases.

The U-values in the 2007/2010 regulations were chosen based on a technical & economic national study. They are incidentally the very close to the cost-optimum U-values estimated by Ecofsys for Oslo climate [5].

Changes to the checklist requirements, i.e. alternative (a):

Parameter	**1997†**	**2007/2010**
Wall U-value [W/m^2K]	0.22	0.18
Roof U-value [W/m^2K]	0.15	0.13
Floor U-value [W/m^2K]	0.30	0.15
Windows/doors [W/m^2K]	2.0 [1.6*]	1.20
Thermal bridges [$(W/K)/m^2_{floor}$]	†	0.06 [0.03*]
Airtightness, n_{50} [h^{-1}]		1.5 [2.5*]
Heat recovery [%]		80% [70%*]
Specific fan power [$kW/(m^3/s)$]		2/1‡ [2.5*]
Glazing area [% of floor]	20 %	20 %
Night-time setback [°C]		19 °C
Minimum requirements:		
Wall U-value [W/m^2K]		0.22 ▫
Roof/floor U-value [W/m^2K]		0.18 ▪
Windows/doors [W/m^2K]		1.60 ▪
Airtightness, n_{50} [h^{-1}]	1.5 [4*]	3.0 ▫
Solar shading / glazing system		g_t<0.1 if no A/C
RES % of heating demand		≥ 40%

* Special values for dwellings (single- or multifamily) in square brackets.
† Thermal bridges included in U-values in 1997 regulations.
‡ Daytime(occupied)/night-time(unoccupied) Specific Fan Power (SFP)
▫ No minimum requirements for log constructions.
▪ Stricter minimum requirements for log constructions over 150 m^2.

Changes to EP calculation requirements, i.e. alternative (b):
The 1997 EP calculations limited only space heating demand, while the 1997 'checklist' approach did not regulate ventilation heat loss at all, and thus posed a loophole to avoid for heat recovery.

This loophole was closed in the 2007 regulations, which have a much more complete 'checklist' including parameters that affect both space heating & cooling demand. Similarly, alternative (b) sets limits on the building's total net energy demand[1] [(kWh/m^2)/yr], and thus encompasses all heating & cooling energy. Primary energy use is limited by a simple requirement that ≥40 % of a building's heat demand shall be supplied by renewable energy carriers other than electricity or fossil fuels[2]. This percentage will be increased in the near future. District heating originates mostly from refuse, which must be burnt anyway. There is still discussion on the choice of primary energy weighting factors in Norway, partly due to uncertainties about import/export of electricity, combined with local hydroelectricity, and on the 'renewableness' of district heating.

Energy labelling is based on calculated delivered energy (bought energy) and a secondary label for the fraction of primary energy that is from renewable sources. The certificate also declares the measured energy consumption [kWh/yr] and the expected calculated for the local climate. The table below summarizes parameters that have been added/tightened:

[1] As defined in ISO 13790. Total net energy required for heating, cooling, ventilation, hot water, and all electrical equipment & lighting, taking account of solar & internal gains on the building's heat balance. Independent of energy delivery system efficiency (e.g. efficiency of boilers, heat pumps, solar collectors).
[2] Small buildings (<17000 kWh/yr) are exempted from this requirement.

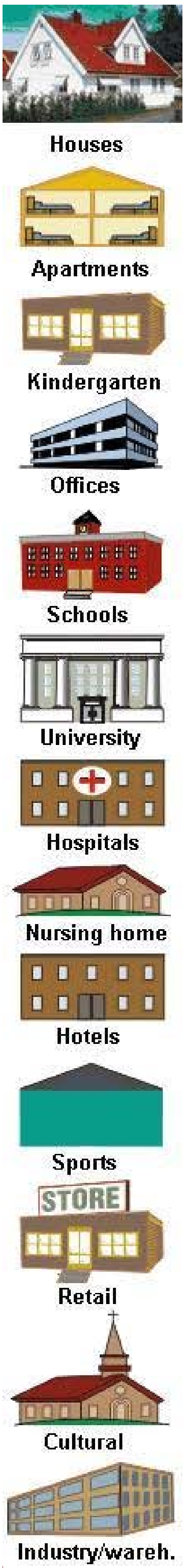


Fig.9 The 13 building categories

		Old regulations: 1997 (a) Simple prescriptive	Old regulations: 1997 (b) EP calculation	EPBD implementation: 2007 / 2010 (a) Simple prescriptive	EPBD implementation: 2007/ 2010 (b) EP calculation	EPBD implementation: 2010 Energy labelling	EPBD implementation: 2010 Inspections
Number of building categories		1	7	1	13	13	-
Heat loss	U-values	■	■	■*	■*	■	
	Thermal bridges	■	■	■*	■*	■	
	Infiltration		■	■*	■*	■	
	Heat recovery		■	■*†	■*	■	■
Energy use	Heat recovery defrost			■	■	■	
	Fan energy (SFP)			■	■	■	■
	Space heating		■	■	■	■	■
	Hot water (DHW)			■	■	■	■
	Pumps, lighting, eqpt.			■	■	■	
	Space cooling			■	■	■	■
	System efficiency					■	■
Minimum require-ments	U-values		■	■*	■*		
	Airtightness (n_{50})	■	■	■*	■*		
	Ventilation rates	■	■	■	■	●	■
	Thermal comfort	■	■	■	■	●	
	Window area (< %floor)	■		■†	■†		
	Glazing solar properties			■†	■†		
	% renewable energy			■	■	●	

* Indicates parameters from the last building regulations that were tightened in the new EPBD building regulations in 2007.
† Small revision of the building regulations in 2010, for non-residential buildings: Heat recovery and limiting window area and glazing solar gain factor (g-value).
● There is a secondary label for % renewable energy. Also the ventilation rate and indoor temperature set-point should comply with minimum values.

Ensuring long-term building quality: Two important features of the Norwegian approach to EPBD implementation are:

(1) the regulations limit *net* energy demand, thus ignoring the efficiency of energy delivery systems (e.g. boiler efficiency), and
(2) the EP calculation standard fixes input data related to occupant behaviour, including all heat gains (equipment, people, default lighting), hot water use, operating hours, set-point temperatures for heating & cooling, and minimum ventilation rates.

The combined effect of these two features has two benefits:

> ☺ It will ensure long-term and uniform quality of all building envelopes. It prevents misuse whereby a building designer could cut corners on thermal insulation by making overly optimistic assumptions about low-energy technical building services, building operation, and occupant behaviour. These can easily change/deteriorate over the lifetime of the building. Misuse has been further mitigated by placing limits on minimum U-values and airtightness. It seems sensible to that system efficiency affects the energy label but *not* building permit applications. Energy labels will be updated over the building's lifetime, thus capturing any changes to the energy systems. Systems have a shorter life than the building, and are cheaper to upgrade.

> ☺ A building's energy label is calculated assuming fixed 'typical' user behaviour and internal heat gains. This is sensible because occupants

might not have the same habits/activities as previous owners/tenants. User behaviour can have a significant impact on energy use.

And two downsides:

> ☹ The fixed input parameters in the EP calculation can pose a barrier to some innovative building services, especially ones that reduce internal heat gains (e.g. Energy Star equipment), hot water usage (e.g. water-saving showers), or that exploit adaptive thermal comfort. However, other innovative systems can in principle be accommodated in EP calculations with little problem (e.g. light dimming/ VAV/ efficient heating/cooling systems, insulated night shutters), given proper documentation and capable software.
> ☹ Another consequence is a distinction between air-to-air heat exchangers and air-to-air heat pumps in ventilation units. Unlike heat exchangers, heat pumps are considered an energy delivery system, and thus reduce bought energy but not *net* energy demand. This could affect the market for ventilation units with heat pumps. However, this effect might be mitigated by the energy labelling scheme, which is based on delivered energy.

Building categories: The number of building categories has been doubled from 7 to 13 (Fig.9). Multifunctional buildings should be subdivided into zones chosen from the 13 categories.

Vacation property (e.g. weekend cottages) was previously exempted from the regulations. Those above 50 m^2 are now included, because they are becoming increasingly luxurious, some with year-round heating. Small ones (<150 m^2) need only satisfy the minimum requirements. Also log cabins/homes need only meet minimum requirements, to uphold cultural heritage. Antiquarian buildings and cold storage buildings are also treated specially.

The regulations apply to new buildings and major renovations. 'Major renovations' is generally defined as over 50 % of the building area. The new regulations apply only to the affected areas/parts. Unfortunately, local authorities are very liberal in the case of renovation, often giving dispensation from EP requirements. This must be tightened in future.

Indoor climate: The minimum requirements for indoor climate and air quality remain largely unchanged since 1997, and are harmonized with EN 15251 Class II (7 ℓ/s·person + 0.7 ℓ/s·m^2 low polluting building). For dwellings, a mix of Class II & III presently suffices (0.5 ac/h, or 0.3 ac/h when unoccupied, and 7 ℓ/s·person in occupied bedrooms, and minimum extract flow rates from wet rooms & kitchen hoods).

Guidance notes to the regulations say that operative temperature in workspaces (non-residential) should be designed so as not to exceed 26 °C more than 50 hours/year. Adaptive thermal comfort is not explicitly accommodated in the EP regulations.

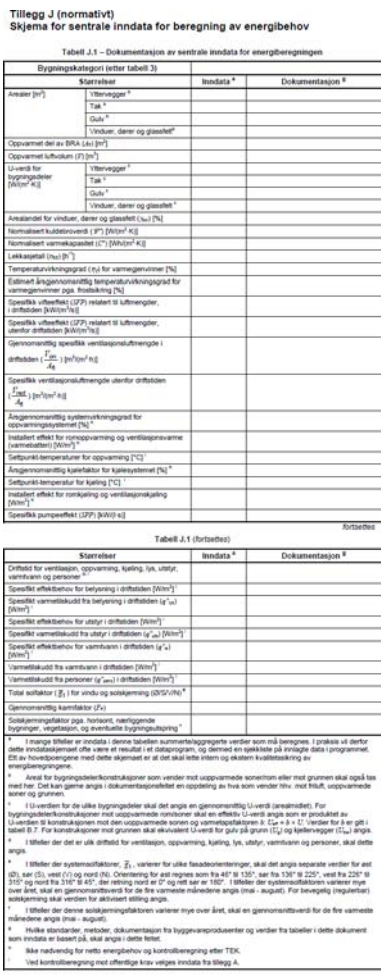
There are also requirements related to air quality & radon, noise, daylight, and moisture damage prevention. None of these are changed as direct consequence of EPBD. The Health & Safety Inspectorate publish their own requirements for workspaces.

2.3 Building Regulations: Compliance and Control [3]

Construction errors are a significant problem in Norway. Approximately 10 % of the industry's costs are due to errors; half of which appear during the construction phase, and the remaining half are discovered after acquisition. Some appear only after many years (e.g. moisture damage). Insurance companies have a vested interest in improving construction quality. However, EP is rarely flagged as an issue.

[3] Compliance means the fulfilment of EP requirements and EP certification process, while control is the mechanism for checking compliance of individual buildings.

Fig.10



Tillegg J (normativt)
Skjema for sentrale inndata for beregning av energibehov

Tabell J.1 – Dokumentasjon av sentrale inndata for energiberegningen

Bygningskategori (etter tabell 3)			
Størrelser		Inndata [a]	Dokumentasjon [g]
Arealer [m²]	Yttervegger [b]		
	Tak [b]		
	Gulv [b]		
	Vinduer, dører og glassfelt [b]		
Oppvarmet del av BRA (A_{fl}) [m²]			
Oppvarmet luftvolum (V) [m³]			
U-verdi for bygningsdeler [W/(m² K)]	Yttervegger [c]		
	Tak [c]		
	Gulv [c]		
	Vinduer, dører og glassfelt [c]		
Arealandel for vinduer, dører og glassfelt (ζ_{ws}) [%]			
Normalisert kuldebroverdi (Ψ'') [W/(m² K)]			
Normalisert varmekapasitet (C'') [Wh/(m² K)]			
Lekkasjetall (n_{50}) [h⁻¹]			
Temperaturvirkningsgrad (η_t) for varmegjenvinner [%]			
Estimert årsgjennomsnittlig temperaturvirkningsgrad for varmegjenvinner pga. frostsikring [%]			
Spesifikk vifteeffekt (SFP) relatert til luftmengder, i driftstiden [kW/(m³/s)]			
Spesifikk vifteeffekt (SFP) relatert til luftmengder, utenfor driftstiden [kW/(m³/s)]			
Gjennomsnittlig spesifikk ventilasjonsluftmengde i driftstiden ($\frac{V_{on}}{A_{fl}}$) [m³/(m² h)]			
Spesifikk ventilasjonsluftmengde utenfor driftstiden ($\frac{V_{red}}{A_{fl}}$) [m³/(m² h)]			
Årsgjennomsnittlig systemvirkningsgrad for oppvarmingssystemet [%] [h]			
Installert effekt for romoppvarming og ventilasjonsvarme (varmebatteri) [W/m²] [h]			
Settpunkt-temperaturer for oppvarming [°C] [i]			
Årsgjennomsnittlig kjølefaktor for kjølesystemet [%] [h]			
Settpunkt-temperatur for kjøling [°C] [i]			
Installert effekt for romkjøling og ventilasjonskjøling [W/m²] [h]			
Spesifikk pumpeeffekt (SPP) [kW/(l/s)]			

fortsettes

Tabell J.1 (fortsettes)

Størrelser	Inndata [a]	Dokumentasjon [g]
Driftstid for ventilasjon, oppvarming, kjøling, lys, utstyr, varmtvann og personer [d, i]		
Spesifikt effektbehov for belysning i driftstiden [W/m²] [i]		
Spesifikt varmetilskudd fra belysning i driftstiden (ϕ''_{lys}) [W/m²] [i]		
Spesifikt effektbehov for utstyr i driftstiden [W/m²] [i]		
Spesifikt varmetilskudd fra utstyr i driftstiden (ϕ''_{uts}) [W/m²] [i]		
Spesifikt effektbehov for varmtvann i driftstiden (ϕ''_{w}) [W/m²] [i]		
Varmetilskudd fra varmtvann i driftstiden [W/m²] [i]		
Varmetilskudd fra personer (ϕ''_{pers}) i driftstiden [W/m²] [i]		
Total solfaktor ($\bar{g}_t$) for vindu og solskjerming (Ø/S/V/N) [e]		
Gjennomsnittlig karmfaktor (F_F)		
Solskjermingsfaktor pga. horisont, nærliggende bygninger, vegetasjon, og eventuelle bygningsutspring [f]		

a I mange tilfeller er inndata i denne tabellen summerte/aggregerte verdier som må beregnes. I praksis vil derfor dette inndataskjemaet ofte være et resultat i et dataprogram, og dermed en sjekkliste på innlagte data i programmet. Ett av hovedpoengene med dette skjemaet er at det skal lette intern og ekstern kvalitetssikring av energiberegningene.

b Areal for bygningsdeler/konstruksjoner som vender mot uoppvarmede soner/rom eller mot grunnen skal også tas med her. Det kan gjerne angis i dokumentasjonsfeltet en oppdeling av hva som vender hhv. mot friluft, uoppvarmede soner og grunnen.

c I U-verdien for de ulike bygningsdeler skal det angis en gjennomsnittlig U-verdi (arealmidlet). For bygningsdeler/konstruksjoner mot uoppvarmede rom/soner skal en effektiv U-verdi angis som er produktet av U-verdien til konstruksjonen mot den uoppvarmede sonen og varmetapsfaktoren b: $U_{eff} = b \times U$. Verdier for b er gitt i tabell B.7. For konstruksjoner mot grunnen skal ekvivalent U-verdi for gulv på grunn (U_g) og kjellervegger (U_{bw}) angis.

d I tilfeller der det er ulik driftstid for ventilasjon, oppvarming, kjøling, lys, utstyr, varmtvann og personer, skal dette angis.

e I tilfeller der systemsolfaktorer, $\bar{g}_t$, varierer for ulike fasadeorienteringer, skal det angis separate verdier for øst (Ø), sør (S), vest (V) og nord (N). Orientering for øst regnes som fra 46° til 135°, sør fra 136° til 225°, vest fra 226° til 315° og nord fra 316° til 45°, der retning nord er 0° og rett sør er 180°. I tilfeller der systemsolfaktoren varierer mye over året, skal en gjennomsnittsverdi for de fire varmeste månedene angis (mai - august). For bevegelig (regulerbar) solskjerming skal verdien for aktivisert stilling angis.

f I tilfeller der denne solskjermingsfaktoren varierer mye over året, skal en gjennomsnittsverdi for de fire varmeste månedene angis (mai - august).

g Hvilke standarder, metoder, dokumentasjon fra byggevareprodusenter og verdier fra tabeller i dette dokument som inndata er basert på, skal angis i dette feltet.

h Ikke nødvendig for netto energibehov og kontrollberegning etter TEK.

i Ved kontrollberegning mot offentlige krav velges inndata fra tillegg A.

Fig.11: *Two-page EP calculation summary*

Handling of building permit applications: Applications are generally submitted and administrated electronically (*http://byggsok.no/*). Output from the EP calculation is submitted together will any underlying product-documentation for non-default values in the calculation. Generally, a two-page summary will suffice (Fig.11). The format of this mandatory 2-page document is defined in NS 3031 Appendix J. It gives experts/clerks an instant overview of key data. Each data value has an associated comment field for referencing documentation. The clerk quickly sees whether the comment fields are used seriously to refer to appended documentation that proves the validity of the values taken forward.

Control of the regulations is the responsibility of the municipality where the building is located. This is mainly an administrative check that all QC forms and reports are completed & submitted. The local authorities do not necessarily have the resources or competence to check the underlying EP documentation, so in practice the system is largely based on trust. Builders will naturally wish to avoid mistakes that could result in sanctions or civil litigation by the building owner. Most noncompliance with the EP regulations is therefore probably done unawares, but there is probably a degree of deliberate noncompliance by hard-pressed builders who exploit the owner's incompetence and the superficiality of the authorities' control.

Some important parameters should strictly always be documented in a building permit, such as heat recovery efficiency or window U-values. However, in practice, the documentation can be very basic, such as declared product type, not necessarily manufacturer. This is reasonable, since the builder does not necessarily decide on specific building products until after receiving the building permit. Sadly, this practice can contribute to a gap between required and true performance of new buildings. Fortunately, energy labels can potentially reveal this.

The National Office of Building Technology and Administration administers a central national register for authorizing companies (designers, contractors and controllers) in the building trade.

A recent revision of the law has made the control system more stringent by enforcing third party on-site technical checks.

Sanctions and litigation: The Planning-&-Building Act lists sanctions that may be applied in case of law infringements. It is the responsibility of local municipalities to exercise control. The most common sanction is a fine together with enforced remedial work, and that the offending company can (partly or wholly) lose their authorization, but imprisonment is possible. If the planning-&-building authorities find that the offence is trifling, they usually refrain from subjecting it to any sanctions.

The authorities often do not have the capacity to uncover minor breaches of the building regulations, especially related to EP. This is confounded by socially accepted wisdom that buildings often use more energy than predicted, due in part to occupant behaviour. Often it is the building user (owner or tenant) who discovers infringements of the law, or deviations from contracted specifications. Therefore, in practice, most cases end up as disputes between, for example, the owner and builder, and can be solved by civil litigation.

3 > IMPLEMENTATION OF ENERGY LABELLING

It has been decided that the energy-labelling scheme will be a free web-based service/database (EnergiMerkeSystemet, "EMS"). Its website (*http://www.energimerking.no/*) gives access to data acquisition, an EP calculation program, issuing of the certificates, and background information related to the scheme. Fig.13 illustrates the system.

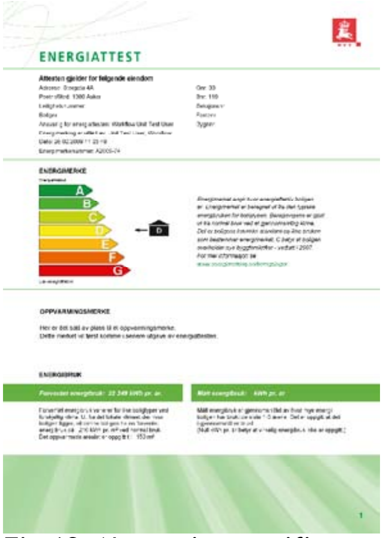


Fig.12: *Norwegian certificate*

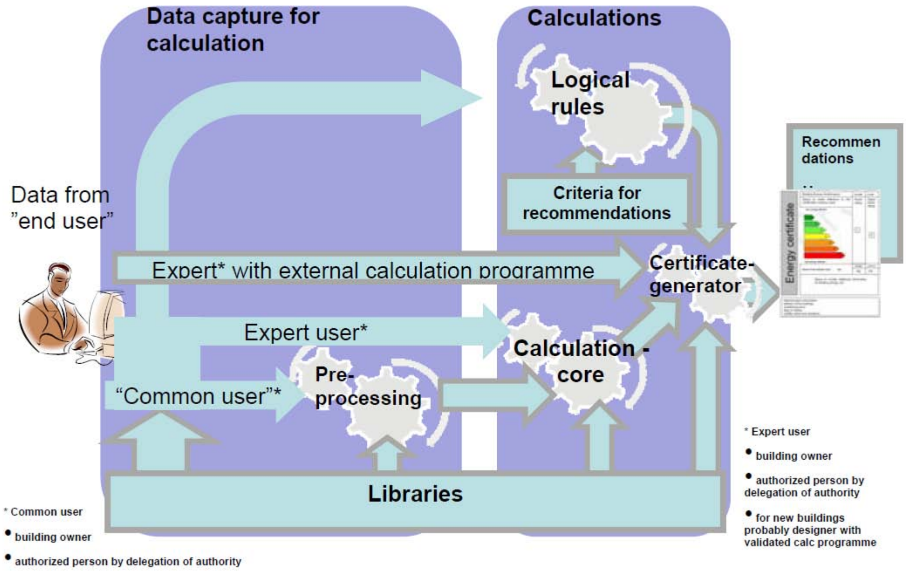


Fig.13: *Schematic showing information flow and processing in the Energy Marking System (EMS). [source: Rode & Isachsen, NVE]*

Which buildings?: Energy labelling will encompass generally all buildings over 50 m². Energy labelling will comply with EPBD Article 7. All buildings (not only public) over 1000 m² shall have the label on display at all times. This is wider than the scope of Article 7.3. However, listed buildings (cultural monuments), churches, agricultural work buildings, and industrial process premises will be exempted. Labels will last 10 years.

Who is qualified to label?: The website is available to all building owners to certify their own building. Owners can delegate the task to anybody who they deem more competent. All Norwegians have received a password card ('AltInn'/'MinID') for web access to some State services. There are two different categories of label:

Simple: For all residential buildings (single or multifamily housing), there will be no qualification requirements, and owners can cerfity the building themselves. This, and the lack of impartiality, has been strongly criticized by much of the building industry, and violates EBPD Article 10 that requires certification to be conducted by independent experts. However, the government has invested significant resources, relative to other countries, in developing the robust and user-friendly interface ('pre-processor' in Fig.13) and advanced automatic recommendation generator ('logical rules' in Fig.13). Moreover, it will be a cheap and unbureaucratic way of implementing the EPBD. This avoids an immediate bottleneck due to shortage of certified assessors.

Advanced: For all other buildings, there is a need for more detailed input to the software. The building owner can delegate the task of certifying to anyone they choose. However, certifiers must confirm that their qualifications are adequate against a predefined set of requirements. It is also be possible to upload calculations conducted on other validated EP calculation software.

Fig.14
Who is qualified to label?

Control and sanctions: Building owners are responsible for the quality of documentation that is stored in the national certification database (EMS). Potential buyers or tenants can check the documentation and decide whether the labelling has been done in a satisfactory manner. Any underlying documentation will also be available in the database. Most cases of missing or incorrect certificates will be a question that must be resolved by civil litigation between the buyer/tenant and seller, to settle claims for compensation. Such civil sanctions will of course not occur for breaches of the duty to display certificates in large buildings.

Fig.15
Sanctions for noncompliance

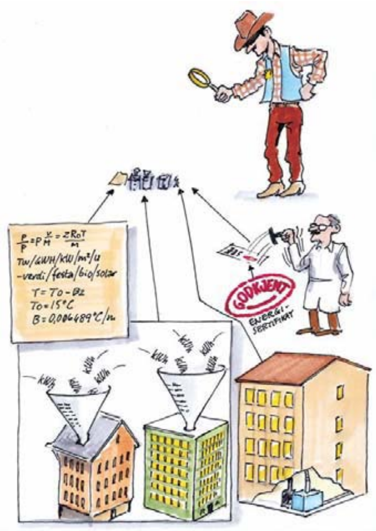


Fig.16: *Control and spot checks. NVE acts as sheriff! [source: NVE]*

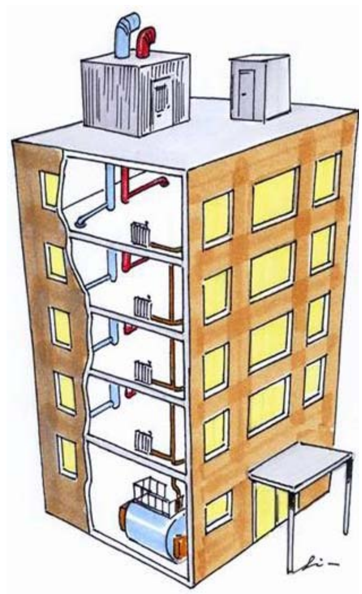


Fig.17: *Inspected systems [source: NVE]*

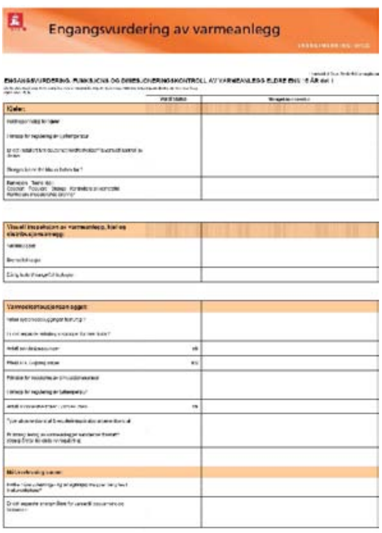

Engangsvurdering av varmeanlegg

Fig.18: *Heating system inspection form [source: NVE]*

It is important for the credibility of the scheme that the authorities can impose sanctions for violations. The certification database is administered by the Norwegian Water Resources and Energy Directorate (*http://www.nve.no/*). Their control activities will include spot checks of the quality of energy labelling and inspection reports, and buildings that should have a visible certificate. This complies with EPBD article 17. The minor offence of missing or incorrect certification/inspection will incur an administrative fine.

4 > IMPLEMENTATION OF INSPECTION SCHEME

Inspection schemes: This will be an extension of already established voluntary inspection regimes by qualified service personnel, e.g. '*EO-ordningen*' for boilers and '*TELFO/KELF-ordningen*' for chillers/heat pumps, making them mandatory. Inspection reports are registered the same web-based central database as energy labels.
There will be three schemes; provisional details are given below:

- Regular (2-yearly for >100 kW, 4-yearly for >20 kW) inspection of fossil-fuel **boilers** irrespective of building type. Focus on energy.
- One-off inspection of old (>15 year) **heating systems** with fossil-fuel boilers (>20 kW) irrespective of building type. Encompasses whole heating system, including distribution & sizing.
- Regular (probably 5-yearly) inspection of **refrigeration** and **ventilation** systems in buildings (>12 kW nominal cooling capacity). Encompasses AC-equipment, air handling units, and distribution. Focus on energy.

Who is qualified to conduct inspections?: It is provisionally intended that:

- >20 kW boilers will require relevant competence with 2 years of experience from inspection and operation.
- >100 kW boilers: As above but with 5 years of experience.
- One-off inspections of the rest of the heating system will require HVAC-related competence at engineer-level (bachelor) and 2 years of experience from building energy calculations.
- AC/ventilation installations will require HVAC-related competence at engineer-level (bachelor) and 2 years of experience from installing or evaluating such systems.

Control and sanctions will be the same as for the labelling scheme, with spot checks and administrative fines for missing reports. Professional misconduct of inspectors will may result in the loss of right to practice.

5 > OTHER NATIONAL INCENTIVES

There are many existing incentives for promoting energy efficiency. The energy labelling and inspection schemes will be coordinated with these:

- The Norwegian State Housing Bank gives higher loans for low energy housing. These loans have favourable interest rates.
- The national energy agency, Enova (*http://www.enova.no/*), provides financial support to new projects and energy retrofits.
- The municipality of Oslo has an energy-efficiency fund that can support energy-efficiency projects, usually retrofit.
- Regulation on informative billing, implemented 1999. High impact [7].

6 > IMPACT OF EPBD

It is difficult to analyse the impact of EBPD by isolating it from the other ongoing national measures. The building regulations were due for revision

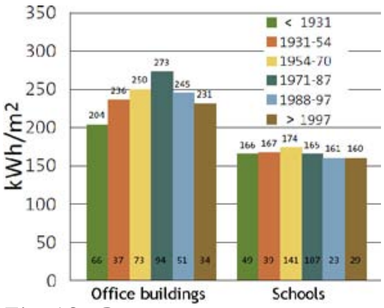


Fig.19: *Present energy consumption of offices & schools by construction year. Buildings from <1931 do not use more energy. Many older buildings in this sample have probably been rehabilitated. The picture for housing is the same. [source: ENOVA]*

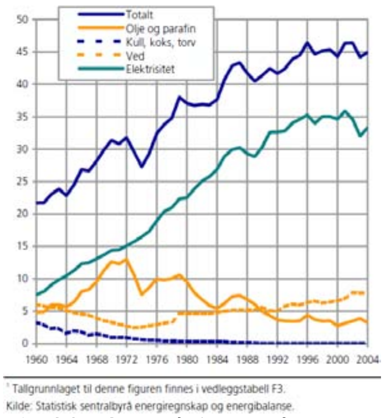


Fig.20: *Growth in total energy consumption of housing since 1960 [source: SSB]*

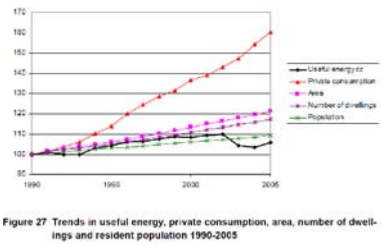


Fig.21: *Growth in wealth, built housing area, no. of dwellings and population since 1960 [source: IFE/ODYSSEE]*

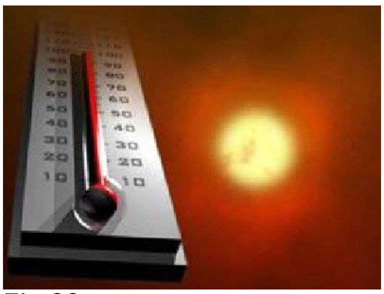


Fig.22

anyway in 2007. We might get a rough idea of the potential impact of EPBD by looking at the outcome of previous building regulations.

Impact of regulations on energy efficiency: The Norwegian building regulations have had requirements on thermal insulation since 1949 (Fig.6). Over the years, most recently 1987 & '97, the requirements have been both sharpened and extended to several other factors that affect energy use and indoor environment. There is strong historical evidence that tightening building regulations in 1987 & '97 influenced the energy efficiency of the building stock (Fig.19).

It is too early to say what impact EPBD has on the energy consumption of the building stock as a whole. However, the few new buildings that are being constructed after the new EPBD regulations are approx. 25 % more energy-efficient than buildings from 1997-2007.

Other historic influences: There was a longstanding trend of increasing energy consumption up to the mid 1990s (Fig.20). This was due to increasing wealth leading to growing dwelling size and energy-intensive use/in of dwellings, combined with the fact that the number of dwellings has increased as the population has grown and a larger fraction of people live alone (Fig.21). Since then, the degree-day-corrected energy consumption of the housing stock has stabilized (right-hand side of Fig.20), despite continued population growth and lower area-efficiency. It seems that housing standards have now plateaued, such that further increases in private wealth no longer result in increased energy use. Since the mid '90s, the energy consumption per m^2 has decreased, as well as consumption per dwelling and per capita. This improvement in energy-efficiency is due to a combination of factors, most notably higher energy costs, but also more focus on energy conservation (e.g. heat pumps), better insulation and more efficient equipment.

Summertime temperatures: Although the climate in Scandinavia is subarctic, tightening the thermal insulation requirements has worsened the problem of overheating in summer, most notably in apartment & office buildings. Another point to note is that the sun is lower in the sky at high latitudes, leading to more perpendicular solar radiation though windows in the East/South/West facades. Moreover, high latitudes experience more hours of daylight than Southern Europe during summer.

To reduce the risk of overheating, the new regulations are formulated to promote passive measures such as shading and limiting glazing area. Other beneficial changes to the calculation method thermal comfort are already described on pages 2-3 & 5. However, experience has shown us that the 2007 regulations are not strict enough on this topic. The building regulations will therefore be revised in 2010 to limit solar gain factor for non-residential buildings ($g_t \leq 0.1$) if cooling is installed. Another additional minimum requirement will be limiting window area ($\Sigma UA_{window}/A_{floor} \leq 0.24$), which should affect both cooling and heating load. These new requirements alone might not be sufficient, as it will still be possible to design wide office buildings with 100 % glazing.

Although it remains to be seen how effective these measures are. Norway has at least taken a large step in the right direction, given that the previous building regulations (1997) did not limit energy for cooling.

Market effects: It is too early to say how energy labelling or inspection will affect the market value of buildings, and the trade of building products/services. However, it is expected to have an impact, aided by rising public concern for climate change.
We have already observed positive impacts of the new building regulations.

> Parts of the building industry were initially very concerned about the ability to economically adapt manufacturing & construction practices.

For example, many SME window manufacturers were concerned about losing market shares because their windows did not have low U-values. However, this concern has ceased. Manufacturers have managed, with help, to upgrade and document their products.

Another example was airtightness. The requirement for houses was tightened from $n_{50} \leq 4$ to 2.5. Builders have now discovered that simple changes in construction practice can easily achieve $n_{50}=1$[4] without increased construction costs. The requirement for larger buildings ($n_{50} \leq 1.5$) remained unchanged from the 1997 regulations, and has been proven to be achievable long ago.

- There is a general understanding that the increased building costs are profitable. The severity of the energy-efficiency measures in the new EPBD building regulations were based on an economic evaluation, with a payback period of 4.4~9.0 years depending on building type.
- The regulations have led to increased interest in building products for low U-value insulation, glazing, and airtightness. Leakage testing is expected to become more common, though it is not yet mandatory.
- Balanced ventilation with efficient heat recovery was already standard in large buildings before EPBD, and is now effectively standard for all. The ‘checklist’ heat exchanger efficiency will be increased to 80 % after 2010 (70 % for dwellings, and zones where recirculation must be avoided, e.g. isolation wards). The EP calculation standard properly calculates energy for defrosting heat exchangers[5].The software user must specify the type of heat exchanger (which decides the limiting exhaust temperature). The consequence of this is that regenerative heat exchangers (especially rotary) are predominant, as they generally do not experience icing. Plate heat exchangers, especially counter-flow devices, suffer a drop in efficiency due to defrosting in the subarctic climate. There is still potential for product development.

7 > SUGGESTED FUTURE IMPROVEMENTS

A government-appointed committee of experts has recently completed its report with national energy-conservation recommendations[6]. It suggests that it is possible to halve the building sector’s energy use over 30 years. Such a halving can be achieved by tighter regulations for new buildings, considerable effort to make major rehabilitations energy-effective, and energy conservation measures in other buildings. Achieving these goals will require a long-term large-scale coordinated plan to change the market for energy-efficient solutions and empower the building trade to deliver the necessary solutions.

The following set of policy actions was recommended:

1. National action plan to improve energy-effectiveness of buildings
2. Large-scale competence plan for the building industry
3. Forewarned incremental tightening of the building regulations (Fig.23)
4. Stricter control of energy requirements for rehabilitation projects
5. Influential forerunner projects and demonstration buildings
6. Revised energy labelling scheme with ‘energy plan’ for existing buildings
7. Simplify, widen, and increase investment support from energy agency
8. State loan scheme for energy conservation/retrofit measures
9. White certificates for energy saving and tax incentives for energy efficient buildings
10. Special requirements for public buildings
11. Better information and advice to improve buyer competence

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[4] Buildings with balanced ventilation do not have fresh air vents. Vents can increase n_{50} by at least 1 h^{-1}.

[5] A further development of the method given in EN 15241. Defrost energy is best calculated using hourly weather data.

Fig.23: *Suggested plan for incremental tightening of building regulations, approaching Zero Energy standard by 2027 [6]*

8 > REFERENCES

[1] Norwegian Standard NS 3031:2007, 'Calculation of energy performance of buildings - Method and data', *http://www.standardnorge.no/*

[2] Norwegian Standard NS 3940:2007, 'Areas and volumes of buildings', *http://www.standardnorge.no/*

[3] National Office of Building Technology & Administration (Statens bygningstekniske etat), *http://www.be.no/*

[4] Act relating to the generation, conversion, transmission, trading distribution and use of energy etc. (The Energy Act).

[5] Booklet '*U-values for better energy performance of buildings*'. Brussels: Eurima (European Insulation Manufacturers Association)

[6] Report '*Lavenergiutvalget: Energieffektivisering*'. Oslo: Ministry of Petroleum & Energy (Olje- & energidepartementet)June 2009

[7] Regulation of 11 March 1999 concerning metering, settlement and coordination of electricity trading and invoicing of network services.

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Poland: Impact, Compliance and Control of legislation

The paper describes Impact, Compliance and Control related to implementation of EPBD in Poland. Impact is analysed as a driving force towards application of new more demanding requirements, and their results. Compliance is referred to fulfilment of country's obligation, whereas control is discussed as a country's approach to quality of legal solutions.

1 > Implementation of EPBD in Poland - expectations

The implementation of the Energy Performance of Buildings Directive (EPBD) in Poland was initially conceived as an opportunity to improve energy performance and modernise building regulations. It was also seen as a sort of external motivation to improve energy efficiency, especially given that the various stakeholders had divergent views of what the system of energy certificates would look like. The European mandate was an opportunity for immediate action, not only related to the aims of the directive, but as a means to safeguard the environment. Even though the energy efficiency of the Polish economy is lacklustre and the energy standards of the existing Polish building stock are not impressive, they are improving with the time. In 2005, the Association of Energy Auditors -- a non-governmental organisation -- took on the leadership and coordination of a group of expert volunteers represented by academia, professional associations and industry leaders. These were the stakeholders who prepared proposals for legislative changes that could be implemented into Polish law. A country-wide debate and discussion concluded in November 2008 with the publication of an ordinance that describes a certain methodology for calculating energy performance. The final version, however, regarding the energy certificates was a long way off from what was proposed initially. These regulations were rather disappointing and caused the publication of many critical articles. Due mainly to incorrect assumptions, calculation errors and misleading methods the energy certificate is a piece of paper required by law that does not provide much useful information *[1]*.

2 > Impact of the EPBD on national requirements

The legal framework for implementation is based on a national act and accompanying ordinances. Beginning from the 1st of January 2009, according the regulations of the Construction Act, a certificate of energy performance is required:

- new buildings licensed for operation
- buildings that are modernised or renovated, if a change in energy performance took place as a result,
- upon sale or rent (However, in spite of being stated outright in the Construction Act, the official interpretation of the Ministry of Infrastructure is that the requirement must be demanded by both parties).

Intelligent Energy Europe

The Construction Act provides a mandate for amending different secondary legislation, among them the ordinance on the Technical Criteria to be met by buildings at a given location (Official Journal nr.75 position 6590, with later changes published in the Official Journal 2008 nr.201 position 1238). These criteria determine which energy standard should be chosen with respect to buildings and installed technologies and outlines a method of assessing energy use. Mandatory requirements for the performance of buildings and their installed technologies are specified for existing buildings with a total usable area over 1000 m^2. This includes any renovation, reconstruction, modernisation or extension for which a building permit is required.

Implementation of the EPBD on the building stock in terms of energy efficiency

Polish regulation makes provision for two alternative ways of fulfilling energy requirements. The first method is prescriptive and consists of a list of detailed requirements for different building components. The second method is performance based and defines permissible values of specific non-renewable primary energy use or EP, expressed in kWh/(m^{2}year).

Scheme of calculation algorithm

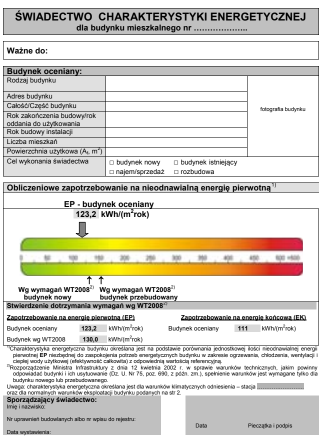
Both methods allow for a lower energy performance in modernised buildings, with respect to new buildings identical in form and function. In the first method, the mean heat transfer coefficient for the whole building envelope can be 15% higher than in a typical new building. In the second method, modernized buildings can have a 15% higher primary energy use (EP). A more detailed description of specific requirements can be found in the *Country Status Reports* section prepared within the curricula of *EPBD Concerted Actions* and can be downloaded from: ***www.buildup.eu***.

The fulfilment of EP requirements can be achieved in two ways:

I. Compliance with prescriptive values for components

The energy requirements for both new and modernised buildings of useful area over 1000 m^2 are set in Ordinance on technical criteria to be met by buildings at given location and encompassing:

- maximum permissible U-value, 0,3 W/m^{2}K for external walls, 0,25 roofs, 0,45 floor on ground, 1,7-1,9 W/m^{2}K for windows – for new residential buildings (for other types of building different values are set), for modernised buildings the above values can be increased by 15%,
- minimal solar radiation coefficient, gc <0,5, with exception to windows and glazed or transparent partitions, that have share in external wall over 50%,
- maximal area of windows and glazed or transparent partitions with U-value >1,5 W/m^{2}K cannot exceed limits defined according to the type of building,
- parameters of indoor air quality, introduction of duty to ensure that necessary rate of outdoor air is supplied through vents mounted in external partitions or through mechanical supply ventilation,
- minimal efficiency and requirements for elements of heating, cooling installations, lighting i.e. maximal permissible specific fan power, minimal depth of thermal insulation of installations: heating, hot water, cooling and air heating,
- reference electric specific power PN depending on time of electric light utilization.



ŚWIADECTWO CHARAKTERYSTYKI ENERGETYCZNEJ
dla budynku mieszkalnego nr ....

Ważne do:

Budynek oceniany:		
Rodzaj budynku		fotografia budynku
Adres budynku		
Całość/Część budynku		
Rok zakończenia budowy/rok oddania do użytkowania		
Rok budowy instalacji		
Liczba mieszkań		
Powierzchnia użytkowa (A_f, m^2)		
Cel wykonania świadectwa	□ budynek nowy □ budynek istniejący □ najem/sprzedaż □ rozbudowa	

Obliczeniowe zapotrzebowanie na nieodnawialną energię pierwotną 1)

EP - budynek oceniany
123,2 kWh/(m^{2}rok)

0 50 100 150 200 250 300 350 400 450 500 >500

Wg wymagań WT2008 2) **budynek nowy** **Wg wymagań WT2008** 2) **budynek przebudowany**

Stwierdzenie dotrzymania wymagań wg WT2008 2)

Zapotrzebowanie na energię pierwotną (EP)			**Zapotrzebowanie na energię końcową (EK)**		
Budynek oceniany	123,2	kWh/(m^{2}rok)	Budynek oceniany	111	kWh/(m^{2}rok)
Budynek wg WT2008	130,0	kWh/(m^{2}rok)			

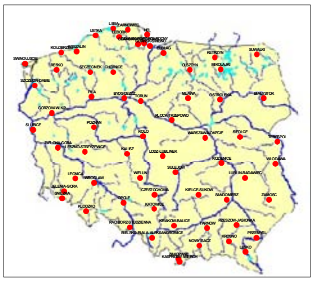
1) Charakterystyka energetyczna budynku określana jest na podstawie porównania jednostkowej ilości nieodnawialnej energii pierwotnej **EP** niezbędnej do zaspokojenia potrzeb energetycznych budynku w zakresie ogrzewania, chłodzenia, wentylacji i ciepłej wody użytkowej (efektywność całkowita) z odpowiednią wartością referencyjną.
2) Rozporządzenie Ministra Infrastruktury z dnia 12 kwietnia 2002 r. w sprawie warunków technicznych, jakim powinny odpowiadać budynki i ich usytuowanie (Dz. U. Nr 75, poz. 690, z późn. zm.), spełnienie warunków jest wymagane tylko dla budynku nowego lub przebudowanego.
Uwaga: charakterystyka energetyczna określana jest dla warunków klimatycznych odniesienia – stacja .... oraz dla normalnych warunków eksploatacji budynku podanych na str 2.

Sporządzający świadectwo:
Imię i nazwisko:
Nr uprawnień budowlanych albo nr wpisu do rejestru:
Data wystawienia:
Data Pieczątka i podpis

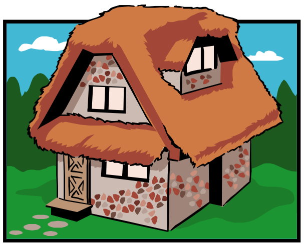
First page of Polish Energy Certificate

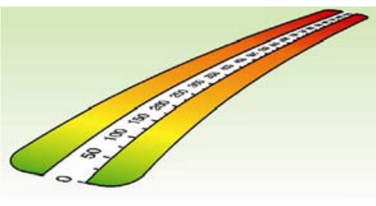
II. Compliance with primary energy values

The regulation defines requirement by presenting permissible value of specific non-renewable primary energy EP expressed in kWh/(m2year) that



New database of climate parameters has been prepared for 61 meteorological stations (data available on the internet http://www.mi.gov.pl/2-48203f1e24e2f-1787735-p_1.htm*), contains monthly and hourly data.*





cannot be exceeded (for modernised buildings the permissble EP value is increased by 15%). The permissible values depend on type of the building and building shape coefficient. For example, in residential buildings permissible prmary energy for heating, ventilation and hot water preparation (EP_{H+W} in kWh/(m^2 year)) calculated for whole year:

for $A/V_e \le 0,2$; $EP_{H+W} = 73 + \Delta EP$;
for $0,2 \le A/V_e \le 1,05$; $EP_{H+W} = 55 + 90 \cdot (A/V_e) + \Delta EP$;
for $A/V_e \ge 1,05$; $EP_{H+W} = 149,5 + \Delta EP$;

where:
$\Delta EP = \Delta EP_W$ – addition to specific use of non-renewable primary energy for preparation of hot water during the year,

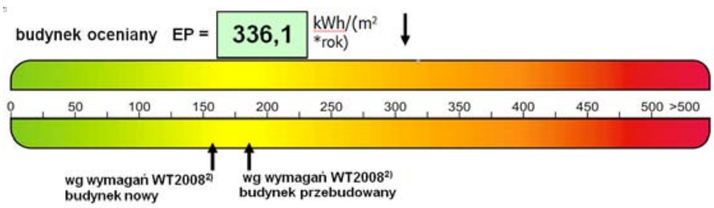
$\Delta EP_W = 7800/(300 + 0,1\ A_f)$; [kWh/(m^2 . year)],

A – the sum of surface areas of all outer partitions which separate the building's heated parts from ambient air, ground or adjacent unheated spaces defined along outer boundaries,

V_e – the cubic capacity of the building's heated section defined along outer boundaries, diminished by volume of balconies, loggias and galleries,

A_f – useful heated area of building (apartment);

The requirements are not consistent. In fact, this means that if one chooses according to the component pathway the primary energy requirements cannot be reached.

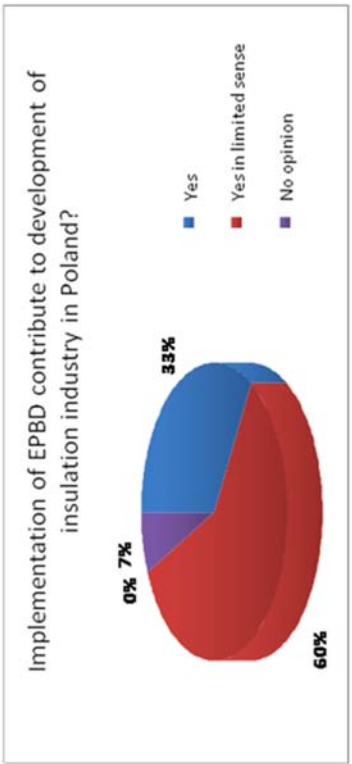


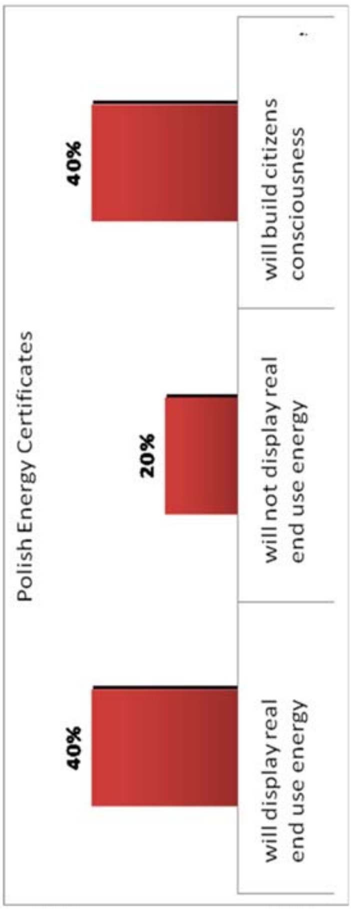
Moreover after looking for reasons why, it comes out that the prescriptive requirements are related to U_0 (a value that does not consider thermal bridging) whereas the old ones were related to U_{kmax} values (thermal bridges included).

For performance requirments a single formula for EP for heating (dependent on the shape factor A/V) was provided for all types of buildings, and if compared with previous requirements, the new one is less demanding, especially for single-family and small residential buildings. Paradoxically, in the case of heating, the new energy performance requirements introduced in Poland due to EPBD are less demanding that the old ones. Due to the regulation, new requirements have been set for hot water (related to usful area for residential buildings !!!),for cooling and for lighting and these required values have been specified without any apparent economic justification.

Impact of the implementation of the EPBD on the building stock

The official interpretation of the Construction Act requires an energy certificate only for buildings that have been sold or will be rented and only if the involved parties express the will for it. So in practice, the energy certificate is prepared only for buildings designated for operation, that is to say new construction or after a major renovation that modifies the use energy characteristics. The Polish certificate is not correlated with end-use energy consumption, and as such, cannot be used for drawing





conclusions about the building's energy cost. From the point of view of the owner or developer the certificate is only a piece of paper required by law, and because the energy requirements are less strict, it does not positively influence the quality of the building stock. Unfortunately, these shortcomings have been causing a misunderstanding as most of certificates are indicating not a fulfilment of performance requirements but a fulfilment of prescriptive values. Thus any positive momentum from the initial good intentions has been lost.

EP requirements introduced by national regulation are wider than in EPBD Art. 7

The scope of the EP requirements is the same as described in Art 7. The only exemption is that the energy certificate is required for buildings that have undergone construction works when the energy performance has been changed. Thus, the threshold of 1000 m^2 is soon overcome and by this fact Polish requirements are wider than those in Art. 7. However, the certificate is required only if after the construction works conclude, the building needs to get a permit for operation, which unfortunately does not include even major renovations.

Regulations related to energy efficiency and indoor climate

The Polish Standard PN-78/B-03421 puts forward a requirement for fresh outdoor air provided through vents mounted in external partitions or through mechanical supply ventilation (see details below). It also specifies thermal comfort in mechanically ventilated or air-conditioned spaces, and neither the fresh air nor thermal comfort specification has been changed by the new implementation. The standard, however, introduces the concept of optimal and permissible conditions for both winter and summer. The Ordinance about Technical criteria defines general requirements regarding indoor comfort (§ 154.1.) It states that air-circulating devices, mechanical ventilation and air conditioning elements should be installed to maintain environmental indoor air quality and that the use of energy for heating, cooling and electrical supply should be on a rational basis.

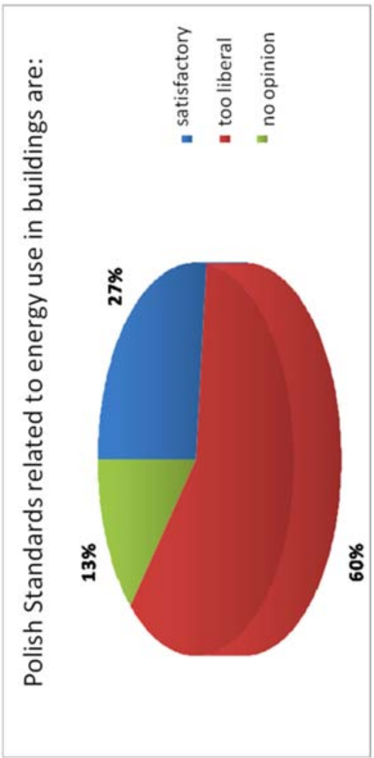
What technical measures are chosen for better energy performance since the implementation of the EPBD?

No specific technical measures are chosen because of the new regulation. There are two hints- suggestions given to obtain a better EP value on the energy assessment. These include the extension of conditioned area (by way of increasing the denominator in expressing specific end use energy) and the application of a biomass boiler (primary energy factor 0,2). The measures are artificial and not justified by real energy efficiency, and were during the first period of time taken up for marketing purposes.

Does the EPBD affect building prices, the building market and the selection of building products?

The energy certificate in Poland does not provide useful information to the owner. Thus, it does not influence building prices. On the contrary, new requirements are less demanding then the old ones so it can be expected that new construction should be even cheaper than before, and this fact is related to the performance of the overall economy and not with respect to energy use.

According to the inquiry of a PR agency, building product manufacturers are not seeing an increase of demand in insulation products due to the implementation of EPBD *[2]*.



Minimum ventilation requirements for certain building types and ventilation systems?

The minimum ventilation requirements remain unchanged and in the case of natural ventilation, even for new buildings, these requirements are given. This means that the designer is sizing ventilation ducts without designing inlets.

Air flow for an apartment is the sum of the air flows extracted from its different spaces. Examples:

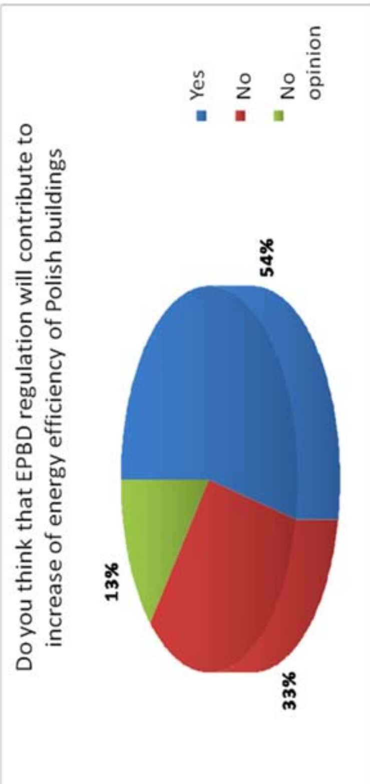
- for kitchens with external windows using gas or coal cookers: 70 m^3/h
- for bathrooms (with or without toilet): 50 m^3/h
- for toilets: 30 m^3/h

In public utility buildings, ventilation requirements are defined by minimum ventilation rates (in terms of outdoor air) per person. Examples include:

spaces where smoking is not allowed:

- rooms permanently or temporarily occupied by people -20 m^3/h
- kindergartens, day nurseries- 15 m^3/h
- air conditioned rooms or rooms with no operable windows: 30 m^3/h

In mechanical ventilation or in air-conditioning systems of volume exceeding 2000 m^3/h it is required to install heat recovery of at least 50% of efficiency or recirculation, when it is permissible. In case of recirculation, the air volume should not be smaller than hygienic requirements, and not less than 10% of intake air.



Regulations related to renewable energy

Regulations about renewable energy are included in the Energy Law, but refer only to energy producers. There are no specific regulations related to the use of renewable energy in buildings.

What about the policy on renewable energy and conversion factors used to convert from delivered to primary energy?

There is no requirement to use renewable energy in buildings however there are instruments supporting such investments:

- The system of financial support for environmentally clean technologies is based on environmental protection funds, i.e. on the National Fund for Environmental Protection and Water Management and funds of particular provinces, and on co-financing by the Bank for Environmental Protection, or EcoFund;
- These institutions should earmark funds to support utilisation of renewable energy sources and to provide aid for the introduction of more environmentally friendly energy carriers.

The official target for 2010 aims at 7.5 % of electricity from renewable sources which is well below the EU target 22.1 %.

Conversion factors from delivered energy into primary energy (EP), defined for the purpose of a certification scheme:

No.	End energy carrier		Coefficient *wi*
1	Fuel/Energy source	Oil	1,1
2		Natural gas	1,1
3		LPG	1,1
4		Hard coal	1,1
5		Brown coal	1,1
6		Biomass	0,2
7		Solar collector (thermal)	0,0
8	Heat from cogeneration [1)]	Hard coal, natural gas[3)]	0,8
9		Renewable energy (biogas,biomass)	0,15
10	Local district heating systems	Heat from coal fired heat stations	1,3
11		Heat from gas/oil fired heat stations	1,2
12		Heat from biomass fired heat stations	0,2
13	Electricity	Mixed production[2)]	3,0
14		PV systems[4)]	0,70

[1)]combined production of electricity and heat, [2)]relates to the electricity supply from the national network , [3)]in the case of lack of information on energy parameters of heat from a cogeneration plant, the assumed value is w_H= 1,2, [4)]photovoltaic panels (production of electricity from solar energy)

Impact of the implementation of the EPBD on the requirements and independence of energy experts for certification process?

Experts qualified for preparing energy performance certificates, according to the Construction Act of the 19th of September 2007, are persons who fall into any one of the following three categories:

- Licensed architects and engineers, whose professional experience includes the design and construction of buildings, are eligible without undergoing training and passing examination,
- Persons with graduate studies and an M.Sc. degree who have completed a specialized training course and passed the exam at the Ministry of Construction, Spatial Planning and Housing,
- Persons who have completed at least one year of postgraduate study in architecture, construction, environmental engineering, energy or related subjects, such as energy auditing for thermomodernisation or for the energy certificate.

The independence of experts is not addressed in Polish regulation.

3 > Compliance and control[1]

Compliance of the EP requirements for buildings

The implementation of the EPBD in Poland is executed by the Ministry of Infrastructure (former Ministry of Construction) under the supervision of the Ministry of Economy.

The legal framework of implementation is based on the national act and accompanying ordinances. On the 19th of September 2007, the Polish Parliament accepted changes to the Construction Act. The changes define rules for creating an energy assessment and certification system together with an inspection of a building's energy efficiency, by regulating:

- legal transactions between investors, building managers and owners where there exists an obligation for possessing a certificate of energy performance for buildings and apartments,

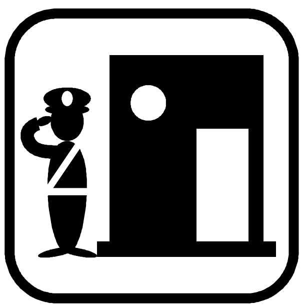
[1] Compliance means the fulfilment of EP requirements and EP certification process while control is the mechanism for checking the compliance.

- defined requirements and conditions for experts to prepare certificates of energy performance,
- defined conditions for inspection of boilers and air-conditioning systems, and one-off inspections of heating installations with boilers older than 15 years.

Conformity of the Polish law to comply with the Directive is still lacking:
- energy performance certificates with comparison to reference values,
- rules of professional responsibility and a requirement for insurance, as well as a stipulation that auditors not be a judge in their own affairs,
- conditions for conformity and verification of energy efficiency of installations,
- obligations related to monitoring energy performance and inspecting installations

Compliance with new EP requirements is validated when obtaining a building permit from local authorities. The designer should prepare a design energy performance characteristic (however the regulations do not define the form this should take). Usually, the architect provides a table with values of building components based on prescriptive requirements. The local authority is simply checking for completeness and is assuming that the licensed architect will bear responsibility.

In a case where the investor, owner or tenant questions compliance with requirements he or she can file a complaint against the designer before the Chamber of Architects or Civil Engineers, and also on the basis of the Civil Code, he or she can sue the designer, on a personal basis, and make an appeal to the Civil Courts.



In concluding, there is no special administrative procedure to check compliance with EP requirements. The only way is to follow a standard path in the case of a problem, with the Chamber of Architects or Engineers and/or Court.

Compliance of the EP certification process

Beginning from the 1st of January 2009, according to the regulations in the Construction Act, the certificate of energy performance is to be required for buildings:
- designated for operation,
- modernised or renovated, if a change of energy performance takes place,
- upon sale or rental.

Adequately, also from the 1st of January 2009, apartments for sale will be obligated to have an energy certification, as well as a periodical inspection of the energy efficiency of installed boilers, air-conditioning systems and a one-time only inspection of heating installations equipped with boilers of nominal capacity over 20 kW or older than 15 years.

Nevertheless, stemming from the regulation mentioned above, only the certification process was implemented and in practice this applies only to new buildings. Only buildings which are put into operation will have a certificate. The certificate itself is not checked by any relevant authority, as its compliance with the requirements is the sole responsibility of the expert.

There is no country-wide database of certificates. Rather, the expert is obliged to keep a record of the certificate for 10 years. No quality control procedure has been set up yet, however unofficially the Ministry of Infrastructure has declared it will conduct random checks in the future.

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In concluding, there is no special administrative procedure to check compliance of the EP certification process. The only way to register a complaint is to follow the standard path - going to either the Chamber of Architects or Engineers (in case when the expert is their member) and/or the Courts (in other cases).

Are there sanctions or penalties in case of non-compliance with EP requirements? How are those applied?

The only sanctions for non-compliance of the EP requirements can be a withdrawal from a Licensed Association of Architects or Engineers. Those penalized will lose the right to design and supervise construction and/or will be obligated to repay the losses incurred to the building owner according to the sentence issued by a Civil Court.

Withdrawal is only a theoretical possibility as there is an internal procedure within the Associations that gives the designer a chance to redeem their standing. Only a few decision to revoke the privileges of their members by associations have made so far. The civil path case is costly and the process lengthy and is very often completed with a financial settlement or agreement.

Additional incentive policies related to the EPBD (e.g. financial schemes such as subsidies, favourable interest rates, soft loans, third party financing, tax benefits …)?

The Thermo-Modernisation Programme and Fund, which have been in operation since 1999, provide technical and financial support for energy improvements in buildings, the reduction of energy loses in heat distribution networks and the substitution of conventional energy by non-conventional sources, including renewables.

Recently the old Thermomodernisation Act has been replaced by the Thermomodernisation and Overhaul Act and adequate Ordinance *[3]*, so that modernisations not related to energy-investments can also be financed in some limited way. In both cases, the mechanism of support is similar: a given percentage of the loan is deducted from the total amount of the investment. The award is a 20% refund of the loan taken to implement a thermomodernisation measure by an investor when the energy saving requirements are fulfilled.

4 > References

1. *http://www.zae.org.pl/materialy-publikacje/opinie%20i%20raporty%20zae.aspx*
2. *http://tinyurl.com/ygyksae*
3. *http://www.mi.gov.pl/files/0/1790902/zak.pdf*

Disclaimer: ASIEPI has received funding from the Community's Intelligent Energy Europe programme under the contract EIE/07/169/SI2.466278.

Spain: Impact, compliance and control of legislation

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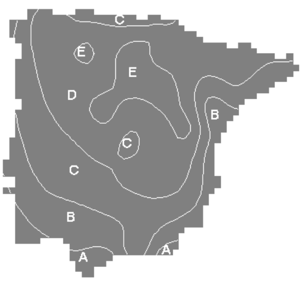
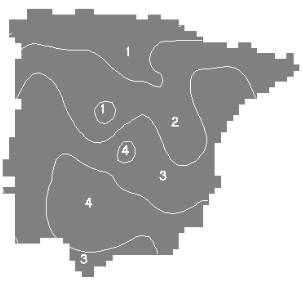


Winter Climatic Zones (A-E)



Summer Climatic Zones (1-4)

This paper aims to summarise how in SPAIN the implementation of the EPBD has changed the national EP requirements and has influenced the building stock. It describes the national way of handling with EPBD compliance and control and tries to identify interesting approaches and possible bottlenecks.

1 > Impact of the EPBD on the national requirements

Up to date, only the procedures for new buildings, published in the Royal Decree 47/2007 [1], are in practice in Spain. The Royal Decree for certification of existing building will be ready by the end of 2009. So, all the following comments affect only to the certification of new buildings.

In Spain, prior to 2002, in parallel with the development of the EPBD, a complete renovation of all building related national standards had been undertaken for being integrated in the new Building Technical Code, CTE [2], in such a way, that the EPBD minimum requirements are supposed to be fulfilled when the building complies with the requirements stated in the basic document about the building energy aspects in the new building technical code. In terms of net energy demand, the new requirements were selected for obtaining a 25% reduction. As a result of this works, Spain is divided in 5 climatic winter zones and 4 climatic summer regions, in total, 12 climatic zones. For every one of these zones, in addition to a minimum level of insulation for avoiding condensations and moulds, prescriptive limits for thermal transmittances for opaque components and glazing are imposed. For summer conditions maximum values of modified solar factors for windows have been selected, depending on the internal gains of the buildings. Compliance is obtained in two ways:

1) Prescription: all the building elements are better than the maximum values;

2) Performance: the calculated net energy demand is lower than that of a reference building built with the prescriptive elements.

In addition to minimum requirements for energy demand, there is also requirements for a minimum level of air renovation in residential buildings, and the same for the air renovation in non residential buildings, according to the building type, plus an indication in terms of indoor (operative) temperature and relative humidity for winter and summer periods. These examples and all of the rest of Technical Instructions for the thermal installations in buildings are regulated by another Royal Decree, the RD 1027/2007 RITE [3].

The EPBD transposition was a first step since 1979, after almost 30 years without a signal of activity and without complying with any building thermal regulation. In this first step, the EP requirements are indirectly set by limiting on the one hand the net energy demand, and in the other hand the efficiency of equipments (not systems!). It is foreseen that the CTE should be revised every 5 years, and the first revision will be carried out in 2010/2011.

Whereas the minimum requirements are not related to the actual energy consumption, the certification is very restrictive in what respect the assignation of the Class of energy. So, for residential buildings, it was decided that 90% of the buildings just passing the CTE minimum requirements was assigned to class D (50%) or C (40%), 5% would be E and another 5% would be B. The limit between B and C classes is 70% of the limit between C and D. The limit between B and A classes is an additional reduction of 70%. So the A class building has an energy performance lower than 50% than the average building that just complies with the CTE.

In the frame of the EPBD transposition and for guiding the path towards 2020, the Spanish government has published a Document on the National Strategy for Energy Efficiency [4] in part devoted to the energy efficiency measures applicable to both new and existing buildings. The public awareness of the EPC of buildings is not high mostly because for the moment in Spain only new buildings are being certified. Once the certification for existing buildings will be in place it is expected that the awareness will be raised.

Concerning the introduction of renewable energy sources in the building sector, solar energy is mandatory for all Domestic Hot Water (DHW) installations, in all types of buildings with a DHW demand. This has been a huge impact in the sector, as the typical fraction to be covered by solar energy is 70%.

Photovoltaic solar energy is also mandatory for almost all non residential buildings, with a minimum power which is depending on the building size; the minimum being 6.25 kWp.

Renewable energy production in the building is directly detracted from the delivered energy required by the building, reducing the CO_2 emissions. In Spain, the EP is expressed in terms of CO_2 emissions. The conversion factors are published by the Institute for Diversification and Energy Saving (IDAE) which depends of the Industry, Tourism and Trade Ministry (MITYC) and are applicable to the whole country:

Energy Carrier	PE Conversion Factors	CO_2 emissions conversion factors (kg CO_2/kWh)
Domestic Coal	1.000	0.347
LPG	1.081	0.244
GasOil	1.081	0.287
FuelOil	1.081	0.280
Natural Gas	1.011	0.204
Biomass, BioFuels	1.000	0.000
Electricity (Continental Spain)	2.603	0.649
Electricity (Canary Islands, Baleares, Ceuta, Melilla)	3.347	0.981

The experts qualified for carry out the certification are the same qualified for designing the building and its technical installations (Arquitects, engineers). There are training activities, bust mostly related to the use of the tools.

Spain is divided in seventeen regions plus two autonomous cities.

2 > Compliance and control[1]

EP REQUIREMENTS and Certification COMPLIANCE AND CONTROL

The referred decree about certification of new buildings states the compliance procedures for EP requirements. The certificate is obtained first in the project phase, for obtaining the building permit, and must be confirmed later when the building is finished, as built. The actual checking is done by each regional government. Most of the 17 regions are working in the development of the administrative procedures, for registry, control and inspection. Up to date, only four regions have all the basic procedures stated, but only two have finished all the works; none of them have actually started the procedures. All of them plan on having them finished for the end of 2009. See for instance the one prepared in Andalucía [5].

In the Royal Decree 47/2007, the sanctions are related to the consumer law. The are three different laws that could be applicable depending on what parts of the regulations have not been fulfilled.

If the building does not comply with the requirements specified in the CTE, the applicable law would be the Law 38/1999 for the Ordination of the Building Sector (LOE), in this law the different actors participating in the construction process are liable for the defects that compromise the stability of the building during 10 years and for defect that compromise its habitability (insulation, installations…) during 3 years. This law obliges the people participating in the construction to take an insurance to cover the possible defects that could arise during the use of the building.

If the building installations do not comply with the requirements specified in the RITE the applicable law would be the Industry Law (Law 21/1992) which states different penalties going from economic fines to activity suspensions.

If the EPC has not been issued according to the building project or the final building the applicable law would be the General Law for the Defence of Consumers and Users (Law 26/1984). This could result in administrative penalties which would not substitute the possible civil or penal responsibilities which will be applicable. The expenditure and register of an EPC does not imply the fulfilment of the CTE and the RITE.

The regions can state a specific set of sanctions. Some of them have done so.

Most of the technical staff at the responsible organisms has been trained for understanding the basics of the procedures. Unfortunately, there are not enough man-power for undertaking all the control.

Additional topics

Some activity is started to be seen in the building sector, but due to the actual economic turndown the market is not taking the new perspective of building energy efficiency as fast as it would be desirable. Some regions and the Spanish government are stating specific minimum requirements for the public buildings, and/or for social housing. Some companies want its own [new] buildings to get the best possible label [A Class, even zero or positive energy].

As pointed above, the Spanish government has transferred funds to the regional governments, in the frame of the National Strategy for Energy

[1] Compliance means the fulfilment of EP requirements and EP certification process while control is the mechanism for checking the compliance.

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Efficiency, in particular for Buildings, in which there are subsidies schemes for the building sector, both new and existing, according to next table:

Measure	Public Funds Application	Direct Savings kTep	Emissions Savings kt CO_2	Public Funds k€	Total Investments k€
Renovation of existing buildings envelope	Direct subsidy or Reduction of interest rate	1.450	5.232	175.150	2.667.295
Energy efficiency Improvement for HVAC systems in existing buildings	Direct subsidy or Reduction of interest rate	1.685	6.452	243.315	3.719.205
Energy efficiency Improvement for lighting systems	Direct subsidy or Reduction of interest rate	3.339	17.397	176.292	2.694.681
Promotion of new buildings or renovation of existing buildings to obtain A or B class of energy	Direct subsidy or Reduction of interest rate	1.315	5.322	208.914	3.969.362
Revision of EP requirements		148	598	0	408.934
		7.936	35.540	803.671	13.469.477

In addition to the National Strategy for Energy Efficiency the Ministry of Housing in the frame of the National Plan for Housing and Refurbishment subsidises the construction of social houses with a high EPC (A, B or C).

Some local authorities are introducing into their requirements in the public contests for the construction of social houses promoted by them the requirement of obtaining a high energy efficiency rate.

3 > References

1. REAL DECRETO 47/2007, de 19 de enero, Procedimiento básico para la certificación de eficiencia energética de edificios de nueva construcción.
2. REAL DECRETO 314/2006, de 17 de marzo, Código Técnico de la Edificación
3. REAL DECRETO 1027/2007, de 20 de julio, Reglamento de Instalaciones Térmicas en los Edificios
4. Plan de Acción 2008-2012 de la Estrategia de Ahorro y Eficiencia Energética en España. IDAE.
5. ORDEN de 25 de junio de 2008, Creación del Registro Electrónico de Certificados de eficiencia energética de edificios de nueva construcción y regulación de su organización y funcionamiento.

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GREECE

Greece: Impact, compliance and control of legislation

This paper aims to summarise how in **Greece** the implementation of the EPBD has changed the national EP requirements and has influenced the building stock. It describes the national way of handling with EPBD compliance and control and tries to identify interesting approaches and possible bottlenecks.

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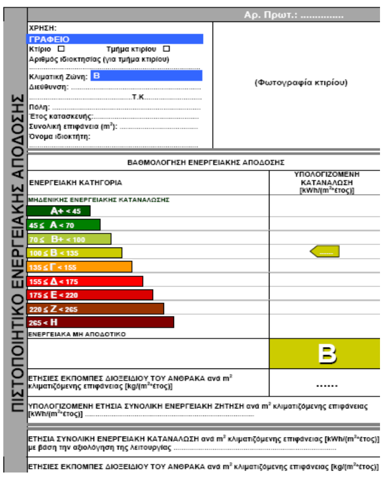

Energy performance certificate

1 > Introduction

In Greece there was no specific regulation concerning the energy performance and certification of buildings until the Energy Performance of Buildings Directive (EPBD). The pre-existing relevant regulations have been:

- the Greek Thermal Regulation, implemented in 1981, which prescribed limits for U-values and restricted heat transfer through the building envelope,
- the Technical Codes of the Technical Chamber of Greece (TOTEE): 2421/86 for the installation of boilers for the heating of buildings, 2423/86 for the installation of cooling systems in buildings and 2425/86 for the calculation of cooling loads in buildings.

In 2008, the Greek Law 3661/2008 'Measures for decreasing the energy consumption of buildings' was voted, according to which the Energy Performance Regulation for Buildings (KENAK) is foreseen. The Energy Performance Regulation for Buildings is going to be implemented during 2009 and it refers to the energy performance of new buildings, as well as existing buildings under specific conditions. The new regulation defines the methodology for the calculation of the energy consumption of buildings, sets the minimum energy performance requirements and prescribes the issue of an energy performance certificate, the inspection of boilers and air-conditioning systems and the implementation of a national body of energy inspectors, in compliance with the European Directive 2002/91/EC.

The calculation method will be based on the simply hourly method (ISO: 13790:2008 E). The proposed methodology is the asset rating methodology (according to CEN) and concerns the classification of a building by its energy consumption, taking into account the thermal characteristics and the electromechanical equipment of the building.

Table 1: Limit values for energy classification according to KENAK

Classification	Limit values
A	$EP < 0.50R_r$
B	$0.50R_r \leq EP < R_r$
Γ	$R_r \leq EP < 0.50(R_r + R_s)$
Δ	$0.50(R_r + R_s) \leq EP < R_s$
E	$R_s \leq EP < 1.25R_s$
Z	$1.25R_s \leq EP < 1.50R_s$
H	$1.50R_s \leq EP$

All new buildings, as well as existing buildings >1000m^2 which undergo major renovation, should be at least category B, according to the limit values set in Table 1.

2 > Impact of the EPBD on the national requirements

As there were no energy performance requirements in Greece - other than the maximum U values for new constructions build after 1981 - the implementation of the EPBD clearly has impact on the severity of the requirements in terms of energy efficiency. Main changes are:

- the introduction, for the first time, of the energy performance certificate,
- the definition of specific energy performance levels,
- the definition of specifications for different building systems,
- the consideration of renewables in buildings above 1.000 m^2

and many more. Additionally, with the implementation of the EPBD, for the first time there are requirements for existing buildings >1.000 m^2 when being renovated.

Similarly, the existing requirements for indoor climate, including airflow rates and ventilation requirements, set points for heating and cooling, humidity levels, etc., as described in the Technical Order of the Technical Chamber of Greece (T.O.T.E.E. 2425/86), are becoming obligatory and more widely used. With the Energy Performance Regulation (KENAK), climatic zones are increased to 4 instead of the existing 3 in the previous national regulation.

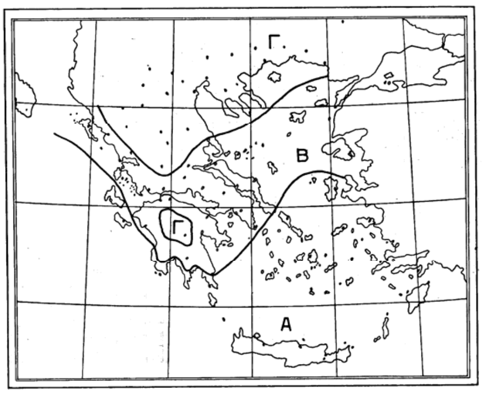

Figure 1: climatic zones according to the existing thermal insulation regulation of 1979

Figure 2: climatic zones according to the new energy performance regulation (KENAK)

In general, the requirements introduced in the country through the KENAK do not differentiate much from those of EPBD Art. 7. In specific related to the validity of the certificate, the regulation implies that the validity shall not exceed 10 years and in case a building, which already has a certification, undergoes renovation or extension in a way that affects its energy performance, the validity of the certification expires at the end of the renovation or extension.

The building sector in Greece corresponds to about 36% of the total final energy demand and consumption. The implementation of the EPBD is expected to lead to effective measures for energy efficiency in buildings, sometimes leading to energy conservations of up to 20 – 40%. Since new buildings should meet the minimum energy requirements when being constructed, a clear reduction of the energy consumption for new buildings is expected and hopefully a change in tendency towards building more efficient buildings. Existing buildings with a total area >1000m^2, which undergo major renovation, will also be upgraded in order to meet the minimum energy requirements. National action plans include the creation of energy performance certificates, energy audits and measures taken in order to upgrade buildings. The proposed requirements are expected to change the building market and affect the market prices, especially for new buildings.

Although implementation has not yet started, already some technical measures for better energy performance of buildings are being taken. The Greek Thermal Insulation Regulation already imposes better thermal insulation in buildings, as well as the use of double-glazing systems. Every day factors, like the energy prices and the rise in temperature, especially in the urban areas, are forcing people to think about cost-effective energy solutions, like the use of passive cooling techniques (night ventilation, solar shading etc.), or even more advanced techniques like cool paints, green roofs, PV's, glazing with thermal breaks and other. The actual implementation of such techniques is not yet advanced, but it is expected that the implementation of the EPBD in 2009 will boost the market for such mechanisms of energy efficiency.

The building market is already being affected. New products promoting energy efficiency in buildings have been launched: new insulation materials, new types of glazing, cool materials and other building products, which contribute to a better energy performance of buildings.

It is anticipated that the owners of the better energy performing buildings will be able to demand higher prices for them, since their performance means that lower running costs are expected. Conversely, owners of poorly performing buildings will have to lower prices, or invest in improving their performance, in order to make them attractive.

Minimum ventilation requirements

There are already minimum ventilation requirements set by national legislation in Greece. These requirements will not be differentiated by the implementation of the EPBD. However, in the new regulation, the audit of the air-conditioning system includes the audit of the ventilation system as well.

According to the new regulation KENAK, the reference building is naturally ventilated. The ventilation requirements for buildings set by KENAK are differentiating according to the use and type of building. For tertiary buildings, or buildings with mechanical ventilation, the ventilation system of the reference building should have the following prerequisites:

- Ventilation according to the maximum expected number of people and the minimum quantity of air per person.
- Mechanical ventilation system is included by heat exchanger with a heat recovery coefficient n_R=0,6.
- For the reference building the absorption power is set at 1,0 kW(m^3/s).

Additional requirements and related regulations

Besides requirements explicitly demanded by the EPBD, other relevant regulations mainly motivate energy efficiency and the use of renewable energy. There is no obligation to use renewable energy in buildings. However, the objective of the Greek Government is to increase the use of renewable energy resources by 20% until 2010. Implementation is often slow and bureaucratic. There are, however, good examples of initiatives to promote the use of renewable energy, like Law 3468/2006 on the electricity production from renewable energy sources and cogeneration and the recently proposed financial and practical incentives to stimulate as well the low scale and building installation of photovoltaics by simplifying the installation procedures. According to those, the PV installation up to 10 kWp can be realised with a small permission of works by the Ministry of Environment, Physical Planning and Public Works. This is a motive for citizens to install PV on their roofs without being involved in very time-consuming and costly procedures.

The use of solar collectors appears in Greece from 1980. The wide use of solar collectors is due to tax incentives set by the Greek Government in the past. According to the new regulation, solar collectors should cover a specific percentage of the yearly thermal loads due to domestic hot water consumption. This percentage depends on the climate zone and the possibility of installation of a solar collector on the roof of the building.

Table 2: conversion of final energy to primary energy use.

Final energy use	Conversion to primary energy	CO_2 emissions per energy unit [$kgCO_2$/kWh]
Natural gas	1,05	0,196
Heating oil	1,1	0,264
Electricity	2,9	0,989
Biomass	1,0	---

3 > Compliance and control[1]

With the implementation of the EPBD the definition of energy inspector and energy expert is being officially introduced for the first time in Greece. A group of energy experts will be authorised to serve the certification process objectives. This group will be certified by national legislation and its task will be to perform energy audits of buildings (new and old). The energy experts will be an independent group under Governmental supervision.

Energy experts should fulfil specific requirements. They might be engineers or experts from other scientific fields related to energy aspects.

There will be a register of energy experts controlled by a national authorised Service. All experts should be registered and should obtain a permission in order to carry out energy audits.

The permissions will be categorised by the type of energy audits each expert will be authorised to carry out. Specifically, there will be two main categories of permissions; category A concerns audits of buildings with a total area less than 1000 m^2, while category B concerns audits of buildings of any total area (including areas exceeding the 1000 m^2). Three subcategories will define the work field for each expert: energy expert of buildings, energy experts of boilers and heating systems, energy experts of cooling systems.

There will be a record of Energy Inspectors, Energy Audits and Energy Certifications. The record will be in e-version, as database, under the responsibility of the Ministry of Development. This database could be elaborated for scientific outcomes.

Compliance of EP requirements and EP certification

The energy regulation KENAK, will enforce the compilation of an Energy Performance Study before construction. The Energy Performance Study:

- will be obligatory for the approval of a building permit,
- will be a study of the energy characteristics of the building, additional to architectural, physical planning, heating, cooling, domestic hot water and lighting studies,
- will substitute the thermal insulation regulation (3661/2008 art.3). All calculations related to the thermal insulation of the building envelop will be part of the Energy Performance Study.

The Study will be obligatory for new buildings and existing buildings >1000 m^2 when being renovated and will be submitted to the authorities responsible for the building permit. The relevant Town Planning Authority is responsible for approval of the building permit and, by extension, for approving the energy study.

[1] Compliance means the fulfilment of EP requirements and EP certification process while control is the mechanism for checking the compliance.

The checks of compliance of new buildings with the energy requirements will be performed by the energy consultants who also issue the energy certificate. The energy performance of a building is proved after the completion of its construction. If a new building or an existing building >1000 m^2 which undergoes major renovation, is not classified as at least category B, this building will be assessed as illegal construction, according to the relevant legislation. In theory, an illegal construction has to be upgraded to comply with the minimum requirements, or it should be demolished. How this will be in practice will prove after a few years of implementation of the KENAK.

The energy experts group, responsible also for compliance checks, will be consisted by a large number of engineers or experts from other scientific fields related to energy aspects that will carry out the audits and will issue the certification. Energy experts should follow a training session in order to achieve the right to realize energy audits. This procedure allows for sufficient expertise at the energy experts side, although the training programs are not yet in place.

Existing authorities responsible for checks or compliance (like f.e. the Town Planning authorities), may need some upgrading of expertise and personnel in order to meet the new expectations.

Control and penalty imposition

There will be a responsible Institution who will control the process and the quality of energy audits. The Institution will inform and collaborate with the Consultative Committee set responsible by the Ministry of Development. The Consultative Committee will also be responsible for the economic management and accounting aspects for the proper implementation of the EPBD.

The quality control of energy audits will be carried out by the Centre of Renewable Energy Sources (CRES). Control will be based upon ad hoc sampling and will be carried out either ex officio, or upon denouncements, or upon recommendation of the Consultative Committee.

In case the quality of the energy audits or the soundness of certification is doubtful, the Institution could perform a countercheck and certification by another energy expert or by an executive expert from the Committee. Extra cost will overload the denouncement.

Once the control is performed and it is noted that the certification includes information which is false, the Ministry of Development imposes penalties. The Consultative Committee is responsible to inform the energy inspector in question 15 days in advance, in order for him/her to answer and for the Committee to find out if a penalty should be imposed. Penalties related to energy inspectors include:

- Inspector exclusion from energy audits for 1 up to 3 years.
- Total inspector exclusion from record.

The Consultative Committee could also impose a pecuniary fine related to the severity of delinquency.

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Link: www.asiepi.eu

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Incentives

Several regulations and initiatives provide incentives for improved energy efficiency in buildings. One of these is the attractive kWh price for selling energy from renewables as defined in the Law for renewables. Several banks provide special loans for the integration of photovoltaics in buildings. Additionally, the Greek Government has recently developed the Project 'EXIKONOMO' which subsidies local government to upgrade the energy performance of existing public buildings and the improvement of the microclimate of open spaces. The project's aim is to improve the energy efficiency in local level, to promote applicable actions for demonstration and to motivate citizens in aspects of energy conservation and protection of urban environment.

A draft Law "Measures for the improvement of energy efficiency in final use and energy services" defines the legal frame and the financial means in order to achieve energy efficiency in the final use. The aim is to overcome the barriers in energy efficiency and promote the use of energy services of the final user. The Law allows for Third Party Financing of energy measures and other incentives to achieve better energy performance.

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4 > References

1. Energy Performance Regulation (KENAK), *www.ypan.gr*
2. Technical guidelines 2425/86, Technical Chamber of Greece, *www.tee.gr*
3. Implementation of the EPBD in Greece: Status January 2007, Ilias Sofronis, *www.buildup.eu*
4. Implementation of the EPBD in Greece: Status and planning - May 2008, Ilias Sofronis, *www.buildup.eu*
5. 'EXIKONOMO', Reduction of energy consumption in urban environment, Ministry of Development, *www.ypan.gr*
6. Draft Law: "Measures for the improvement of energy efficiency in final use and energy services", *www.ypan.gr*
7. Law 3468/2006: 'Electricity production from renewable energy sources and cogeneration', *www.ypan.gr*
8. Common Ministerial Decision: 'Special Development Project for photovoltaic installation in building sector and especially on the roofs", *www.ypan.gr*

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[European projects]

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Belgium: Impact, compliance and control of legislation

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More information can be found at the ASIEPI project website: *www.asiepi.eu*

Similar Information Papers on ASIEPI and/or other European projects can be found at the BuildUP website: *www.buildup.eu*

This paper highlights some elements of the EPB-regulations in Belgium specifically with respect to impact, compliance and control. In Belgium, the implementation of the EPBD is the responsibility of the regions. Therefore, there are 3 different EPB-regulations. A more general overview of each of the regulations can be found in the Information Papers 67 (Brussels), 68 (Flanders) and 137 (Wallonia) [1, 2, 3].

1 > Introduction

Generally speaking, it is difficult to estimate what has been the exact impact of the EPBD. How would the Belgian regulations have evolved if there had never been the European Directive? It is impossible to know.

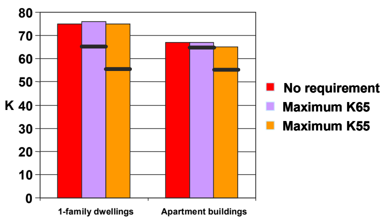
In Flanders EPB-regulations were already under preparation since the late 1990s. The Flemish parliament approved its introduction as a matter of principle in a building code decree in 1999. And practical work to establish EPB-calculation methods had already started at the beginning of 1998. At that time, there were no plans yet for a European EPBD.

As the step towards overall EP-requirements was already initiated well before the EPBD, this text considers the EPB-regulations by themselves, and the changes that have taken/are taking place due to it. Abstraction is made of the precise impact of the European directive.

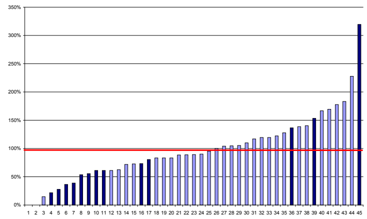
However, an undisputable impact of the European directive EPBD has certainly been that the Walloon and Brussels regions also have implemented EPB-regulations, and that certification of existing buildings is being introduced, which previously had not been on the agenda yet.

In the Flemish thermal insulation regulation preceding the EPB-new regulation, control by the authorities heavily focused on the calculations submitted as part of the demand for building permit. Little on-site control during/after the construction phase was performed, and any non-compliance observed at that stage usually ended up unpunished because of the cumbersome juridical sanctioning system.

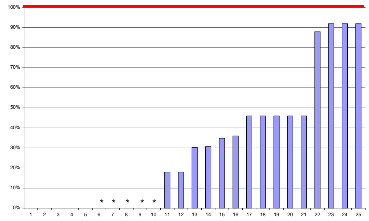
The SENVIVV study [4], which was performed at that time, showed that compliance was very poor, at least during the first few years of application of the regulation. Even though the overall thermal insulation requirements (K-level) were tightened progressively (horizontal black lines: K65 and K55 in the figure on the left), the observed real mean insulation level did not change: see figure.



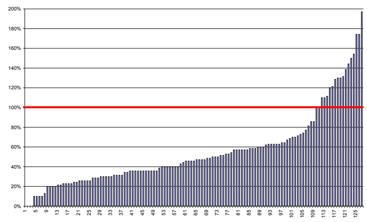
Average value of the overall thermal insulation (K-level) of 200 residential buildings built in the period 1989-1996, when K-requirements where introduced in a stepwise manner. [4]



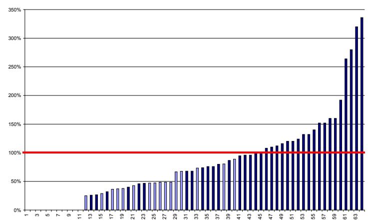
Flow rates of the natural ventilation supply air terminal devices



Flow rates of the natural ventilation extract air terminal devices



Surfaces air transfer devices



Flow rates of mechanical ventilation supply and extract air terminal devices

Main results of the study [5] on ventilation in the Walloon region commissioned by "Test-Achats/Test-Aankoop"("Trial Purchase"). The red line always shows the requirements that are imposed by the regulation.

Although the regulations did not yet make ventilation systems mandatory at that time, the SENVIVV study also made in situ observations of the basic quality of these systems in the rare instances that they were present. It was generally found that the systems failed to live up to the requirements of the Belgian standard on residential ventilation.

In Wallonia, the regulations made residential ventilation systems, satisfying the Belgian standard, mandatory for new dwellings as of 1996. In 2001, the consumer association "Test-Achats/Test-Aankoop" ("Trial purchase") commissioned a study [5] looking into the compliance with these requirements. The main results of this study are presented in the figures on the left, which are drawn from the report that constituted the basis for the public summary article [5].

A first important observation was that 10% of the dwellings of the owners that had responded to the enquiry in the magazine had no ventilation system at all. From the further in situ investigation of 15 dwellings that were equiped with a ventilation system, the following conclusions were drawn:

- Natural ventilation supply:
  - 45 rooms needed such supply air terminal device (trickle ventilator).
  - 2 of these rooms didn't have any (4%).
  - 23 had insufficient flow rates (53%).
  - Globally,less than 50% of the rooms equipped with supply air terminal devices were fully compliant with the regulation;
- Natural ventilation exhaust :
  - 25 rooms needed such exhaust.
  - 5 (20%) had no such provision whatsoever.
  - In 5 (20%) other instances the minimum requirements with respect to controllability were not satisfied.
  - Globally, not a single extract air terminal devices was fully compliant with the regulation;
- Air transfer devices :
  - 127 air transfer devices were investigated.
  - Only 18 of these were compliant with the regulation (14%);
- Mechanical ventilation openings :
  - In 64 rooms the flow rates could be determined[1].
  - 11 of these had no air terminal device at all (17%).
  - In another 32 (50%) the flow was insufficient.
  - So, only in 21 rooms (33%) did the air flow rate satisfy the regulatory requirements.

On the basis of the evidence produced by these 2 studies, as part of the new EPB-regulations there has been a shift of focus to the as-built situation when it comes to the control of the compliance. A system of nearly-automatic administrative financial fines has been instituted, as will be explained further in the paper. The as-built evaluation also allows to promote the real product characteristics of the materials and systems that have been applied, thus creating an extra drive for high performance products and the precise characterisation of their properties.

2 > Impact of the EPBD on the national requirements

In comparison with the previous regulations in the three regions of Belgium, the introduction of the EPB-regulations has had many impacts on the requirements imposed. These requirements concern both the energy efficiency and the indoor climate.

[1] The flow of some air terminal devices could not be measured, because e.g. the fan was broken or they were not sufficiently accessible for the measurement equipment.

Previously, only minimum levels of thermal insulation were imposed: for each individual element, as well as for the average thermal transmittance of the entire envelope. But this was only applicable to certain types of buildings. The thermal insulation requirements have now been extended to (nearly) all types of buildings, and have been complemented with other requirements on energy efficiency. In the present EPB-regulations [6,7,8,9,10,11,12], various energy uses are taken into account for residential buildings. These include space heating and DHW consumption, auxiliary energy consumption, and cooling consumption, but also energy production through PV cells or a cogeneration installation. For educational and office buildings, the consumption related to lighting is also accounted for.

The EPB-regulations have also set requirements for some aspects of the indoor climate. In the past, requirements on the ventilation system were already defined in the Walloon region, but only for dwellings and in a rudimentary way for offices and schools. In the Flemish or Brussels-Capital regions there were no requirements on the ventilation systems. With the introduction of the EPB-regulations, requirements have now been imposed on the ventilation systems in the three regions. These requirements mostly concern the sizing of the system. Another aspect of the indoor climate that is dealt with in the EPB-regulations is the problem of overheating in dwellings. This requirement was not present in past regulations. It aims to limit the risk of overheating.

While the EPB-regulations leave complete freedom to the designers in the choice of the technologies and materials, some of them have appeared to be more frequently used, compared to the situation under the previous regulations. Some tendencies appear to be:

a. condensing boilers are more and more being used for heating
b. buildings tend to get better thermally insulated
c. increased use of mechanical ventilation systems with heat recovery
d. more attention on the air tightness of the envelope (mostly in low energy buildings, performing (much) better than the common average in the past)
e. increased interest in heat pumps

Another impact of the introduction of the EPB-regulation is to be found on the quality of the information on the building products. Indeed, due to the legal framework of the regulations, an increased attention has been drawn to the product characteristics and the justification of these. Standardised quantifications are now used rather than qualitative arguments.

3 > Compliance and control

EP-requirements

In order to achieve compliance with the EP-requirements, the responsibilities of the various actors are defined in the EPB-regulations of each of the three regions. While the procedures are similar among the regions, some variations exist. In the table below, the procedures and the actors involved are presented for the three regions for each step of the construction process. The information is not exhaustive; only the main elements are reported. The main roles of the persons that specifically deal with the EP-aspects and that are new actors in the building process in the three regions are as follows:

- **Flemish region**: The *EPB-rapporteur*: draws up the EPB-declaration in conformity with the work realised. He describes the measures that define the EP and the indoor climate of the building and he calculates if the building fulfils the EP-requirements. He is responsible for the correct reporting in the EPB-declaration of the real state of the building.

- **Brussels-Capital region**: The *EPB-advisor* draws up and updates the technical file that records the information on the works related to the EPB throughout the construction phase. He calculates the EP of the buildings and establishes the EPB-declaration on the base of the realised work.
- **Walloon region**: The *EPB-responsible* is in charge of the conception and the description of the measures to implement in order to fulfil the EP-requirements. He is responsible for the follow-up and the control of the aspects related to EP throughout the construction phase. He must also draw up the EPB-declaration on the base of the realised work.

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A key element, common to all 3 regions, is the so-called "(final) EPB-declaration". For each project, the building team itself must draw up an as-built dossier with respect to the different EP and indoor climate aspects. It must be submitted upon (sufficient) completion of the works. It gives all input variables of the EP-calculations as effectively executed, and the calculation results, and thus documents whether or not all EP-requirements are fully respected. It thus constitutes a systematic, primary control of the works.

The (final) EPB-declaration must be compiled by a dedicated expert who has to be designated before the start of the works. The expert is variously called "EPB-rapporteur", "EPB-advisor" or "EPB-responsible" in each of the 3 regions (see above), reflecting different further legal (co-)responsibilities of this person (see table).

On the basis of this (final) EPB-declaration, an administrative fine is given in case of non-compliance with the EP-requirements. The fine increases proportionally to the infringement. For instance, the fine for not respecting the maximum U-values is 60 euro per W/K. Example: if the U-value of a 90 m^2 roof is 0.55 $W/m^2/K$, whereas the maximum allowed value is 0.3 $W/m^2/K$, then the fine is 90 x (0.55 – 0.30) x 60 = 1350 euro. Similar fines exist for the energy performance (0.24 euro/MJ), overheating (0.48 euro per 1000 Kh and m^3) and ventilation system sizing (4 euro per m^3/h). These values are typically about 24 times the annual energy savings (at the fuel cost of 0.01 euro/MJ of 5-10 years ago). This corresponds to a factor of 8 for a reasonable payback period, and an extra penalisation factor of 3. The fines are thus very dissuasive.

In Flanders the full electronic EPB-declaration must be uploaded on a central server for computerised processing and archiving. Any non-respect of an EP-requirement is thus automatically detected and fined. In 2008 about 6% of the EPB-declarations have reported non-compliance with 1 or more EP-requirements. In Brussels and in Wallonia, a similar system is planned to be set up but is not operational yet.

Complementary to the systematic primary auto-control by the building team itself, the authorities execute on an (intelligent) random basis further secondary controls to verify that all rules are complied with.

The aspects that are being controlled include the respect of the timings and the procedures, and the correct reporting in the (final) EPB-declaration (by means of random on-site controls throughout the entire construction process).

As the EPB-regulations in Brussels and Wallonia are gradually being phased in only since mid 2008, no information on controls has been made public as yet. In Flanders the new procedures already took effect at the beginning of 2006 and more operational experience has thus already been acquired.

	Flemish region	Brussels-capital region	Walloon region
Demand for building permit	**Notification in demand for building permit** BY : the building permit applicant and the architect WHEN : at the introduction of the building permit demand PENALTY : refusal of the building permit	**EPB-proposal** BY : the building permit applicant WHEN : at the introduction of the building permit demand PENALTY : refusal of the building permit	**EPB-commitment** BY : the building permit applicant WHEN : at the introduction of the building permit demand PENALTY : refusal of the building permit
Start of the construction	**Start declaration** BY : the EPB-rapporteur, signed by the EPB-rapporteur, the architect and the declarant WHEN : at the lastest 8 days before the beginning of the work HOW : submitted electronicaly to the Flemish energy agency PENALTY : 250€ fine for the owner for any delay 250€ fine for the EPB-rapporter if any missing content	**Notification of the start of the work and the availability of the EPB-evaluation** BY : the declarant, signed by the declarant, the architect and the EPB-advisor WHEN : at the lastest 8 days before the beginning of the work HOW : sended to the Brussels administration PENALTY : variable fine for the declarant	**Initial EPB-declaration** BY : the EPB-responsible, signed by the declarant and the EPB-responsible WHEN : At the latest 15 days before the beginning of the work HOW : sended to the local administration PENALTY : variable fine for the declarant
During the construction	**Checking of the good execution of the work, and the particular EP-aspects** BY : the architect WHEN : continuously PENALTY : -	**Making and update of the EPB-technical file** BY : EPB-advisor, signed by the EPB-advisor and all the building contractors involved WHEN : throughout the whole construction phase PENALTY : - variable fine for the EPB-advisor - variable fine for the architect, building contractor or declarant if they don't provide the required information to the EPB-advisor	**Control of the execution of the works related to the EPB** BY : EPB responsible WHEN : throughout the whole construction phase PENALTY : variable fine for the EPB responsible if the EPB requirements are not fulfilled
Reception of the building	**EPB-declaration** BY : the EPB-rapporteur, signed by the EPB-rapporteur and the declarant WHEN : At the latest 6 month after the building commissioning HOW : submitted electronically to the Flemish administration PENALTY : - Incorrect EPB-declaration : 250€ fine for the EPB-rapporteur - EPB-declaration not submitted on time : 250€ fine (+variable surplus) for the declarant - EP-requirements not fullfilled : fines for the declarant proportional to the threspassing - EPB-declaration not in correspondance with reality : fines for the EPB-rapporteur proportional to the threspassing	**EPB-declaration** BY : the EPB-advisor, signed by the declarant, the EPB-advisor and the architect WHEN : a the latest 6 months after the end of the work or 2 months after the temporary acceptance of the building HOW : submitted electronically to the Brussels administration PENALTY : - notification of the EPB-declaration not done : fine for the EPB-advisor or the declarant as a function of their responsibility - EP-requirements not fulfilled : fines for the declarant proportional to the threspassing - EPB-declaration not in correspondance with reality : fines for the EPB-advisor proportional to the threspassing	**Final EPB-declaration** BY : the EPB-responsible, signed by the EPB-responsible and the declarant WHEN : At the latest 6 months after the building acceptance or 18 months after the end of the work or the building commissioning HOW : sended to the local administration PENALTY : - notification of the final EPB-declaration not done : fine for the declarant - incorrect final EPB-declaration : fine for the EPB-responsible - EP-requirements not fulfilled : fine for the the EPB-responsible, the building contractor and the architect each for their part of the responsibility

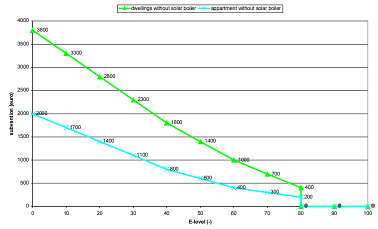

Figure: subsidies in the Flemish region as a function of the energy performance (E-level).

As an example, some features of the control strategy worked out by the Flemish authorities with respect to correct reporting in the EPB-declaration, are (both through in-office control of calculations, and through on-site inspections):

- all EPB-rapporteurs are periodically controlled
- special focus on projects without start declaration
- further focus on companies/rapporteurs/architects that have been found wanting in the past

In 2008 more than 125 000 euro has been collected, and many more fines were pending.

EP-certification

Different certification procedures are defined depending on the following parameters:

- New or existing building
- Residential, non-residential building or public building

In Belgium, the certification procedures [13,14,15] and the status of the legislation also vary from one region to another.

In the Walloon region, the legislation related to the EP-certification is not yet published and the EP-certification is thus not yet in application. Therefore, we have at the present time no information on the compliance and the control.

In the Brussels-Capital region, the EP-certification is already in force for some types of new buildings (dwellings, office and service buildings, and schools). In these particular cases, the certification is based on the EPB-declaration, and is delivered by the administration shortly after the EPB-declaration is submitted. Consequently, any negative observation in case of the control of the EPB-declaration automatically implies the cancellation of the EP-certificate. Concerning the requirements imposed on the experts, for the certification of existing buildings, they must follow a particular training. If the expert delivering a certificate has not followed the training or if the certificate doesn’t correspond to reality, a fine is imposed.

In the Flemish region the EP-certification of some types for both existing buildings (only dwellings) and new buildings (dwellings, offices and schools) is operational.

For new buildings, the EP-certificate is based on the EPB-declaration and is established at the same time as the EPB-declaration. If a control shows that the EPB-declaration is not correct, the EP-certificate is automatically cancelled. The control of the EP-certificate for new buildings is therefore based on the control of the EPB-declaration.

For existing buildings, the control concerns the energy experts allowed to issue the certificate, as well as the certificate itself. The experts must have followed a recognized training. The quality of the certificates is randomly checked. If 1 or more problems are identified with respect to a certificate, it is cancelled. If the controls show that a particular expert is not competent enough, his license can be abrogated.

Incentives

Many different incentives are proposed in the three Belgian Regions in order to encourage the energy efficiency of buildings. These incentives include subsidies, zero interest loans, fiscal deductions, etc. Most of these economic supports for energy efficiency are focused on particular technologies (heat pump, insulation of walls or roof, photovoltaic panels, etc.). Recently, a more global approach has been adopted by the Flemish Region: the subsidy allocated is based on the overall energy performance of the building and not on the particular systems. This approach is more coherent with the philosophy of the EPB-regulation, which aims at increasing the energy efficiency of the buildings without imposing the particular technologies used to achieve this goal. This approach allows more freedom to the designer and reinforces the importance and the central role of the EPB-regulation.

4 > Acknowledgement

The consumer organisation “Test-Achats/Test-Aankoop” ("Trial Purchase") granted the authorisation to use previously unpublished figures of the study which they commissioned on residential ventilation in the Walloon region. This permission is gratefully acknowledged.

5 > References

1. IP 67 Implementation of the EPBD in Belgium - Brussels Capital Region: Status and planning – December 2008, EPBD Buildings Platform, 2008
2. IP 68 Implementation of the EPBD in the Flemish Region (Belgium) - Status March 2008, EPBD Buildings Platform, 2008
3. IP137 Implementation of the EPBD in Belgium (Walloon Region): Status December 2008, EPBD Buildings Platform, 2008
4. SENVIVV, "Insulation, ventilation, and heating in new dwellings. Results of a survey.”. BBRI-report #4, March 19998 (available in Dutch and French).
5. La ventilation dans les nouveaux bâtiments : maisons à tous vents ?/Luchtverversing in nieuwbouwwoningen : luchtkastelen bouwen ?, Test-Achats 453/Test-Aankoop 453, April 2002 (available in French and Dutch)
6. 22 December 2006 – Decree setting requirements and enforcement measures concerning energy performance and indoor climate of buildings and dealing with the institution of an energy performance certificate and modifying the article 22 of the REG decree (in Dutch and French), Moniteur belge/Belgisch Staatsblad, 27th of March 2007
7. 11 March 2005 – Order of the Flemish Government for the setting of the requirements on the energy performances and the indoor climate of buildings (in Dutch and French), Moniteur belge/Belgisch Staatsblad, 17th of June 2005
8. 9 May 2008 – Order of the Flemish Government modifying the order of the Flemish Government of the 11th of March 2005 setting the requirements concerning the energy performance and the indoor climate of buildings (in Dutch and French), Moniteur belge/Belgisch Staatsblad, 11th of June 2008
9. 7 June 2007 – Ordinance related to the energy performance and the indoor climate of buildings(in Dutch and French), Moniteur belge/Belgisch Staatsblad, 11th of July 2007
10. 21 December 2007 – Order of the Brussels Capital Government for the setting of the requirements on the energy performances and the indoor climate of buildings (in Dutch and French), Moniteur belge/Belgisch Staatsblad, 5th of February 2008
11. 19 April 2007 – Decree modifying the Walloon Code of the land settlement, the town planning and the patrimony with the aim to promote the energy performance of buildings (in French, Dutch and German), Moniteur belge/Belgisch Staatsblad, 29th of May 2007
12. 17 April 2008 – Order of the Walloon Government setting the calculation method and the requirements, the approvals and the penalties concerning the energy performance and the indoor climate of buildings (in French, Dutch and German), Moniteur belge/Belgisch Staatsblad, 30th of July 2008

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13. 2 December 2005 - Order of the Flemish Government modifying the order of the Flemish Government of the 11th of March 2005 for the setting of the requirements on the energy performances and the indoor climate of buildings, concerning the energy performance certificate in buildings, Moniteur belge/Belgisch Staatsblad (in Dutch and French), 2nd of February 2006
14. 2 April 2007 – Ministerial order concerning the setting of the form and the content of the EPB-declaration and the model of the energy performance certificate for buildings (in Dutch and French), Moniteur belge/Belgisch Staatblad, 11th of May 2007
15. 19 June 2008 - Order of the Brussels-Capital Government concerning the energy performance certificate for new buildings that are dedicated to housing, offices and services, and education (in Dutch and French), Moniteur belge/Belgisch Staatsblad, 4th of July 2008

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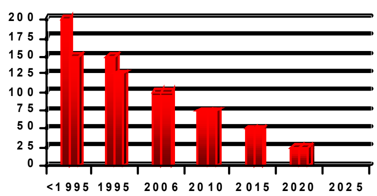

Energy consumption in new buildings until 2025 (2006 is 100 %).

Denmark: Impact, compliance and control of legislation

In Denmark the implementation of the EPBD has changed the national energy performance (EP) requirements and the certification schemes. This has an influence on the building stock. This paper describes the Danish way of handling EPBD compliance and control. The Danish rules are described in more detail in IP 136 [1].

1 > Impact of the EPBD on national requirements

The implementation of the Energy Performance Building Directive (EPBD) is the responsibility of the Danish Energy Agency (Articles 3, 5, 7, 8, 9 and 10) and of the Danish National Agency of Enterprise and Construction (Articles 3, 4, 5 and 6). Denmark has implemented the EPBD since 1 January, 2006. For many years Denmark has had fairly strict energy requirements in its building regulations and an obligatory certification scheme for buildings as well as an obligatory inspection scheme for boilers. Denmark has now further tightened the energy requirements in the building regulations and developed new certification and inspection schemes.

An energy policy agreement of 21 February 2008 stipulated that new buildings should cut back energy consumption by at least 25 % in 2010, by least an additional 25 % in 2015 and furthermore by least an additional 25 % in 2020, totalling a reduction of at least 75 % by 2020. The effect is higher targets for energy efficiency. The annual savings should be increased to 1.5 % of the final energy consumption in 2006, corresponding to annual savings of 10.3 PJ.

Furthermore a so-called "Knowledge Centre for Energy Savings in Buildings" was launched in 2008 and up to DKK 10 million will be allocated annually from 2008 to 2011.

The following figure shows the Danish energy consumption in households. It has stayed rather constant over the years in spite of an ever growing number of m^2. The energy consumption per m^2 is decreasing due to better insulation and boiler efficiencies, etc.

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Air tightness proven by Blower Door test

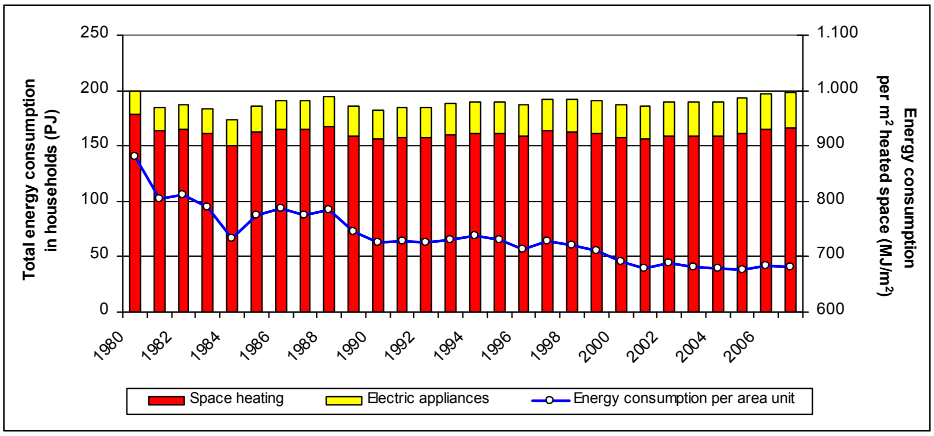


Figure 1. Total energy consumption in households and consumption per m² heated space in Denmark. Adjusted for climate.

Danish Building Regulations

New buildings

Due to the EPBD and new energy regulations, the energy consumption always has to be calculated and kept inside the energy frame. The new calculation method includes e.g. thermal bridges, solar gains, natural ventilation, heat recovery, air conditioning, lighting (for large buildings), boiler and heat pump efficiency. Furthermore, if the average monthly indoor temperature exceeds 26°C, a fictive mechanical cooling system is assumed to be installed and the electricity for the cooling is taken into account in the calculation. Overheating is often caused by architectural decisions, e.g. large glazed areas, lack of solar shading, etc.

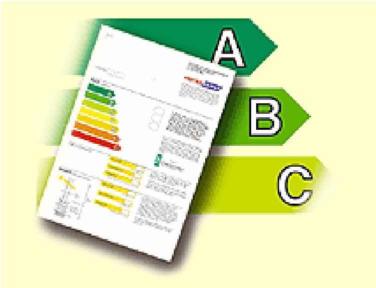
For new non-residential buildings or zones needing e.g. a high lighting level (>200 lux), extra ventilation (>1.2 liter/s per m²) or high consumption of domestic hot water (>100 liter/m² per year) or many operational hours (>45 hours/week) there is a supplement to the energy frame intended to cover the calculated additional energy demand for these purpose.

It is necessary to build airtight to comply with the energy requirements. Local authorities can demand documentation of airtightness. For larger buildings the airtightness can be proven by part of a building. If a test has been made, the result can be used in the calculation of the energy consumption for ventilation. If not, the value 1.5 l/s per m² heated floor area at 50 Pa is used.

In Denmark there have been ventilation requirements for all kinds of buildings for many years and it has not been necessary to change them because of the EPBD.

When energy consumption is estimated, the electricity consumption for building operations (ventilators, pumps etc.) is multiplied by 2.5 to compensate for the efficiency of the power production, high CO_2 emissions and high energy prices. All other energy sources have a factor 1.0.

Due to the EPBD, renewable energy has gained a more central position. At the moment Denmark has a total of 19 % coverage and the goal is 30 % in 2020. All types of renewable sources are taken into account in the calculation of energy consumption. Normally the building regulations do not recommend stoves because of their pollution of the local urban area. After introduction to the new requirements in 2006 an increase in solar



Energy certificates.

thermal, heat pumps and mechanical ventilation system have been observed.

The building market has expanded with the introduction of products and materials that comply the new low energy class 1 and class 2 buildings. Building prices increased due to the higher energy efficiency standard. The price for a new building compared with a building built according to the previous building regulation is approx 15-30 euros higher per m².

Renovation

There are requirements when a building is renovated in a major way. The definition of a major renovation is given in the Directive. A major renovation is when 25 % of the value of the building or more than 25 % of the building envelope are affected. When it is a major renovation, **all** cost-effective energy savings must be performed. This is a stricter rule than the EPBD requirement.

Furthermore it is required that some individual, profitable measures have to fulfil the requirements, regardless of the size of the renovation. Individual measures are insulation of external walls when changing the weather shield, insulation of attic and roof when changing roof, change of boilers and change of heat supply.

To be a profitable measure, the saving (in DKK) multiplied by the lifetime (in years) divided by investment (in DKK) should be higher than 1.33. These measures will normally be listed in the certification scheme.

Furthermore it is mandatory for public authorities to implement energy-saving measures with a pay-back time of less than five years as described in the energy certificate of the buildings. This is also a stricter rule than the EPBD requirement.

Energy certification

Since 1997 Denmark has had a certification scheme for nearly all kinds of buildings. This scheme has been revised to accommodate the requirements of the EPBD and adjusted to benefit from findings and experience gained over the years.

Since the beginning of 2006, an energy certificate is issued when a building or an apartment is constructed, sold or rented. Denmark has different certification schemes for different users: single-family houses, blocks of flats and buildings with public service, trade and service.

Due to the EPBD, another big adjustment was made that all certificates have to be calculated. Denmark used operational rating for large buildings before the EPBD was introduced.

The energy regulations and the rules for energy certification are linked in several ways. Before the official permit to use a new building is given, an energy audit has to be performed by a certified or approved energy consultant who checks that the energy calculation is correct, a quality and compliance check.

In Denmark the lifetime of the certificate is 5 years, so this is tighter than the EPBD requirement.

In Denmark there are rather strict requirements to the qualifications and also to the independence of the energy consultants. This was not changed after introduction of the EPBD.

The gross heating consumption for houses based on approx. 300 000 energy certificates is shown below. Due to the EPBD, Denmark has a really good knowledge of the building stock. This is used among others to estimate energy savings in different building types and during different periods.

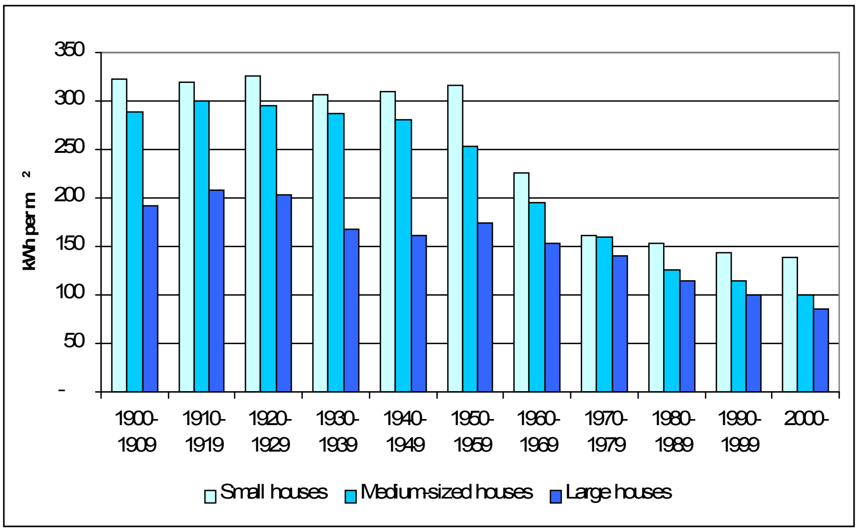


Figure 2. Gross heating consumption for houses - distributed over the decades of houses (data from the energy certification schemes).

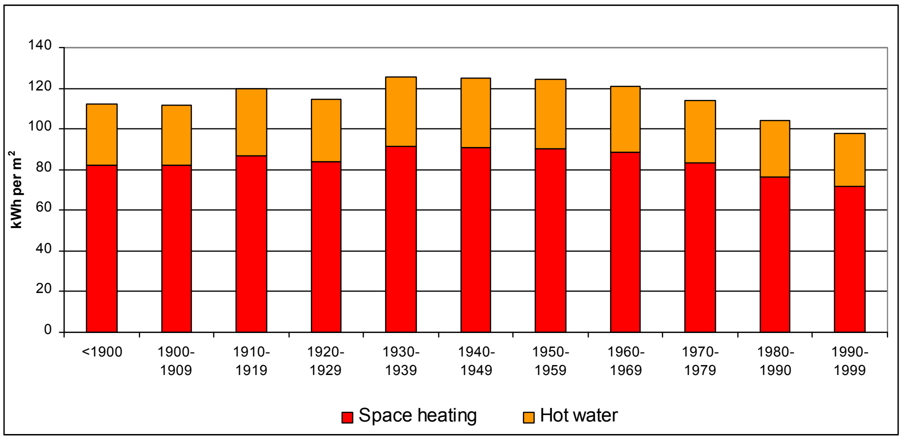
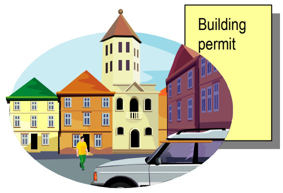


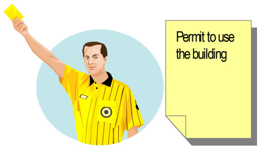
Figure 3. Actual heating consumption in Danish blocks of flats - distributed over the decades of building (data from the energy certification schemes).

2 > Compliance and control

Danish Building Regulations

To get a building permit, a calculation of the energy consumption has to be made. The local authorities are responsible for controlling compliance with regulations. In Denmark 98 local authorities control compliance with the requirements in different ways. Some do it very detailed, others in a more cursory way.





A building permit is given by the local authorities. A permit to use the building is given after a certificate and a quality control is made

In practice the control of the new building in relation to the energy requirements is performed by the energy consultants who also issue the energy certificate. This rule was introduced in 2006. The proof of compliance with the energy requirements for new buildings must be made after the completion of the building in order to get the permit to use the building. If the building does not comply with the energy performance requirements, it has to be made to do so!

For large buildings the building owner normally has an additional external consultant to make the quality check and follow up.

At present there is no financial support for energy saving measures in Denmark. The political climate has not been in favour of financial support; however it is currently on the political agenda and negotiations are ongoing and it seems that they will be successful.

Energy certification

The Danish Energy Agency is responsible for the certification scheme. The daily operation of the scheme is delegated to a secretariat also operating the other schemes related to the EPBD. From April 2008 it became possible to appoint a company official to issue the certificates, thus permitting companies to appoint their own consultants. The companies carry out their own quality checks according to DS/EN ISO 9001. The Danish Energy Agency carries out a market surveillance of the companies. These quality checks are made regularly, but also when there are complaints from clients, out-of-range values, etc. They also check the energy consultants' independence and qualifications by checking the consultants' CV presenting their expertise and projects involvements. In this way the consultants' business experience is evidenced.

Quality assessment of energy certificates of buildings include:

- All certifications must be reported
- Automatic screening at receipt
- General control for instance by consultant
- Visual control - desk report control
- Field control - new inspection and report
- Complaints from consumers
- Other activities

If certification is omitted, the possibility of penalties exists.

In a report published by the AKF, the Danish Institute of Governmental Research *[2],* the author claims that there are no real difference in consumption levels between houses with a certificate and those without one. This study is based on data on 3 956 single-family houses obtained under the old scheme. But the conclusion is also: Even though analysis of the data did not reveal any significant reduction in natural gas consumption for houses with an energy certificate compared with those without one, the certification scheme might still have an effect. If the owner of a certified house implements some or all of the recommended improvements and thereby obtains the same indoor temperature at a lower energy level/price, he might decide to raise the indoor temperature with the saved amount of energy, and reach a higher utility level, instead of saving the money and energy. This would be a welfare gain, but since indoor temperature is not registered, it would not be possible to use this change for estimation of the certification effect. It must be emphasised that all data in this report are based on the old certification scheme. There have been changes made to the certification scheme after this survey was made.

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A certification scheme is a good basis for energy savings, but the scheme in itself does not necessarily generate savings. The certification scheme draws the building owners' attention to the fact that there are possibilities for energy savings etc. The certificates are now beginning to be available to the public on the "Public Information Server" (www.ois.dk). Hopefully this will help activate the recommendations in the certificates.

3 > References

1. Søren Aggerholm. IP 136, EPBD Buildings Platform, Implementation of the EPBD in Denmark: Status 2008. November 2008.
2. Vibeke Hansen Kjærby. Does energy certification of Residential Housing Cause Energy Savings? AKF Working paper, December 2008. *http://www.akf.dk/udgivelser_en/container/2008/udgivelse_2642/*

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France: Impact, compliance and control of legislation

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This paper discusses how compliance and control of legislation concerning energy performance of buildings regulations is handled in France. It describes the legal mechanisms and measures that have been defined mainly since 2002 to improve the energy performance of new and existing buildings.

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1 > Background

There has been a regulation framework for the energy performance of new and non-residential buildings in France for many years. This framework started in 1974, and went through 2 major revisions in 1982 and 1989, which lead in 2000 to a new regulation based on a calculation method that takes into account summer comfort. Parallel to the directive, many national initiatives (Air Law (1996), Climate act (2004), POPE law (2005), Grenelle law (2009)) established converging objectives with those of the directive. Therefore, the impact of the EPBD alone for the past 7 years is difficult to isolate.

To be more precise about the French energy performance regulation, the idea is to compare the energy performance of the building in project, with the performance of a theoretical building, called the reference building (notional building). This reference building has the same geometry as the project, but its thermal characteristics are set at the reference level of the regulation (envelope, systems). Once the calculation is done, to comply with the regulation, the energy consumption of the project must be lower than that of the reference. The idea is similar with summer comfort where temperatures reached during a hot period are compared. The project characteristics are therefore free, the obligation being the results achieved in consumption and summer comfort. Nonetheless, to prevent too inefficient designs or products, (for example, a minor insulation level balanced by high-performance systems), minimum requirements are established, on envelope elements and on systems, and have all to be met.

2 > Impact of the EPBD on the national requirements

Status

The implementation of the EPBD (but also national action plans) have lead to effective measures for energy efficiency.
For example for new buildings :

- More stringent requirements on energy consumptions: -15% compared to RT 2000
- Global minimum requirement on consumption for residential buildings expressed in kWh/m²/year
- Feasibility studies on RES for buildings over 1000 m²
- Energy Performance Certificate

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And for existing buildings :

- Energy Performance Certificate when a building or an apartment is rented or sold
- A regulation for existing buildings, similar to new buildings for major renovations, and based minimum requirements otherwise
- Feasibility studies on RES for buildings over 1000 m^2 in case of important energy renovation
- Energy Performance Certificate for public buildings

These measures are accompanied by fiscal and financial schemes in order to get owners, especially for private housing, to build or renovate according these requirements (lower taxes, fiscal deductions, soft loans…).

What is the actual impact of the implementation of the EPBD in terms of energy efficiency?

The strongest effect of EP regulation reinforcement is to encourage the development of more efficient designs and products. In some cases, it leads to the decline of some systems (e.g., direct electric heating), and the generalisation of others (e.g., humidity-controlled ventilation). For the first time with RT 2005, the regulation tries to influence the design (orientation, structural choices) through the climatic conception of the reference building, but it remains possible to compensate a poor design with good systems. Also, good air-tightness can be rewarded through a measurement or an approved quality management approach, otherwise a default value is used whatever the quality of the construction is. In sum, although the strengthening between the 2000 and 2005 regulations was calibrated to lead to 15% savings on energy consumption, complying 2005 regulation requires neither a technical nor a design breakdown compared to the previous regulation. Campaigns of controls still reveal non-compliances, and buildings built with no EP compulsory study, but depending on building types (single housing, collective, or non-residential), the compliance rate lies between 80% to 90% of the sample.

One first really significant step towards higher energy performance lies in the definition of the French low energy building certification "*BBC – Bâtiment Basse Consommation*" and local incentive programmes (e.g., PREBAT demonstration buildings) to support the first buildings aiming this level of performance. This label is strictly based on the French regulation, i.e., the calculation procedure is identical; it is promoted through the *Effinergie association* in accordance with the French Ministry for Energy. For residences, it requires that the calculated primary energy use (including heating, cooling, auxiliaries, domestic hot water, lighting) be smaller than 50 kWh-pe/m^2/year. To reach this high performance, innovative systems are entering the market: solar collectors combined with a heat pump for heating and DHW, heat pumps for DHW, combined ventilation and heat pump systems coupled with ventilation with heat recovery…

The "*Grenelle de l'Environnement*" in 2008, really spread climate change and sustainable development concerns among a wide audience. Many projects now plan higher energy performance than the minimum required by regulation; many anticipate the 2012 EP regulation level which will correspond to the BBC-certification level. Energy efficiency improvements in all types of existing buildings has also become an important market for craftsmen, engineers and architects. This market will continue to grow as social housing estates and State properties have the objective to cut their consumption by 40% in 2020 and by 4 in 2050. In private existing houses, investments in heat pumps, solar collectors, wood-burning stoves or boilers, condensing boilers have also considerably increased thanks to various financial incentives.

What is the actual impact of the implementation of the EPBD in terms of indoor climate?

Main points in EP regulations related to indoor climate are :
- Consideration of summer comfort in new buildings, especially through indoor temperature for unconditioned buildings (calculated temperature with an hourly method)
- Compliance of airflow rates with applicable regulations (minimum ventilation airflow rate) before calculation of the energy consumption

Those points were already quoted in the former regulation.

What regulations related to energy efficiency and indoor climate are there besides explicitly demanded by the EPBD (EP-label, inspection of systems and regulations related to renovation)?

- Air conditioning for comfort can be used and kept in operation only when the room temperature is over 26°C: the lower authorized set point, except for some uses that require lower temperatures, is 26°C
- Provisions must be made in electric-heated (direct) buildings so that another energy source can be used
- Regulation for renovations of small buildings (< 1000 m²), which is not required by the EPBD
- Feasibility studies on RES for buildings over 1000 m² in case of important energy renovation, when EPDB only requires these studies for new buildings.

What are the already uptaken technical measures for better energy performance since the implementation of the EPBD?

RT 2005 included a timetable for the reinforcement of some requirements, for example:
- requirements on thermal bridges have been strengthened in 2008
- oil or gas-fired boilers performance have been raised in 2008
- air conditioning consumption, in buildings or rooms where air conditioning is not indispensable, has to be balanced by lowered consumptions for heating, lighting, water heating since 2008.

How has the implementation of the EPBD affected the building prices, the building market and the building products?

A study was ordered by the administration to evaluate the cost overrun of a RT2005 compliant building compared to a RT2000 compliant one. Conclusions are the following: with good design, the increase of building price compared to a RT2000 compliant building is low. An average increase of 2% was expected, which has to be compared in euros with energy savings that should reach 15%. The cost increase will probably be the highest for buildings where a new technology will have to be used, but this increase should remain under 5%.

Are there any minimum ventilation requirements for certain building types and ventilation systems?

As mentioned above, compliance of airflow rates with applicable regulations (minimum ventilation airflow rate) is required before calculation of the energy consumption. Moreover, there are additional minimum requirements for ventilation :
- To prevent excessive air humidification
- To use independent systems when emissions are very different between zones (non-residential buildings)
- To reduce airflow rates to minimum ventilation airflow rate when unoccupied (non-residential buildings)
- To time-control manual increase of airflow rates

- To insulate ducts in unconditioned spaces
- To prevent air pre-warming during non-heating seasons

In case of renovation, measures are required to ease the future use of a ventilation system (for example, to provide air intakes in main rooms windows, when no supply system is installed), and to prevent a decrease of indoor air quality and avoid damages.

Are there additional regulations related to renewable energy, e.g. the obligation to use a renewable energy source and what types of renewable energy sources are taken into account?

First note that the kernel of the calculation method is identical for new and existing buildings, and for feasibility studies on RES.
RES taken into account in this kernel are : DHW solar collectors, photovoltaics, biomass boilers, heat pumps.

Innovative systems that have become more and more common since 2005 are now covered by calculations defined in accordance with the equivalence principle (called « *Titre V* » in France) (wood-burning stoves, underground heat exchanger, heat pumps for DHW, cogeneration, underground heat exchanger). The integration of these systems and others will naturally be integrated in the next version of the regulation.

Today, it is not required to use RES, but there are incentives (notional building based on solar collectors for DHW in residential buildings). The compulsory use of RES in 2012 is foreseen. Besides, energy performance quality labels encourage the use of RES.

What is the policy on renewable energy (solar collectors, photovoltaic, heat pumps, waste heat from industry, biomass, heat recovery from ventilation or other sources …) and which conversion factors are used to convert from delivered to primary energy?

France commitments on RES are written down in several energy and climate change related laws. In 2005, POPE law raised the objective of 21% of electricity consumption coming from RES in the year 2010. The Grenelle Law in 2009 sets the objective of 23% of RES in the energy consumption (all energy count) in the year 2020. Other ambitious objectives concerning each renewable source are also written down in technical works preparing the law.

Conversion factors are 2.58 for electricity, 0.6 or 1 for wood, 1 for other sources of energy. Conversion factor for photovoltaic electricity is 2.58, as a convention in the calculation method of the EP regulation, so that the production of the building can be directly deducted from its consumption.

What is the impact of the implementation EPBD on the independence and qualification requirements for energy experts for certification process?

The directive requires independence and qualification of assessors and inspectors in art.10 « independent experts ». French regulation already establishes in Housing and Building Code independence criteria for real-estate diagnostics (asbestos, lead diagnostics…). They are identical for assessors and inspectors. They also must be qualified and they receive this qualification after training with a body approved by the state.

Regulation concerning boiler inspections and air conditioning systems aren't available yet : therefore no control is required.

3 > Compliance and control[1]

How is compliance of the EP requirements for buildings handled?

The building owner signs a commitment to comply with regulations with the building permit. Therefore, he is legally responsible for the compliance with the EP regulation. The authorities have the legal power to proceed with a control on his building. When controlled, the owner must be able to prove that his building complies with the regulation through supply of calculation notes and written proofs, often helped by his engineering team.

For existing buildings, in case of important renovation, the building owner is also responsible and signs commitment to comply with regulations with building permit (if the renovation requires a permit). In case of lighter energy performance renovation, the owner has to choose insulation products and systems that comply with minimum requirements; especially financial subsidies are only granted when these requirements are met (fiscal deductions, soft loans). If the owner is not a professional of the building field (e.g., a private individual for his house), craftsmen and architects have the duty to advise him to meet the regulations requirements.

Concerning compliance with EP regulation, for new buildings, controls are performed by state employees in CETE, appointed to record breach of the housing and building code. They are allowed to visit any building during three years after it is finished. Control campaigns are annual, and the sample of operations is extracted with representative criteria. Several regulations can be controlled, including EP regulation. Regarding control of EP regulation, the control is based on :

- Analysis of plans, specifications, calculations
- Visit on site to check insulation
- Visit at commissioning

The objective of visits is to check if calculation hypothesis comply with products really used in the building. After visits, in case of differences, calculation has to be updated and performance justified by technical papers. The control doesn't consist in a new calculation, but in checking the validity of the hypotheses.

A national method to perform EP regulation controls and computer tools were released in 2008. It is operational and used by state controllers; it is available for private building inspectors.

One of the difficulties in this procedure is to evaluate the impact of mishandled products (insulation mostly) on the performance and to prove that it constitutes a non-compliance from the EP regulation point of view, since calculation methods consider the resistance of the product. It is also difficult to prove non-compliance on the consumption when it relies on calculation because the controller would have to be sure of each data, which requires expertise.

[1] Compliance means the fulfilment of EP requirements and EP certification process while control is the mechanism for checking the validity of the design, assessment and certification process.

Another question, which is under study, is to improve the selection of the sample. Currently, selection relies on quantitative criteria (proportion in the building stock, proportion in the local area), but there are no quality criteria on the estimated performance or the results of previous controls on the same building team. Highly efficient buildings, with almost no risk of non-compliance, are controlled as well as just-compliant ones. However, the control strategy should be improved thanks to a first screening of the selected operations based on compulsory justifications (calculation standard synthesis and /or compliance certificate) that the owner has to produce. This screening will enlarge the number of operations going under control and help focusing control on the ones showing a higher risk of non-compliance. Some regions have already implemented this strategy (Bourgogne, Limousin…) but it still has to gain more experience.

The various calculation methods of energy consumption on which are based some non-regulatory labels such as Passiv-Haus or Minergie, sometimes confuse the owners who often regret to have to pay for two studies: the one required by regulation and the other one required for the label.

Concerning existing buildings, housing and building code also allows to perform controls but there is not yet any scheme to perform them like on new buildings.

How is compliance of the EP certification process handled?

About certificates, they must be provided when renting (residential) or selling (residential and others), and for every new building. When renting or selling, the certificate must be attached to contract. The owner or landlord has to pay for it and make it available to candidates for buying or renting. The qualification of assessors has to be certified by a certification organisation itself certified by an independent committee. Administration defines certification criteria, especially skills that must be proofed during the exam. The certification is valid 5 years.

Concerning EP certificates, the lawyer verifies its availability for sales. But in case of renting, there isn't always an independent authority to control that the document is really available. Many contracts are signed between two private individuals. Nonetheless, assessors are controlled by the organization that provided the certification during the 5 years, on a certain number of certificates whose validity is examined.

Are there additional incentive policies related to the EPBD (e.g. financial schemes like subsidies, fiscal deduction, favourable interests, soft loans, third party financing, taxes …)?

There are a great number of incentive schemes for energy performance in buildings granted by the State or local authorities.

- Tax deduction and soft loans, e.g. for solar collectors, heat pumps, low-energy label
- Possibility to increase of 20% the ratio of land built subjected to energy performance requirements
- Many local authorities and the national energy agency (ADEME) subsidy the installation of RES. Electricity produced with photovoltaic panels which are well integrated to the building is bought by French electricity company EDF at a very incentive financial level.
- Many local authorities have launched innovative techniques application programmes or low energy building programmes with specific funding schemes, in general with national energy agency (ADEME)
- Some urban or rural areas chosen by local authorities to receive energy renovation: the idea is to trigger renovations by the owners through different incentive measures like professional support, study and work

funding…

The administration subsidies or encourages building techniques based uniquely on criteria stated in official documents derived from laws. The performance of products and materials must be proofed with French "*Avis technique*" notes or European Technical Approvals. Techniques and energy sources are developed by companies or unions that must make sure that performance are sufficient and justified to comply with regulations.

How is the certification market organised in practice:

- ✓ **the role of specialised consultancy firms is important?**
- ✓ **the large size of projects results in a better compliance?**
- ✓ **the requirements by insurance companies result in more attention for energy regulations (e.g. by imposing the use of certified products only)?**

- › The role of specialized consultancy firms is important because to prove the compliance with the EP regulation, for new or existing buildings, a calculation is almost systematically necessary
- › Requirements set by insurance companies have little to do with energy performance since guarantees regard more structure safety and solidity, and proper use of the building. Nonetheless, insurance in case of innovative products is granted only if an independent technical note on the product is available.
- › In France, EP quality labels are defined by the regulation for projects with better performance than the regulation minimum requirements. But to deserve this label, the building has to be energy efficient, but also respect conditions about safety and quality of energy performance systems, and other criteria of construction global quality. These EP quality labels are given by certification organizations as an option of standard quality labels (an EP label can not be given without a standard label).

What happens in practice if during the construction or after the completion of a building the proper authorities find out that the building doesn't comply with the EP requirements?

Non-compliance with construction regulation is an offence with financial penalties up to 45000 € against the building owner. Controllers have the duty to write down a report when they record a breach, and they must send it to the attorney general to require that the owner undertake remedial actions to comply with regulation. To start, the procedure is out of court with the owner who has to justify the corrective actions for a given due-date. If there is no action or non-satisfactory ones during the given period, the attorney general starts the justice procedure and decides of the prosecutions: new due-date, contractor designated to proceed with remedial actions on the owner's debt, or if it is too late for corrective measures, he sets the financial sanction. The attorney general has the power to require the building demolition. In general, problems are solved during the informal procedure.

Do the proper authorities have enough expertise to check in practice (so not only the paper calculation, but also at the construction side) if buildings and certificates comply with the regulations and standards?

As the EP regulation gets more complex, and the turnover of state agents is high, the administration has settled a qualification procedure of controllers before they receive their assignment by the ministry to proceed to the controls. This procedure is precisely written down in a reference document that mentions trainings (technical, legal) to follow, library and tools necessary (legal texts, control manuals, report models...) and the number of training controls to do with a senior controller. A controller qualifies as a senior when he has three years long experience

Concerning visits, there is at least the commissioning visit and sometimes a site visit. A computer tool helps controller to prepare the visit and to point out which hypotheses should be checked in priority. The main difficulty is the control of systems in non-residential buildings and the development of non-traditional techniques always more numerous, especially regarding RES. About envelope control, detecting defects in the layout of insulation products requires a certain experience.

Nonetheless, the role of the controller is to check out products on the building and compare with the hypothesis of the calculation. Moreover, after visits, the controller also relies on technical papers to find out main characteristics. And controllers also form a network and can share difficulties.

Concerning certificates, assessors must be certified by a certification organization itself certified by an independent committee. The certification is valid 5 years. During this period, the assessor must provide the certification organization a certain number of certificates to be examined (this examination is defined by the certification organization, counter visit is not compulsory).

How is compliance and control of the experts regarding the independence and qualification organised in your country?

State employees are subjected to rules, and in particular to independence and objectivity. Controllers have to take a pledge in court et their personal responsibility can be charged. Hierarchy also has a role to make sure that controls are done properly.

Concerning qualification, it mainly consists in the first qualification training. There is no exam to pass (neither theoretical nor practical) at the end of the qualification process to assume if the agent is ready to perform controls. The senior controller does not decide whether the junior controller is ready or not. But the hierarchy can judge the aptitude regarding the first works during the training. Once qualified, there is no specified scheme to follow independence and qualification. For instance, no counter control is performed. But specific quality control procedures (e.g., under ISO 9001) may be defined.

For assessors, certification relies on theoretical and practical examination, which has to be renewed every 5 years. Controls are performed by the organization that has issued the certification of the inspector on a sample, and the certification organization defines rules to suspend certification when necessary. Nonetheless, obligation of independence towards the owner or buyer, or any contractor or architect that is involved in the works, is clearly specified by the regulation. The violation of obligations of qualification, certification and insurance for issuing certificates is punished by a 1500 € fine for the assessor as well as the owner who uses an

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unqualified person. However, no control of the obligations stated in this paragraph are not controlled with a national scheme yet.

4 > References

1. *http://www.rt-batiment.fr/*, French administration website on energy performance regulations, in French.
2. *http://www.ademe.fr/*, "Agence de l'Environnement et de la Maîtrise de l'Energie", national energy agency website, information on subsidies and low energy buildings programme.
3. *http://www.effinergie.org/*, "Effinergie" association website promoting the French "BBC-Bâtiments Basse Consommation" certification for low energy buildings.

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Germany: Impact, compliance and control of legislation

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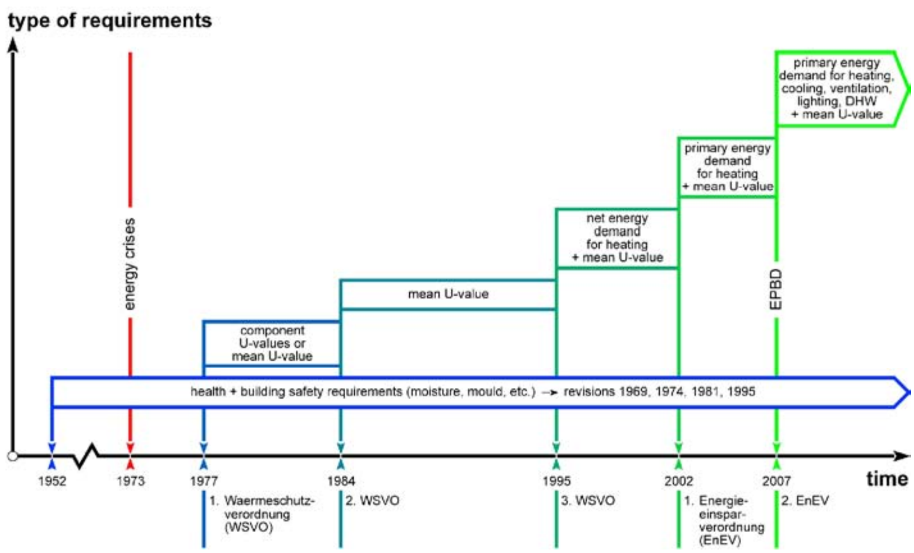
The implementation of the Energy Performance of Buildings Directive (EPBD) did not change the national energy performance requirements in Germany, but it has had a ground-breaking effect on energy certification. In consequence, the German building stock has not become more energy efficient, but energy efficiency has reached a higher level of visibility with certificates for new and existing buildings and especially for public buildings. The main change besides the certificates though was the development of a new holistic calculation method that includes heating, cooling, ventilation, domestic hot water and lighting. This paper describes the way in which Germany is handling EPBD compliance and control. The overall implementation status of Germany is described in greater detail in IP 73 [1].

1 > Impact of the EPBD on the national requirements

Germany had tightened the national energy performance requirements for buildings the last time before the Energy Performance of Buildings Directive in 2002. With the 2002 energy decree, maximum primary energy demands for heating, domestic hot water and ventilation have been fixed. The calculation method (consisting of two standards, namely DIN V 4108-6 [2] and DIN V 4701-10 [3] had to be applied to all types of buildings.



Evolution of the energy performance requirements in Germany.

The requirements referred to the primary energy demand per square meter and year depending on the surface-to-volume-ratio, which has been used as an indicator for the compactness of a building in Germany since 1978. A compact building has less relatively seen less building surface area and less transmission losses and therefore less heating needs.

In 2007 a new energy decree was put into force, leaving the requirements and the calculation procedure for residential buildings unaltered. For non-residential buildings a new calculation standard was developed, the DIN V 18599, taking into account for the first time a detailed approach for the ventilation and cooling systems and the energy demand of lighting systems. The energy performance requirements were set by using a so-called reference building with a fixed set of reference technologies to be compared to the actual building (see also IP 71 [4]). By choosing the reference technologies from among state-of-the-art technologies, also here the general approach was not to tighten the energy performance requirements any further.

The focus in the 2006/2007 EPBD implementation period was on kick-starting the building certification process and developing an advanced calculation standard for non-residential buildings that takes into account all required energy components. At that time, the energy performance requirements were regarded to equal at least average level in Western Europe; a further tightening was planned for later. This further tightening of energy performance requirements by about 30 % has been fixed in the upcoming energy decree, which will be put into practice in autumn 2009.

Therefore the EPBD implementation did not have an influence on the energy performance of the German building stock if we regard strictly the energy performance requirements. It has to be mentioned that for the first time also the use of lighting and cooling energy was limited by integrating these energy shares into the total energy performance requirements. Also, requirements to the energy performance of air-conditioning systems have been fixed.

However,

- the certificates,
- the new calculation method,
- the consideration of renewable energy systems,
- the information and communication activities,
- the requirement for inspection of air-conditioning systems and
- the general discussion on these items

have placed the energy efficiency of buildings into the focus of the public, the building owners and professionals and might thus have led to new and existing buildings with a better energy efficiency.

Additional requirements compared to the EPBD

There are additional requirements concerning the energy performance of buildings if compared with the text of the Energy Performance of Buildings Directive, such as:

- There is no 1000 m² threshold for buildings that undergo a major renovation.
- The energy ordinance includes definitions for regulatory offences concerning inspections, insulation of heating pipes, qualifications for issuing an energy performance certificate and the completeness and punctual availability of the certificate.
- With the “Erneuerbare Wärmegesetz”(EEWärmeG, Renewable Energies Heat Act) [5], Germany has stipulated a 15 % minimum use of renewable energy for all new buildings. The ratio of renewables is dependent on the type of energy source and runs from 15 % (solar

Energy source		Primary energy factor: Total	Primary energy factor: Proportion of non-renewables
Fuels	Fuel oil EL	1.1	1.1
	Natural gas H	1.1	1.1
	Liquid petro-leum gas	1.1	1.1
	Anthraci-te coal	1.1	1.1
	Lignite coal	1.2	1.2
	Wood	1.2	0.2
District heating by CHP	Fossil fuels	0.7	0.7
	Renew-able fuels	0.7	0.0
District heating by heating power plants	Fossil fuels	1.3	1.3
	Renew-able fuels	1.3	0.1
Electricity	Electrical energy mix	3.0	2.7 (2.6)
Eco-energy	Solar energy, ambient heat	1.0	0.0

Primary energy factors according to German DIN V 18599-1 based on the calculation model of the computer program GEMIS. According to the energy decree the values for the proportion of non-renewables have to be chosen for the calculation of the energy performance of buildings.

energy) to 50 % (biomass, geothermal). In some federal states the use of renewable energy is also required for major renovations of existing buildings.

- The 2009 energy performance decree sets a timeline for the removal of electrical night storage heating systems from service. From 2020 onwards all existing electrical night storage heating systems have to be removed depending on the year of their installation.

Economic calculations as a basis for tightening the energy performance requirements

Several versions of the energy decree have been accompanied by economic calculations before fixing the minimum requirements (first maximum U-values, then maximum energy needs for heating and ventilation, and now maximum primary energy values). It has been assessed what kind of measures are necessary to make a building meet the new requirements and how high the additional investment costs are compared to the previous requirements. Those additional investment costs have been contrasted with the lower operational costs due to energy savings, and the resulting payback periods have been calculated. These studies were not only assigned by the responsible ministry but also by the federal states and the involved building industry.

Country policy on renewable energy and conversion factors used

As the “Erneuerbare Wärmegesetz” (Renewable Energies Heat Act) shows, renewable energies have gained great importance in Germany. Many small and medium sized companies that manufacture renewable energy products (such as solar thermal collectors, photovoltaic cells, wind turbines a.s.o.) have been started in the last decade. Especially the PV-production was accelerated by the law, which ensures that renewable energy can be fed into the grid at rather high tariffs. Though the tariffs are slowly decreasing by now, it is still quite cost-efficient to invest in solar cells on the roof.

The table on the left shows the primary energy factors that have to be used when calculating the primary energy performance of buildings in Germany. Renewable energies like solar and ambient heat are calculated with a primary energy factor of 0.0. Wood used as fuel also receives a favourable primary energy factor with 0.2. This has to be compared to fossil fuels such as oil and gas with 1.1 and even the electricity mix with a primary energy factor of 2.7. The primary energy factor for electricity will be changed to 2.6 with the updated energy decree of 2009.

Minimum requirements for ventilation and summer comfort

There are fixed minimum ventilation requirements for certain building usages like for convention halls etc in the health and safety at work act (Arbeitsstättenverordnung) [6] and the health and safety at work guideline no. 5 (Arbeitsstättenrichtlinie ASR5) [7]. A minimum ventilation rate per person or per square meter is required. With the new calculation standard for non-residential buildings, which is based on usage zones, minimum default ventilation rates are included in the energy performance calculation. Especially for zones and buildings in need of a high air change rate (auditoriums, restaurants, kitchens, etc.) it has been proven that the standard ventilation rate for residential buildings, that has been used so far for all buildings, results in energy needs and uses that do not mirror the reality.

Summer comfort for buildings with and without air-conditioning systems has to be proven according to DIN 4108-2 [8]. A so-called solar gain factor limits the maximum heat gain due to solar but also incorporates different measures to reduce the heat (like solar shading, night ventilation, building mass, etc).

The health and safety at work guideline no. 6 [9] also includes requirements for the indoor air temperature, recommending a maximum indoor air temperature of 26 °C.

Impact of the EPBD implementation on the qualification requirements and independency of the energy experts for the certification process

As mentioned before, the building certification process for existing buildings started with the EPBD implementation. For new buildings, energy performance calculations and certificates had to be made much earlier. Until 2007 the energy performance certificates could be issued only by persons authorized by the state to present building documents. Those persons are defined in the ordinances of the different federal states and include mostly:

- Architects and civil engineers
- Experts for acoustics and thermal protection recognized by the state

The same rules are still in force for all types of new buildings.

For existing non-residential buildings the following persons are entitled to issue energy performance certificates:

- Graduates of architecture, civil engineering, building system engineering, building physics, mechanical engineering and electrical engineering studies

For existing residential buildings the group of issuers as defined for existing non-residential buildings is enlarged by the following experts:

- Graduates of interior design studies,
- Craftspersons for construction, interior fittings, building system mechanics and chimney sweepers,
- Technicians authorized by the state,

all with specific further education. The required educational programmes are offered by different institutions.

Impact on the building market and building prices

There is no measurable influence of the EPBD implementation on the building market and building prices in Germany. Building prices are affected much more by the regional, seasonal and general economic situation.

The previously unreleased CO_2 building report 2009 [10] by the German ministry for Transport, Building and Urban Affairs mentions that energy performance certificates are becoming more important for the marketing of residential buildings. Since July 2008 the Internet portal *www.immobilienscout24.de* analyses the ratio of buildings being advertised including an EP certificate:

- August 2008: 2 %
- December 2008: 4 %

For 15 % of the buildings with attached EP certificates, the characteristic energy performance value for the building is indicated within the advertisement text.

2 > Compliance and control

Compliance with both EP certification and EP requirements for new buildings and buildings undergoing major renovations is in the hands of the federal states. There is no authority that checks the EP certificates for existing public buildings or buildings that are sold or let. Here the responsibility is with the building owner as defined in the German energy decree.

Sanctions and penalties

The German energy decree defines in § 27 the following regulatory offenses:

- missing inspections or inspections carried out by unauthorised personnel
- installation of boilers without CE label
- lacking insulation of heating pipes
- inappropriate control system for heating system
- incomplete, incorrect or delayed energy performance certificate
- issuing of EP certificates by unauthorized personnel
- incorrect or lacking confirmation by construction companies regarding the compliance with EP requirements for major renovations and renewed building components or systems

The corresponding penalties are defined in the Energy Saving Act of 2009 (Energieeinsparungsgesetz – EnEG) [11]. Here, penalties between € 5,000 and € 50,000 are defined for:

- regulatory offences against the thermal protection and energy efficiency of building systems requirements (EP requirements) and regulatory offences against the inspection of building systems and the installation of heating control systems: 50,000 €
- regulatory offences against the issuing of EP certificates (missing, delayed, incorrect or issued by unauthorised personnel): 15,000 €
- regulatory offences against the compliance check procedure or incorrect or missing confirmation of private construction companies concerning the compliance of EP requirements for major renovations or renewed building components or systems: 5,000 €

There are also regulatory offences against the Renewable Energies Heat Act as defined in § 17 of the act. Here the offences are divided into:

- not covering or not correctly covering the generated energy by renewable energy (as required);
- not providing (not correctly or in time providing) the proof for covering the generated energy by renewable energy;
- presenting an incorrect ratio of the covered generated energy by renewable energy;
- not keeping the proof for at least 5 years.

The first 3 offences can be penalised by up to 50,000 € and the last one by up to 20,000 €.

Compliance check by the public authorities

The compliance check by the public authority is organised differently in each state. It varies from the simple check of completeness of all documents and plausibility to random expert checks at the construction site.

The previously unreleased CO_2 building report 2009 [10] by the German Ministry for Transport, Building and Urban Affairs states that 70 % of the German citizens support the compliance check of the requirements for energy efficient renovations.

A special type of compliance check was developed for the updated energy decree of 2009: the contractor's declaration. All contractors having made changes at existing buildings that fall into "major renovations", or having added insulations to attic ceilings or having replaced heating boilers have to sign a document declaring that these changes fulfill the requirements defined in the energy decree. The building owner has to keep the declaration for at least 5 years and to show it to the authorities if requested.

Additionally the chimney sweeper is checking during his heat producing appliance check whether electrical night storage heating systems that had to be removed are still in use and whether heating and domestic hot water pipes that had to be insulated are still uninsulated. He also checks whether new central heating systems in existing buildings include an automatic night set-back or a night shut-down and an automatic shut-down for the pumps, circulation pumps are controlled and installation pipes are insulated according to a defined level. If there is any offense to the rules the chimney sweeper explains in written form the offense to the building owner, fixes a deadline for compliance and if not met, informs the authorities.

Certification market

The persons qualified for issuing EP certificates have been defined in chapter 2. There are no specialised consultancy firms for EP certificates though some companies might issue more certificates than others. In general the price for issuing certificates is mostly not high enough for companies wanting to specialise in that field. The efforts for certificates based on calculations are rather high. The prices for certificates based on measurements are rather low.

Government incentives

In general there are no incentives in Germany for the mere compliance with the EPBD or EnEV (Energieeinsparverordnung = energy saving ordinance) requirements. Incentives are only offered for buildings that go beyond the minimum requirements of the energy decree, given by the KfW bank (bank of the state) for:

- energy efficient retrofit of public buildings
- energy efficient retrofit of dwellings
- ecological new buildings
- energy efficient retrofit of social housing

Exemptions are market launch incentives for certain building technologies like wood pellet boilers, solar collectors, micro combined heat and power units, etc.

The German government's incentive policy is mostly realised as soft loans or subsidies. There are no more tax reductions for energy efficient buildings.

Third party financing is used in Germany for some projects but has not such a big impact as for example in the US. On the other hand new financing systems like intracting have been developed. Intracting is a form of “third party” financing where a city or community reserves a special fund for the energy improvement of buildings. This fund is spent as investment and paid back by the energy savings in order to be then again used for the next energy efficient renovation.

Another type of incentives are the rather high tariffs for the renewable energy production to be fed into the local grid defined in the law for renewable energy for electricity (Erneuerbare-Energien-Gesetz, Renewable Energies Act) [12].

3 > References

1. Schettler-Köhler, H. P.: “Implementation of the EPBD in Germany: Status and future Planning – March 2008”. Information Paper P73 of the EPBD Buildings Platform (2008)
2. DIN V 4108-6: 2000-11 “Wärmeschutz und Energie-Einsparung in Gebäuden, Teil 6: Berechnung des Jahresheizwärme- und des Jahresheizenergiebedarfs”. Beuth-Verlag GmbH, 10722 Berlin (2000).

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3. DIN V 4701-10: 2001-02 „Energetische Bewertung heiz- und raumluft-technischer Anlagen, Teil 10: Heizung, Trinkwarmwassererwärmung, Lüftung“. Beuth-Verlag GmbH, 10722 Berlin (2001).
4. Erhorn-Kluttig, H. and Erhorn, H.: „Setting minimum energy performance requirements through reference buildings with reference technologies“. Information Paper P71 of the EPBD Buildings Platform (2008).
5. Gesetz zur Förderung Erneuerbarer Energien im Wärmebereich (Erneuerbare-Energien-Wärmegesetz – EEWärmeG, The Renewable Energies Heat Act). Bundesgesetzblatt (Federal Law Gazette) volume 2008, part I, no. 36 of 18th August 2008, page 1658 ff.
6. Verordnung über Arbeitsstätten (Arbeitsstättenverordnung – ArbStättV, Health and Safety at Work Act), available at *www.juris.de*. (2004).
7. Arbeitsstättenrichtlinien (Health and Safety at Work Guideline) ASR5 Lüftung, available at *http://www.gewerbeaufsicht.baden-wuerttemberg.de/servlet/is/16486/5_005.pdf*
8. DIN 4108-2: 2003-07: „Wärmeschutz und Energie-Einsparung in Gebäuden, Teil 2: Mindestanforderungen an den Wärmeschutz“. Beuth-Verlag GmbH, 10722 Berlin (2003).
9. Arbeitsstättenrichtlinien (Health and Safety at Work Guideline) ASR6 Raumtemperatur, available at *http://www.gewerbeaufsicht.baden-wuerttemberg.de/servlet/is/16486/5_006.pdf*
10. Friedrich, M., Bollich; P.; Treichel, M.; Erhorn, H. and Erhorn-Kluttig, H.: CO2 Gebäudereport 2009 (previously unreleased). German Ministry of Transport, Building and Urban Affairs.
11. Gesetz zur Einsparung von Energie in Gebäuden (Energieeinsparungsgesetz – EnEG, Energy Conservation Saving Act), available at *www.juris.de*. (2009).
12. Erneuerbare-Energien-Gesetz, available at *www.juris.de*. (2008).

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Hungary: Impact, Compliance and Control of legislation

The paper describes Impact, Compliance and Control related to implementation of EPBD in Hungary. Impact is analysed as a driving force towards application of new more demanding requirements, and their results. Compliance is referred to fulfilment of country's obligation, whereas control is discussed as a country's approach to quality of legal solutions.

1 > Hungary: Impact, compliance and control of legislation

As far as the professional problems are concerned Hungary has completed all preparatory actions by January 2006 facilitating the prompt implementation of the EPBD early 2006. At that time the text as well as the numeric values of the requirements, the algorythm of the calculation, a simple software, a printed and an electronic guide were available. Open conferences and a web-site facilitated the discussion. A few hundreds of interested professionals joined the first training courses.

Although the advancement seemed to be promising the Ministerial Decree TNM 7/2006, issued in May 2006 introduced a regulation covering only Articles 3, 4 5 and 6 of the EPBD. The regulation is in force since 01.09.2006. It is to be mentioned that the issue of the Decree would have been more delayed but the regular plenary meeting of the Concerted Action 1 and its satellite conferences in Budapest convinced the decision makers that we are on the right way.

The content of the regulation, covering Article 7 has been discussed and published in January 2006, too. Originally asset method has been chosen, based on the average climatic data and the "standardised" users' behaviour (the last deducted from statistics in case of residential, office and school buildings). The proposed asset method is simply the repeat-calculation of the design with the input data of the real building (existing or under commissioning). This method has been accepted in January 2006 by the professional society as well, as by the State Office of Housing and Building, being responsible for the implementation of the EPBD.

In summer 2006 the State Office has been dissolved, a few of its staff members continued their activity in the Ministry of Local Authorities and Regional Development. In the new administrative environment the ready to publish regulation became a subject of concerns because of the expected reaction of the general public, since a new service is spoken of, which is compulsory and should be paid, although it was not asked for. New ideas have been raised by the Ministry: the certification of existing buildings should be based on the energy bills, the cost of certification should not exceed the equivalent of about 50 € in the case of single family houses and individual flats, the advises, aiming at energy saving measures should be optional only. Finally late 2008 a Governmental Decree has been issued on the implementation of the certification: according to this decree the certification of new buildings is compulsory from January 2009, that of the existing buildings will be started in 2011 only. The category of public buildings, obliged to display the certification has been restricted to the minimum.

There is no information who is developing or will develop the protocol of the energy bill based certification – at least the team, which developed the original proposal, is not involved. The method should be used only from 2011, however the experts would need some months before the start of the activity.

Regarding Article 10 the Chamber of Engineers and the Chamber of Architects agreed early 2006 that a common examination board will issue the licences for the experts. This agreement has been approved by the State Office of Housing and Building. The Chamber of Engineers was about to start the exams already in 2006, however, due to the lack of the regulation the exams were started only one and half year later.

2 > Impact of the EPBD on the national requirements

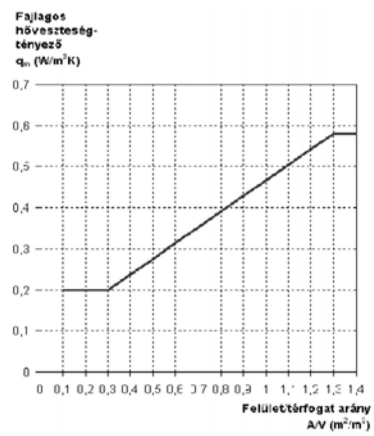
The new requirements are mandatory for building permits requested after September 1st 2006. Building permit must be asked for new buildings as well as for major renovation. In the last case the 1000 m^2 rule is recently applied. The main concept of the requirement system is the separation of the components of energy need into distinct categories: components, depending mainly on the building and those, depending mainly on the users.

Building element	U
Exposed wall	0,45
Flat roof	0,25
Attic floor slab	0,30
Heated attic	0,25
Floor slab over arcade	0,25
Floor slab over basement	0,50
Window, non metal frame	1,60
Window, metal frame	2,00
Non openable glazing	1,50
Toplit	2,50
Entrance gate	3,00
Door	1,80
Partition wall heated-unheated	0,50
Partition wall heated-heated	1,50

Although the distinction could not be “absolute” it is obvious that – at prescribed indoor temperature and climatic conditions – the net heating energy need to cover the transmission losses depends on the thermal envelope of the building whilst e.g. the net energy need to cover the domestic hot water consumption relates to the users. According to this concept the requirement system has three different levels: the building and its service systems must comply with all of them. The levels are the followings:

- Building elements
- Building
- Building and service system together

The proof of compliance must be made at two steps: when requesting the building permit and after completion of the building.

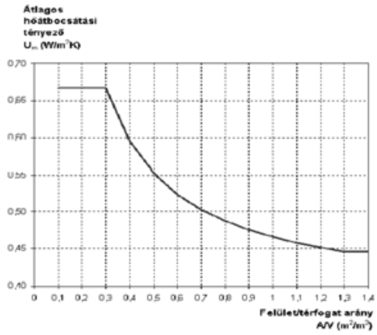


Specific net heating energy demand W/m³K vs surface to volume ratio.

Regarding the building elements the U-values of wall, flat roof, attic floor slab, window, entrance gate, etc. are limited (see a sample in the table). The relative high U-value of wall is the consequence of a lobby actions – this value correspondes to the best masonry blocks without added insulation layer.

Whatever the case of the requirements on the level of the buildings the required U-values must not be exceeded. At the same time it is to be emphasised that the compliance with the requirements of building elements *does not guarantee* the compliance with the requirements of the building as a whole! Many times the requirements on the level of the building can be met only if the elements are better – it depends on the surface to volume ratio, on the glazed ratio, etc.

Regarding the building as a whole a specific heating load requirement and the risk of sumer overheating must be checked.



The overall average U value vs surface to volume ratio.

The specific heat load includes all building related components of the energy balance, namelly:

- transmission heat losses including thermal bridge losses,
- utilised solar gains.

The unit of this specific value is W/m^3K, its range is 0,20 – 0,58 (see figure on the left). The requirement depends on the surface to volume ratio (in other terms on the form factor) of the building. This requirement must be met, whatever building use is. Regarding the utilised solar gains there are more options: they can be neglected (in this case better insulation should be applied), or the gains can be taken into account with a conservative value for shadowed facades or the gains can be taken into account with differentiated values for the different orientations if solar access is proven using shadow mask calculator. The more the utilised solar gains, the lower insulation level can be accepted, however no U-value of any building elements may exceed the limit, given in the table on the left.

The form of the requirement is the same as that of the national standard, being in force since 1993, however, the impulse of the EPBD resulted in more serious numeric values.

At the first sight the diagram may suggest that the requirement for larger and more compact buildings is very strict, however the reality is the opposite: the higher the surface to volume ratio, the more strict thermal insulation must be applied. Providing the solar gains are neglected, the overall average U-value (including windows, doors and thermal bridges) must not exceed the limit, shown in the diagram. The range is 0,44 – 0,67 W/m^2K. The above overall average U value is less by about 40% of the value, prescribed in the previous building regulation, issued in 1993.

With regard to the risk of summer overheating only a simple estimation is possible since the regulation relates to the building as a whole whilst the indoor temperature can be precisely calculated only room per room. The regulation aims at the limitation of the expected daily average indoor temperature. The input data includes the solar gain, the internal gains, correction factors, depending on the possibilities of natural and night ventilation and the thermal mass of the building.

It is important to mention that the fulfilment of the specific heat load requirement does not guarantee that the requirements regarding the building and the services systems together will be fulfilled.

The third level of the regulation includes the building and the service systems together. It is expressed in kWh/m^2a primary energy need. Gross energy need of heating, cooling, ventilation, domestic hot water and – except residential buildings – artificial lighting is taken into account. For residential, office and school buildings the limitation is prescribed as a function of the surface to volume ratio. Numeral values of the efficiency and the specific self-consumption of the service systems can be taken from the Tables of the Annex unless reliable and more precise figures can be given and proven by the designer. For other buildings and buildings of mixed use a reference value should be calculated, based on the assumption that the specific heat load complies with the requirement and the service systems correspond to reference systems, given in the regulation.

It is to be mentioned that the compliance with the specific heat load requirement does not guarantee that the annual primary energy requirement will be fulfilled: it depends on the service systems and on the energy carriers. Would be the last ones less favourable, the negative consequences must be compensated by better building.

The SOLANOVA building before refurbishment.

Impact of the EPBD on the building stock in terms of energy efficiency

The implementation of the new requirements together with the increasing energy cost has a definite impact on the new buildings. Pro forma all buildings with a building permit issued after September 2006 meet the new requirement, and the majority really does. Energy efficiency became a particular aspect in the PR activity of many designers and contractors. The demo project SOLANOVA proved that even an existing block of flats, build with prefabricated sandwich panels can be renovated according to the Passivhaus standard (85 % energy saving compared with the original state). The first single family houses which got the Passivhaus qualification from the Passivhaus Institute Darmstadt are the recurring topics in the media, proving that low energy building is not a mysterious dream but reality. Nevertheless the ratio of the new buildings is low – at the recent rate the change of the existing building stock would require more than a century.

Close up of the SOLANOVA building after refurbishment. Inlets and outlets of heat recovery ventilation and collector array canopy can be seen.

This is why the refurbishment of existing buildings and HVAC systems is of great importance. Investment subsidies in the framework of the Governmental Programmes represent an important share. The part dealing with residential sector supports an implementation of measures for reduction of energy demand in apartment buildings which includes automatic control of heating systems, added thermal insulation, change of windows, in particular cases implementation of solar systems or heat pumps for space heating and DHW. Such programmes existed well before the issue of the EPBD and have been renewed and announced regularly.

It is to be emphasized that in the case of major renovation the same requirements are to be applied as for new buildings providing the floor area exceeds 1 000 m^2. The renovation is “major” if the cost of it exceeds 25% of the price of the building excluding that of the building site *and* the investment is spent for the building shell and/or the HVAC systems.

Regulations related to energy efficiency and indoor climate

Excepting the checking of the risk of the summer overheating which is a simple estimation for the building as a whole no special requirement is prescribed in the regulation since basic requirements (related to air change rate, Indoor Air Quality) are given in existing standards or may be (up to a limit) subject of agreement between the designer and builder.

Qualified Passivhaus in Isaszeg.

A particular problem is the quality categorisation of office buildings. The expectations in the highest category (set indoor temperature in winter and summer, air change rate) seems to be exaggerated and not well established – at least making nearly impossible the fulfilment of the energy requirements.

Does EPBD affect the building prices, the building market and the building products?

No direct impact of the implementation of the EPBD can be proven. Price of the residential buildings or apartments depends on many factors such as the actual economic situation, the unstable exchange rate of the Hungarian currency, the inflation rate, the interest rate, the taxation and the subsidy system.

Passivhaus in Szada just before comissioning.

Regulations related to renewable energy

The Ministerial Decree 7/2006 includes the requirement that for buildings over 1 000 m^2. floor area the feasibility of use of renewable energy must be checked. The regulation includes the following steps:

Checking the technical possibilities (enough building area of appropriate orientation, slope and solar access for collector or PV array, existing nearby district heating plant and network with free capacity, transportation distance and storage facility of biomass).

If one of the above possibilities exists, calculation of the primary energy is needed for that system, and calculation of the primary energy need for the same building with the reference heating system.

Preference is given to the system with lower primary energy need. Nevertheless the feasibility study in financial terms (discounted pay-back time, net present value) is not prescribed due to the unstable economic and financial situation.

Impact of the implementation of the EPBD on the qualification requirements and independence of energy experts for certification process.

The qualification requirements have been determined by the Camber of Engineers. Certification may be issued by licensed experts. Licence can be obtained after having passed the exam. The examination boards consist of the representatives of the Chamber of Architects or Chamber of Engineers. The applicant must have a BSc or MSc degree in the relevant field (Mechanical Engineering with specialisation of HVAC systems or energy, Building Engineering, Architecture) and practical experience (the required length depends on the degree). In any case the applicant must be registered member of the relevant Chamber.

This license is valid exclusively for issuing certificate. The chambers provide other types of licenses authorizing other type of activities.

On the other hand the experts are not independent. It has already been mentioned that the Governmental Order limited the number of hours spent for a certification as well the hourly rate. The expert has no time allowance to check whether the building has been built according to the design. His/her possibility is restricted to review the calculation of the designer and to accept the statement of the contractor that the work has been carried out without any change comparing with the design.

The value of the certificate is further decreased by the fact, that according to the Governmental Decree the certification is to be issued within 60 days *after* the commissioning of the building. As a result the certificate is hardly more than a blank paper.

3 > Compliance and control[1]

Compliance of the EP requirements for buildings

The fulfilment of EP requirements in respect of the design is acceptable. Requirements exist on three levels and are to be applied in case of major renovation. Design guides and unified software are available. Technical feasibility of the use of renewable energies must be checked. The fulfilment of the regulation on all three levels of the requirements is the precondition of the building permit. Pro forma the local authorities have to check the calculation and the design however many times they settle for the declaration of the designer that the requirements are met.

Compliance of the EP certification process

No compliance can be spoken of since the certification of existing buildings will be started only in 2011. As far as new buildings are concerned the restricted time allowance and hourly rate mean hardly more than a signature on a form.

[1] Compliance means the fulfilment of EP requirements and EP certification process while control is the mechanism for checking the compliance.

Qualified Experts

Certification may be issued by licensed experts. Licence can be obtained after having passed the exam. The examination boards consist of the representatives of the Chamber of Architects or Chamber of Engineers. The applicant must have a BSc or MSc degree in the relevant field (Mechanical Engineering with specialisation of HVAC systems or energy, Building Engineering, Architecture) and practical experience (the required length depends on the degree). In any case the applicant must be registered member of the relevant Chamber.

Although participation at training course is not a precondition of the examination (since printed guide and interactive electronic guide are available) about 1500 practicing engineers and architects joined the training courses, run by universities and other bodies. The Chamber of Engineers together with the Chamber of Architects started the examinations in 2008. The subject area of the examination is the asset method of certification since disregarding the before mentioned ominous sentence no rules, protocols of certification based on energy bills have been published. At this moment (end of 2009 it does not represent a problem (!), since the certification of existing buildings will be launched only in 2011. Providing the certification method will really be changed for existing buildings, the training courses as well as the examinations should be restarted or it will be supposed that those having already the licence will learn the new regulation on their own.

The intention that certification may be issued by energy suppliers makes disputable the independence of experts.

Quality control

When the question of the Quality Assurance has been raised the responsible ministry has had different offers. One of its background institutes as well as both of the Chambers shown interest, all of them have had neither experience nor infrastructure for data collection and elaboration. The necessary development would have cost of 80-90 Million HUF. There was a commercial initiative (from RAMSYS), which has a long term experience in the field of data collection and elaboration. It means that the data of the certification can be uploaded on-line to a central server. During the process the consistence of the data and the accuracy of the calculations are checked: in case of any problem the user will receive an alert. Data are saved safely, can be downloaded by those who have access, data can be filtered and selected for statistical purposes, etc. The infrastructure was and is ready to use, the EPB software was added special modul for the communication of the server, a few hundreds tests have been carried out successfully. No financial support has been requested. This offer has not been accepted. Actually the certificates (together with many other documents) are collected in a background institution of the ministry as a loose pile without checking – the procedure (due to the collection of designs) is on the desk of the ombudsman.

4 > Additional incentive policies related to the EPBD

Investment subsidies in the framework of the Governmental Programmes represent an important share. The part dealing with residential sector supports an implementation of measures for reduction of energy demand in apartment buildings which includes automatic control of heating systems, added thermal insulation, change of windows, implementation of solar systems or heat pumps for space heating and DHW. Such programmes existed well before the issue of the EPBD and have been renewed and announced regularly.

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As the subsidy budget for each Programme is limited only part of the applications are granted. Selection is usually based on the time of application (the earlier submission means bigger chance for grant).

Exigency rather than energy consciousness resulted in the wide spreading or return of the use of biomass in villages where the boiler and the fuel of existing central heating systems have been changed.

A new incentive programme has been prepared. It is based on the Green Investment Scheme, paid out of revenues from emission trading. A further version called Blue Investment Scheme is under development. In these schemes the subsidy depends on the energy efficiency of the renovated building: the higher category will be achieved the higher will be the financial support. Rules of calculation and monitoring have been developed, however due to the unstable economic situation they are not implemented yet. This programme will not be restricted to prefabricated blocks of flats. Eligible applicant for the subsidy will be private owner, housing associations, association of owners and municipalities.

5 > References

1. Dr Csoknyai Tamás: Solanova projekt, a jövő panelháza, part 1 and 2. MAGYAR INSTALLATEUR (ISSN: 0866-6024) 18:(8) pp. 48-49. (2008).
2. Dr. Csoknyai Tamás – Talamon Attila: Passive houses in Hungarian environment. 15th "Building Services, Mechanical and Building Industry Days". International Conference, Debrecen, 15-16 October 2009, ISBN 978-963-473-314-0, pp. 94-106.

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Lithuania: Impact, compliance and control of legislation

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The paper describes Impact, Compliance and Control related to implementation of EPBD in Lithuania. Impact is analysed as a driving force towards application of new more demanding requirements, and their results. Compliance is referred to fulfilment of country's obligation, whereas control is discussed as a country's approach to quality of legal solutions.

More information can be found at the ASIEPI project website: *www.asiepi.eu*

Similar Information Papers on ASIEPI and/or other European projects can be found at the individual project websites and in the publications database of the BUILD UP Portal: *www.buildup.eu*

1 > Impact of the EPBD on the national requirements

The main provisions on the energy performance of buildings and the certification of the energy performance of buildings are described in the Law Amending the Law on Construction no. x-404, adopted 17 November, 2005 by the Parliament of the Republic of Lithuania. The calculation procedure is described in Technical regulation of construction STR 2.01.09:2005 "Energy performance of buildings; Certification of energy performance of buildings", adopted on 20 December, 2005 by the order no. D-1-624 of the Ministry of the Environment. The procedure to qualify for a right to certify energy performance of buildings is described in Technical regulation of construction STR 1.02.09:2005.

The software for calculation of EP of buildings was prepared and adopted by the Ministry of the Environment. The training program, rules and procedures for experts were adopted by the Orders of the Ministry of the Environment. The institutions responsible for the training and attestation of experts were appointed. The Commission was constituted for the attestation of the experts.

Regulation shall be applied for estimation of energy performance of heated residential and tertiary sector buildings and for certification of energy efficiency of the buildings. The targets of the Regulation are action on environmental protection, rational and economic use of energy sources (petroleum products, natural gas, solid fuel etc.), which are the most important sources of carbon dioxide emission; Forming the presumptions of effective energy consumption in residential and tertiary sector buildings, for energy demand management; Reduction and limiting of the emission of carbon dioxide into the environment; provisions; that construction products and the engineering installation shall be designed and built in such a way, that energy consumption shall be as low as possible with regard to local climate and the comfort of inhabitants.

The implementation of the EPBD and related national legislation creates an independent control system of energy performance of buildings. New buildings shall meet the minimal requirements of energy performance and the optimal use of factors relevant to enhancing the energy performance of the buildings shall be promoted. The implementation of requirements of energy performance determines the fulfilling of indoor climate requirements. The requirements presented in the national legislations of Lithuania fully conform to the requirements of EP presented in article 7 of the EPBD. Major repairs of existing big buildings shall be considered an opportunity to implement effective energy saving measures with the aim of increasing the energy efficiency of the buildings. Technical measures for better energy performance then indicated in EPBD are coming in 2010. With the beginning of EP certification of buildings, a relationship between the EP and the price of the building emerged. Minimum ventilation requirement are for residential buildings only, however, the implementation of EPBD results in the ventilation systems evaluation for all types of buildings. There are no requirements for use of renewable energy sources in buildings, but the Government policy is to promote such action. At the moment the evaluation of energy performance of buildings is based on the calculation of energy demand for heating. With the establishment of the Directive, a new independent system of qualification requirements, training, further education and control of experts of EP certification of buildings was created.

2 > Compliance and control of EP requirements

Certification requirements for new buildings came into force on January 1st, 2007. Requirements for new buildings are:
The energy performance class of new buildings (or building part) must be not worse than class C. This requirement is valid for all new buildings, for which the set of the design terms (references) was issued before the Regulation came into force (January 4th , 2006).

Certification requirements for existing and refurbished existing buildings came into force on January 1st, 2009. Requirements for existing buildings are:
The energy performance class of large buildings (or building part) with a heated area of more than 1000 m^2 after major renovation must be not worse than class D. This requirement is valid for all buildings undergone major renovation, for which the completion of the design terms were issued after the Regulation came into force.

All building certificates are published on the internet. The certificates of energy performance are obligatory for new buildings before the procedure of acceptance of structures as serviceable, as well as for buildings (building part) for sale or rent. Buildings that do not conform to the EP requirements cannot be accepted as serviceable, their performance must be improved to conform to the minimal requirements. The experts must inspect the building, the methods of determining the building characteristics are chosen by the expert. The responsibility for the validity of EP of a building lies on the expert.

3 > Compliance and control of EP certification

The first certificate of the energy performance of a building was issued on 10th of January, 2007. The Certification Center of Construction Products under the Ministry of Environment was appointed to manage the attestation of experts and the registration of certificates of the energy performance of buildings. Enclosed with the certificate, general information about the building collected by the expert is sent to Certification center database. A representative of the Certification Center or a different certification expert delegated by the representative is permitted to carry out a primary evaluation of the certification process and the validity of certification. Should instances of improperly carried out certifications be determined, the expert may have his certificate of expert limited or discarded.

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The certificates of energy performance are obligatory for new buildings before accepting them as serviceable, as well as for buildings (or building part) for sale or rent.

No legal action involving the building can be carried out without a valid certificate.

The qualifications required from the experts are: engineer diplomas with experience of three years in construction, special training courses and required certification practice of three buildings.

Expert's training program was prepared on June 21st, 2006 and adopted by the Order no. D-1-305 by the Ministry of the Environment. The training courses for experts started in November and the first group of 30 experts was attested on December 11th, 2006. At the moment, 250 experts have been attested. The software has been prepared and adopted. Two institutions were appointed as teaching organisations for experts: Institute of Architecture and Construction of Kaunas University of Technology and Quality Management Center of Vilnius Gedimino Technical University (32 hours of training and three certified buildings as practical experience). Revision training program of experts takes place every 5 years.

The expert may belong to company or act as a private entity. The sole responsibility for the validity of the results of certification lies on the expert.

4 > Future planning

From 2010 onwards, the Lithuanian Government plans to subsidize only those building modernization projects upon completion of which a level of heat consumption no higher than the regulated. These regulated requirements for renovated buildings are approximately 30 % stricter than the minimal D class requirements.

5 > References

Detailed official information, texts and tools will be available on the national websites. Primary information and related legal acts are already available on the national websites *www.am.lt*; *www.spsc.lt*; *www.ukmin.lt.*

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An effective Handling of Thermal Bridges in the EPBD Context

Summary report

Main authors:

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SUMMARY

The Intelligent Energy Europe project ASIEPI 'Assessment and Improvement of the EPBD Impact (for new buildings and building renovation)' has collected and analysed international and national information from up to 17 EU Member States plus Norway on the topic of thermal bridges in buildings. Seven different tasks have been addressed ranging from EU Member States approaches in regulations to quantification of thermal bridge effects to the energy balance, used software tools and thermal bridge atlases, available good practice guidance and promotion of good building practice to the execution quality and advanced thermal bridge driven technical developments.

For many of these items it can be said that to some degree high quality material is available in most of the EU Member States (like software tools for calculating thermal bridges, thermal bridges atlases and promotion of good practice guidance). It would be desirable that the material is used more often by building practitioners and that some countries catch up with the others. Software for calculating thermal bridges should be validated and the validation results published.

All EU Member States plus Norway consider thermal bridges in the energy performance assessment of new buildings, but to a lesser extent in the assessment of existing buildings that undergo major renovation. A detailed assessment of thermal bridges allows for compensation of other energy influences due to better building junction solutions. The use of default values on the other hand makes the calculation of energy performance faster.

Several Member States have included specific requirements concerning the quality of building junctions in their regulations. These can be maximum linear thermal transmittances or minimum dimensionless temperature factors.

Some countries have a meticulous check of details during or after the design phase of a building. Few countries have a detailed quality assurance of the execution quality on the construction site. ASIEPI has collected ways to assess the execution quality, but also possible sticks and carrots to improve the realisation of building junctions.

The search for thermal bridge driven industry developments was not an easy task. However, the report contains some products that can reduce thermal bridges in buildings significantly. It has to be mentioned that most of these products are produced and used in central Europe. A regulation that allows the detailed assessment of building junctions and is up-to-date with innovations supports these kinds of solutions (see also ASIEPI topic ‘The EPBD as support for market uptake for innovative systems’).

The main recommendations, which are described in more detail in part A, can be summarised as follows.

Policy makers:

- Include the assessment of thermal bridges in the energy performance calculations for new buildings, but also with at least a simplified approach for existing buildings in case of major renovation.

- Set minimum requirements or at least recommendations for inner surface temperatures.

- Include a quality assurance procedure for the design and the realisation of building junctions in your national building regulations.

- Offer to use values lower than the default value for thermal bridges according to the result of detailed calculations. Due to that improved joints can be used as a method to improve the energy performance of buildings, similar to better insulation, more efficient systems, etc.

- Explicitly require that thermal bridge software used in the context of the EPBD-regulation must satisfy the validation cases of EN ISO 10211.

▪ (National) standardisation bodies:

  - Include simplified and detailed assessment methods for thermal bridges in the national energy performance assessment standards.

  - Develop a procedure for setting minimum requirements on the energy quality of building joints that covers the energy impact and - even more importantly - includes the guarantee that no moisture or mould problems occur.

  - The impact of thermal bridges in winter (heating energy demand and heating load) and, depending on the boundary conditions partly on the summer performance of buildings (cooling load) cannot be neglected and should be included in the national calculation methods either using default values and/or detailed calculations.

  - Provide best practice guidelines as part of standards or accompanying information.

▪ CEN/ISO:

  - Publish in the short term a corrigendum for the errors in case 3 of annex A (and elsewhere in the text) of EN ISO 10211:2007. *In the meantime CEN has decided to correct the errors!*

  - In a future revision of EN ISO 10211, a more comprehensive set of validation test cases seems warranted (more complex boundary conditions, non-rectangular geometries and air layers).

▪ Building practitioners:

  - Include the detailed assessment of the building junctions in the calculation of the energy performance of buildings.

  - Have a thorough look at building junctions during the design of the building, but also during the realisation on the construction site.

  - For high-performance buildings the impact of thermal bridges can become significant.

  - Especially for renovation projects building junction solutions have to be checked in order to prevent moisture/mould problems.

Part B gives an overview of all project material that is available on this topic.

Part C is a collection of all the Information Papers produced on this topic.

Finally, Part D presents the related organised web events.

Part A: Final recommendations

1. INTRODUCTION

1.1 THERMAL BRIDGES IN BUILDINGS

Thermal bridges can occur at various locations of the building envelope and can result in increased heat flow, which causes additional transmission losses, lower inner surface temperatures and possibly moisture and mould problems. The additional transmission losses lead to a higher heating energy need and use and are becoming especially important in the case of so-called low energy or high performance buildings. Here, the energy loss due to thermal bridges can be even higher than, for example, the energy benefit provided by thermal solar collectors for domestic hot water. The public awareness of this fact is however very low.

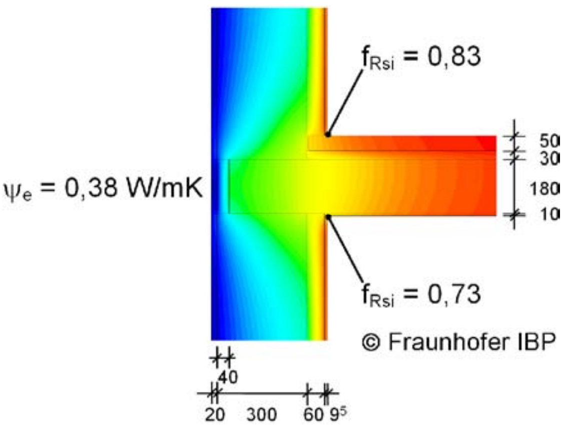

Fig. 1: Example of a thermal bridge effect at a concrete ceiling embedded in the external wall. Calculation of the linear thermal transmittance and the dimensionless temperature factor. The colours illustrate the temperature distribution within the construction.

1.2 TYPES OF THERMAL BRIDGES

Four different types of thermal bridges can be distinguished:

1 Repeating thermal bridges within a construction element (structure or frame constructions). They are included in the overall U-value calculation of the element.

2 Thermal bridges at corners and junctions incl. windows and doors, wall/roof, wall/wall corners. The linear thermal transmittance (psi-value) is multiplied by the length of the thermal bridge.

3 Isolated thermal bridges, like balconies penetrating insulation layers. The punctual heat loss is multiplied by the number of thermal bridges. Many national energy performance calculation procedures do not request the inclusion of the isolated thermal bridges into the energy performance calculation.

4 Air movements within the structure, or between the structure and the outside, or between the structure and the inside (but without direct air transfer all the way from the inside to the outside). Obviously, these (semi) internal air flows affect the transmission heat losses. They can be considered as a form of thermal bridging in a broader sense.

1.3 STANDARDS FOR THERMAL BRIDGES

The international standard EN ISO 10211 [1], [2] is dealing with thermal bridges, but there are national standards available in nearly every European Member State that cover calculation, requirements and good practice solutions.

1.4 ASPECTS OF THERMAL BRIDGES ANALYSED WITHIN IEE ASIEPI

Within the ASIEPI work on thermal bridges the following aspects have been addressed:

- EU Member States approaches in regulations
- Quantification of thermal bridge effects on the energy balance
- Software tools and thermal bridge atlases
- Good practice guidance
- Promotion of good building practice
- Execution quality
- Advanced thermal bridge driven technical developments

1.5 GENERAL APPROACH OF WORK

The approach used in the IEE ASIEPI work was to start with a basic questionnaire answered by experts from up to 17 EU Member States and Norway followed by a collection of more detailed information such as existing national experiences and studies per task.

Based on this various information material documenting the gathered national and international knowledge has been published as listed in Part B.

2. EU MEMBER STATES APPROACHES IN REGULATIONS

2.1 CHALLENGE AND APPROACH

Though thermal bridges are not explicitly mentioned in the Energy Performance of Buildings Directive (EPBD) [3], they are part of the thermal characteristics of the building shell which is one of the aspects that have to be included in the methodology of calculation of energy performances of buildings.

The first aspect within the ASIEPI work on thermal bridges was therefore to analyse if and how the EU Member States' building energy performance regulations deal with thermal bridges and to gather and document the approaches and existing minimum requirements.

The starting point for analysing the countries' calculation procedures and requirements was a questionnaire. The overview of the answers by experts from 13 different Member States was split by geographical and climatic region. Questions were asked concerning the following topics:

- National regulations considering the influence of thermal bridges in new buildings
- National regulations considering the influence of thermal bridges on the renovation of buildings
- Explicit calculation or simplified approach for new buildings
- Explicit calculation or simplified approach for renovation of buildings
- Maximum values for thermal bridges given in national regulations
- Realisation of details checked by authorities during design
- Realisation of details checked by authorities during realisation

The results of the questionnaire [4] could be partly mirrored and discussed at an EPBD Concerted Action [5] meeting with national representatives from all 27 EU Member States.

2.2 CONCLUSIONS

While the assessment of thermal bridges is part of most national calculations of the energy performance of new buildings, many countries do not cover this issue for major renovations in new buildings. Some countries do not set minimum requirements for the energy quality of building junctions. The quality control of the design, but also the execution of building junctions is carried out in different ways. In some Member States there are no controls at all.

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3. QUANTIFICATION OF THERMAL BRIDGE EFFECTS ON THE ENERGY BALANCE

3.1 CHALLENGE AND APPROACH

The ASIEPI project tried to answer the following questions:

- How big are the transmission losses due to thermal bridge effects in absolute and relative values?
- What is the influence on the total final or primary energy consumption of a building?
- Should an energy performance assessment method for buildings include an option for a detailed calculation of the impact of thermal bridges?

Thus ASIEPI has collected and analysed studies dealing with the influence of thermal bridges on the energy performance of buildings which have been performed in different European Member States [6].

3.2 CONCLUSIONS

Most of the collected studies compare existing default values for thermal bridge impacts in national standards with detailed thermal bridge calculations of improved junctions. Other analyses present as results the (total) impact of the thermal bridges on the energy performance without comparing it to default values. Also the number of junctions analysed, the building geometry, the climate, etc. vary between these studies. Still, the results can be summarised as follows:

- The total impact of thermal bridges on the heating energy need is in general considerable and can be as high as 30 %.
- The impact on the cooling energy need is significantly lower. There can be, however, a significant influence regarding the maximum cooling load. Since both cooling needs and cooling loads are strongly related to the “control” strategy of ventilation and cooling (such as night ventilation, use of thermal mass) it can be assumed that these boundary conditions do influence the limited number of studies and experiences available regarding the impact of thermal bridges on the cooling energy issues. Probably there is no simple conclusion concerning the increase/decrease of cooling energy and cooling load based on the impact of thermal bridges. This analysis has to be made for the specific building including building construction, the specific cooling, shading and ventilation strategy, and the specific climate.
- Countries with national default values for thermal bridges have mostly set those values in order to be on the “safe side”, meaning that these are likely to produce slightly higher impacts compared to detailed junction analyses using 3D-simulation programs.
- If national default values are compared with improved junctions with regard to the energy quality, the heating energy impact can be as high as 11 kWh/m²a heating energy need or 13 kWh/m²a

primary energy. Another study showed an influence of 18 kWh/m²a primary energy.

- The relative impact of improved junctions compared to national default values on the primary energy for heating can amount to 15 %.

4. SOFTWARE TOOLS AND THERMAL BRIDGE ATLASES

4.1 CHALLENGE AND APPROACH

Detailed evaluation of the linear or point thermal transmittance can be realised either by numerical calculation software or by thermal bridge atlases. The ASIEPI project has collected and categorised software and atlases used in the EU Member States [7]. A major action has been to motivate the software producers to validate their tools with the relevant method as presented in ISO standard EN ISO 10211.

4.2 CONCLUSIONS

With 26 different software producers, 29 software tools and 26 mostly national thermal bridge atlases as listed in the specific information paper and the final thermal bridge report of ASIEPI (see Part B); there are many tools available for the evaluation of thermal bridges. The software tools can be distinguished by the capabilities (heat transfer only, heat, air and moisture transfer, general/multi-physics), 2D or 3D, steady state or transient, free form or rectangular, possibility for the automatic calculation of the linear thermal transmittance (ψ-value), free or commercial and validated (and documented) or not.

<u>Thermal bridge assessment software:</u>

The main problem encountered at the start of the enquiry was the lack of systematic and up-to-date proof of validation. At the time of publication of this report, some software still did not have documented validation. There lingers a certain degree of doubt over the calculation results of such non-validated software. Their use in the framework of energy performance of buildings regulations of Member States should be therefore better avoided.

As a reaction to the motivation by ASIEPI, 4 software producers updated the available information for in total 9 software tools. 5 additional producers presented the validation for 5 tools for the first time on the internet.

<u>Thermal bridge atlases:</u>

A considerable collection of such documents is available. Most of them are written in the language of their country of origin and have not been translated. Of course, this may be one of the main reasons that make the use of such documents in other countries rather difficult. However, the available thermal bridge atlases mostly show design solutions that are used in a specific Member State, which might be an argument against the translation into other languages. The construction of buildings is still influenced by the cultural and historical boundary conditions. This might result in a limited applicability of a translated thermal bridge atlas.

5. GOOD PRACTICE GUIDANCE

5.1 CHALLENGE AND APPROACH

Most areas of Europe need good thermal insulation in order to conserve energy and to improve indoor climate. Minimising thermal bridges is an important part of achieving this aim. However, even in well-insulated buildings, thermal bridges are often neglected. Good practice guidance documents published by either building authorities, standardisation bodies, energy agencies or organisations planning to publish or update their own construction details can help to improve the situation.

The work on this topic resulted in two information papers, one dealing with suggestions for what should be covered in good practice guidance, how it can be structured and presented and the other one showing a selection of good examples from different countries. The papers have been published together with an electronic archive containing over 60 reference documents with clickable hyperlinks for opening the individual documents [8], [9].

5.2 CONCLUSIONS

Best practice guidelines are a very useful means to stimulate better building details concerning thermal bridges and airtightness. There are various good approaches available in different EU Member States which are presented in this chapter, but there are also many Member States that have limited or no good practice guidance for building details.

A guideline for developing a good practice guidance concerning structure and content was developed and can be used in countries without yet available good practice guidance.

Good practice guidance can be developed as official documents in connection with the building regulation (as for example in UK and Ireland) but also by building practitioners or the building industry. In some countries good practice guidance or tailored thermal bridge atlases have been developed for specific building industry companies, e.g. for pre-fabricated houses. This should be transferred to other companies and other countries.

6. PROMOTION OF GOOD BUILDING PRACTICE

6.1 CHALLENGE AND APPROACH

On the basis of the answers given to the questionnaire circulated in the starting phase of the project, ASIEPI collected promotion means for good building practice used in the countries. The experts from 17 Member States and Norway came up with 10 different possibilities for promotion. Positive examples for the different possibilities are presented in the final ASIEPI report of thermal bridges [10]. It also became clear that in a few countries good building practice seems not to be promoted at all.

6.2 CONCLUSIONS

In the 17 EU Member States and Norway good building practice or more detailed solutions to reduce thermal bridges in buildings are promoted by the following means:

- Special courses for practitioners
- Parts of courses on good application of current building regulation
- Parts of courses on high performance buildings
- Parts of student curricula

- Public relation activities of industry companies and associations
- Workshops/Internet information sessions organised by projects
- Handbooks with example details (see also chapter 5)
- Publications in journals
- Road shows/exhibitions
- Presentations/papers at conferences

Though there are various promotion means for bringing thermal bridges in building envelopes to the awareness of standardisation bodies, policy makers, building practitioners, etc., they are not widely used in the EU Member States, according to the questionnaire in ASIEPI. It is most important that the building practitioners and the future architects and civil engineers, namely the students, will receive good lectures on the impact of thermal bridges and learn how to successfully reduce or even avoid them.

7. EXCECUTION QUALITY

7.1 CHALLENGE AND APPROACH

Execution quality can have a significant effect on the energy consumption of buildings. The occurrence of thermal bridges due to faulty execution can dramatically increase heat losses and, in the worst case, even result in moisture problems seriously affecting the indoor climate. At present, there is little or no information available on this topic. Therefore a study [11] was initiated to quantify the effect of thermal bridges due to faulty execution. The study encompasses two different analyses:

1. A survey conducted among the participating Member States concerning previous, individual national studies on the influence of execution quality and
2. A questionnaire containing questions pertaining to methods for assessing and stimulating execution quality, i.e. an attempt to quantify which factors actually are affecting the execution quality.

7.2 CONCLUSIONS

In the Member States represented in ASIEPI only a few studies have been carried out concerning the relationship between execution quality and thermal bridge effects. These studies indicate that there is a need for increased focus on execution quality.

The Member States use more or less similar methods for assessing and stimulating improved execution quality. Infrared thermography is used to some extent, but is not yet a legal requirement anywhere. Inspections during and after the building process are used quite extensively in all Member States, especially for large buildings. Most countries have legal requirements regulating inspections; however, these do not focus on energy consumption or thermal bridges. There are only very few alternatives to inspections and infrared thermography and they include gas concentration measurements on windows and pre-building process inspections of drawings by specialists. Finally, most Member States use sanctions rather than incentives to ensure good execution quality.

8. ADVANCED THERMAL BRIDGE DRIVEN TECHNICAL DEVELOPMENTS

8.1 CHALLENGE AND APPROACH

In order to inform about actual technical developments to reduce the thermal bridge impact in buildings, the Intelligent Energy Europe project ASIEPI has worked closely together with the building industry via the associated industry partners. Good examples for industry developments have been gathered and have been found and presented by ASIEPI [12]. Though the collected examples do not provide a full market survey they give an idea of the variety of the different currently available developments:

- Thermal breaks for external building components
- Thermals break elements for basement junctions
- Products for mounting insulations material to the wall with reduced thermal bridge impact
- Thermal bridge solutions for window/wall junctions
- Warm-edge spacers for double-glazed and triple-glazed windows

8.2 CONCLUSIONS

Though there are many examples for high quality building junctions published in different good practice guidances that are based on good (architectural/engineering) design, it has to be concluded that not that many products exist that were especially developed to reduce thermal bridges in buildings. A possibility to stay informed, but also to inform others on new technical developments regarding the avoidance of thermal bridges is the new community "Thermal Bridges Forum" on the EU portal for energy efficiency in buildings BUILD UP (http://www.buildup.eu/communities/thermalbridges).

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9. RECOMMENDATIONS

9.1 POLICY MAKERS AND STANDARDISATION BODIES

The assessment of thermal bridges needs to be included in the energy performance calculations for news buildings, but also for existing buildings in case of major renovation. Detailed assessment by calculations with computer software, evaluation based on thermal bridge atlases or use of default values are possible methods than can be integrated in the energy performance calculations.

By setting minimum requirements for the energy quality of building component junctions and other types of thermal bridges, the buildings will reach a higher quality concerning the energy consumption, but even more importantly also guarantee that no moisture or mould problems will occur.

The possibility of using lower thermal bridge impact values, based on detailed calculations in comparison to standard default values will encourage the practitioners to further develop the component joint details. A clear regulatory framework should be created that gives a fair assessment of improved product solutions, compared to poor solutions with a strong thermal bridge effect.

A quality assurance procedure for both the design and the realisation phase will motivate the building practitioners and the building owners to pay attention to the correct realisation of building component junctions. Having inspections before, during and after the building process would be the best solution; however, for economic reasons this will not be viable for all new buildings. The extent of the inspections should be adjusted for each building project, yet energy specialists should always be involved. By increasing the number of mandatory blower door tests, building contractors will be forced to focus on execution quality. The airtight-ness test should be combined with infrared thermography for detecting thermal bridges. Introducing the possibility of withdrawing the license of a designer/contractor for repeatedly providing poor execution quality could significantly centre their focus on this issue. However, the question arises whether this could function in practice. Instead, the public availability of information concerning a contractor's level of execution quality – both good and bad – could have a more positive effect on execution quality. Funding programmes are powerful incentives for increasing focus on execution quality, and previous experience has clearly shown that economic incentives are working well. The reduction of green taxes and/or interest rates for low energy/ passive houses will further reduce the operational cost of the houses. This in turn will increase the demand for this type of houses and thereby decrease their price, meaning that construction companies can cover the extra expenses associated with low energy buildings.

We recommended to explicitly require that thermal bridges software used in the context of the energy performance of buildings regulation at least satisfies the validation cases specified in the most recent version of EN ISO 10211. At present, this is 2007 edition.

It seems highly desirable to publish in the short term a corrigendum for the errors in cases 3 and 4 of annex A (and elsewhere in the text) of EN ISO 10211:2007. (Note: CEN/ISO has decided to correct the errors). In order to avoid repetition of such type of errors in future standards/revisions, structural improvements and systematic quality checks in the process of establishing standards might be advisable. This may require additional funding. In a future revision of the EN ISO 10211, a more comprehensive set of validation test cases seems warranted, e.g. also encompassing more complex boundary conditions, non-rectangular geometries and air layers.

Window U-values should take into account the installation of windows. This would motivate manufacturers to have stronger guidelines for installation and thereby more training for installers.

The number of offered good building practices guidance should be increased especially in countries where few or no such documents exist.

9.2 BUILDING PRACTITIONERS, ARCHITECTS AND BUILDING OWNERS

Better junctions do not only reduce thermal bridge losses but can also improve the airtightness of the building.

If a national regulation foresees the possibility of using lower thermal bridge impact values, based on detailed calculations in comparison to standard default values these low material cost design effort can compensate for more expensive technologies, especially in high performance buildings.

Check whether the software used by you was validated with the most recent version of EN ISO 10211.

Good building practice documents can be very helpful as a basis for good quality building junctions in design and realisation. It is important to stay informed on up-to-date solutions for avoiding thermal bridges on construction sites.

9.3 SOFTWARE DEVELOPERS

In order to improve the reliability of thermal bridge assessment software they should be validated systematically and continuously according to the latest versions of European and International standards and other benchmarking methods, and any proof of validation (including calculation files) should be published on the Internet. The further improvement of the capabilities and user friendliness of thermal bridge software should be continued.

9.4 BUILDING INDUSTRY

A few industry companies have developed specific best practice guidance concerning the reduction of thermal bridge impact for their products. This includes for example prefabricated building companies that have worked together with researchers and designers to optimise their component junctions. This example should be followed by other building industry companies where applicable.

The developments regarding thermal bridge driven details should be increased. Improved solutions should be developed for fixing external loads like balconies, for mounting insulation and/or cladding and for solving re-occuring problematic component junctions. A simple application of the products should also be in the focus of the developments.

9.5 UNIVERSITIES AND OTHER EDUCATIONAL INSTITUTIONS

High quality information on thermal bridges needs to be included in the lectures for architectural and civil engineering students. Educational institutions, but maybe also the building industry should offer courses for building practitioners about the impact of thermal bridges including practical examples on how to reduce/avoid them.

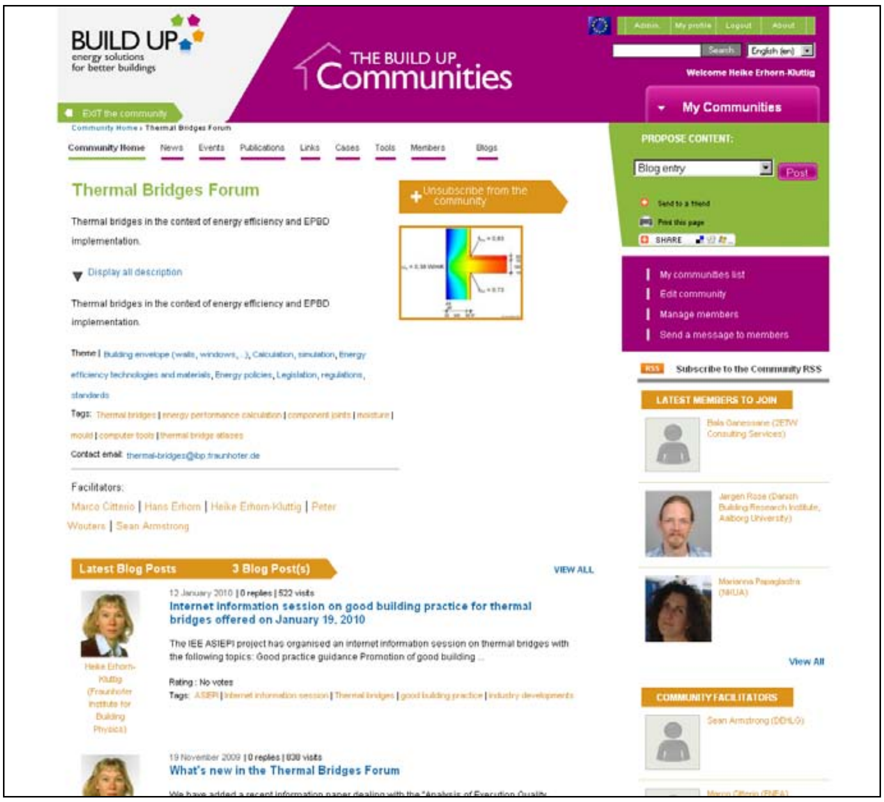


Fig. 2: Screenshot of the BUILD UP community 'Thermal Bridges Forum' that contains together with other relevant information all publications of ASIEPI on the topic thermal bridges.

10. REFERENCES

[1] EN ISO 10211-1:1995 Thermal bridges in building construction - Heat flows and surface temperatures - Part 1: General calculation methods. Standard available via national standardisation platforms as printed version or download.

[2] EN ISO 10211-2:2002 Thermal bridges in building construction - Calculation of heat flows and surface temperatures - Part 2: Linear thermal bridges. Standard available via national standardisation platforms as printed version or download.

[3] EPBD (2002). Directive 2002/91/ EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings, Official Journal of the European Communities, 04.01.2003.

[4] EPBD Concerted Action: Website with information on the joint initiative of the EU Member States and the European Commission. http://www.epbd-ca.org/index.cfm?cat=home.

[5] Citterio, M.; Cocco, M.; Erhorn-Kluttig, H.: Thermal bridges in the EPBD context: overview of MS approaches in regulations. Information paper P064 (2008). http://www.buildup.eu/publications/1449.

[6] Erhorn-Kluttig, H.; Erhorn, H.: Impact of thermal bridges on the energy performance of buildings. Information paper P148 (2009). http://www.buildup.eu/publications/2345.

[7] Tilmans, A.; Van Orshoven, D.: Software and atlases for evaluating thermal bridges. Information paper P197 (2009). http://www.buildup.eu/publications/5657.

[8] Schild, P.; Blom, P.: Good practice guidance on thermal bridges and construction details – Part 1: Principles. Information paper 188 (2010). http://www.buildup.eu/publications/8239

[9] Schild, P.: Good practice guidance on thermal bridges and construction details - Part 2: Good examples. Information paper 189 (2010). http://www.buildup.eu/publications/8241.

[10] Erhorn, H.; Erhorn-Kluttig, H. et al.: An effective Handling of Thermal Bridges in the EPBD Context - Final Report of the IEE ASIEPI Work on Thermal Bridges (2010). http://www.buildup.eu/publications/8832 and http://www.asiepi.eu/wp-4-thermal-bridges/reports.html.

[11] Engelund Thomsen, K.; Rose, J.: Analysis of execution quality related to thermal bridges. Information paper 159 (2009). http://www.buildup.eu/publications/6292.

[12] Erhorn, H.; Erhorn-Kluttig, H.: Advanced thermal bridge driven technical developments. Information paper 190 (2010). http://www.buildup.eu/publications/8665.

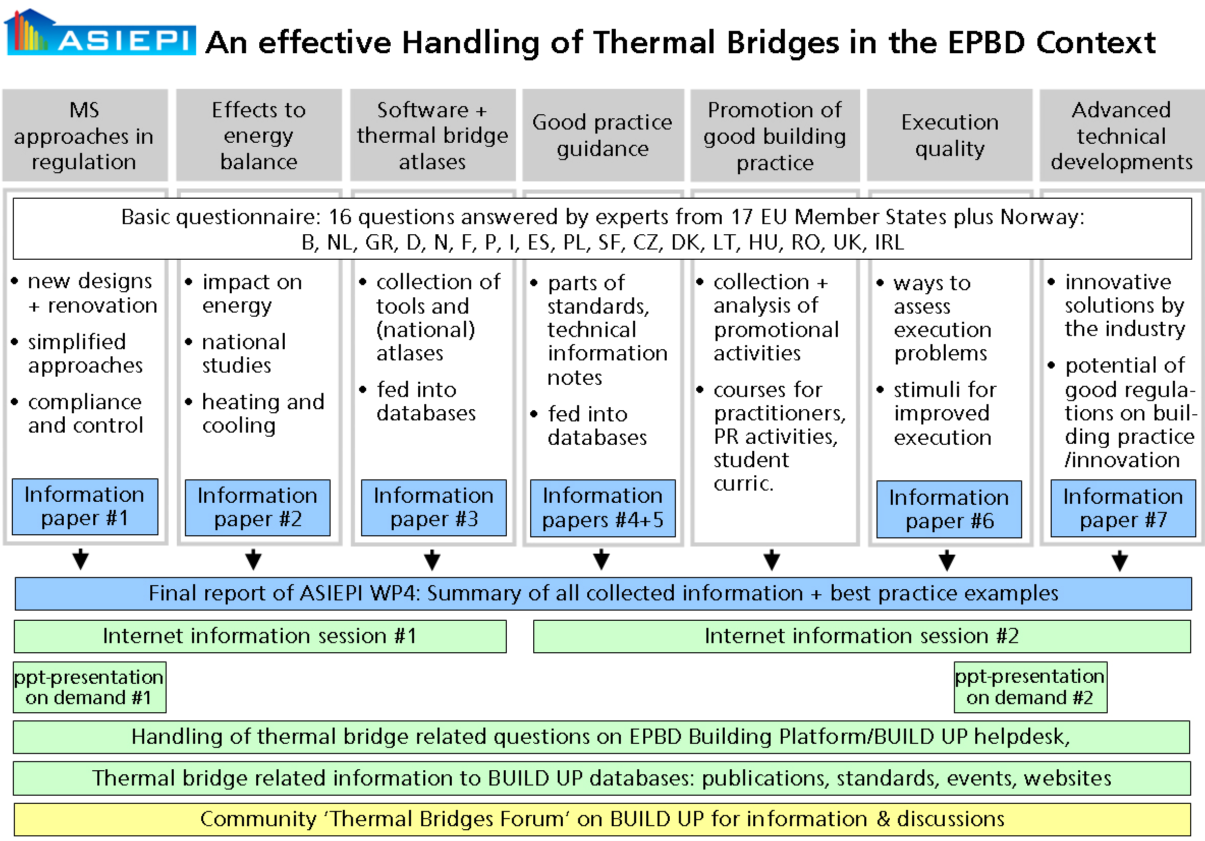
Part B: Bird's eye view of the project results

11. INTRODUCTION

Within the ASIEPI work on thermal bridges the following aspects have been addressed:

- EU Member States approaches in regulations
- Quantification of thermal bridge effects on the energy balance
- Software tools and thermal bridge atlases
- Good practice guidance
- Promotion of good building practice
- Execution quality
- Advanced thermal bridge driven technical developments

The corresponding knowledge, experience and available information material of up to 17 Member States plus Norway has been gathered and made available in various publications and other dissemination means as presented in the scheme below and listed in the following:



12. PUBLISHED RESULTS

12.1 FINAL REPORT

The summary of all collected information and best practice examples on all aspects is presented in the final report of the ASIEPI work on thermal bridges *'An effective handling of thermal bridges in the EPBD context - Final report of the IEE ASIEPI work package 4'*. The report was published in April 2010 and is available via the project website and the BUILD UP portal. It contains detailed recommendations to policy makers, standardisation bodies, building practitioners, building owners, software producers, universities and other educational bodies and the building industry about what they can do to reduce thermal bridges in buildings. The report is the basis of the summary report at hand.

12.2 INFORMATION PAPERS

The work on thermal bridges has resulted in 7 information papers, which are all available on the BUILD UP portal:

- P064 '*Thermal bridges in the EPBD context: overview of MS approaches in regulations*', published in May 2008, summarises the Member States approaches on how to deal with thermal bridges during the energy performance assessment of buildings, but also during the design and realisation phase.
- P148 '*Impact of thermal bridges on the energy performance of buildings*', published in June 2009, presents available national studies regarding the influence of thermal bridges on the energy demand of buildings for both heating and cooling. The possible range of impact is analysed for both, conventional and high performance buildings.
- P197 '*Software and atlases for evaluating thermal bridges*' was published in August 2009. It contains collections of thermal bridges atlases and thermal bridges assessment software used in the EU Member States. It also discusses the relevant EN ISO standard for the validation of thermal bridge assessment software and shows which software tools are presented together with actual validation documents on their websites.
- P188 '*Good practice guidance on thermal bridges and construction details – Part 1: Principles*', published in March 2010 presents a guideline for creating high quality good practice guidance on thermal bridges by proposing relevant content, how the guidance should be made available, what kind of illustrations they should contain, etc.
- P189 '*Good practice guidance on thermal bridges and construction details - Part 2: Good examples*', published in March 2010, highlights several examples of good practice guidance for thermal bridges from United Kingdom, Ireland, Norway, Germany, Belgium, Austria, The Netherlands and Romania. An interactive list of all nationally available thermal bridge guidance is accompanying P188 and P189.
- P159 '*Analysis of execution quality related to thermal bridges*', published in October 2009, presents results of three view available national studies on executions quality of building component junctions with regards to thermal bridges. Additionally possible methods analyse the execution quality, but also to motivate or punish building practitioners for good and bad realisation on construction sites are listed.

- P190 '*Advanced thermal bridge driven technical developments*' was published in April 2010. The paper highlights exemplary thermal bridge related industry development for the following items: thermal breaks for external building components, thermals break elements for basement junctions, products for mounting insulations material to the wall with reduced thermal bridge impact, thermal bridge solutions for window/wall junctions and warm-edge spacers for double-glazed and triple-glazed windows.

12.3 CONFERENCE PAPERS

At the AIVC Conference 2009 in Berlin, the paper '*Thermal bridges in the EPBD context*', presented three different issues in connection with thermal bridges:

- National requirements and calculation procedures (detailed and simplified) in the Member States (MS) participating in ASIEPI. In order to facilitate a correct comparison amongst MS regulations, the overview is split per geographical and climatic area: Northern, Central and Southern Europe.

- Impact of thermal bridges on the energy performance of buildings. Studies that analyse the influence of detailed calculations of thermal bridges in comparison of neglecting the influence, but also in comparison with default values for thermal bridges, have been gathered for both summer and winter conditions.

- Thermal bridge atlases and software to calculate thermal bridge effects. An overview and a categorisation of available atlases and software products have been made.

12.4 WEB EVENTS

Two web events were held in connection with the ASIEPI work on thermal bridges (http://www.asiepi.eu/wp-4-thermal-bridges/web-events.html):

1. On March 4, 2009 a 1.5 hour web event '*An effective handling of thermal bridges in the EPBD context*' presented the results of the first three working aspects (Member States approaches, impact on the energy performance and software tool and thermal bridge atlases) together with an industry presentation by one the project sponsors. 56 people attended the event and based on the resulting poll it achieved an overall satisfaction of 4.2 (from 1 – 5 with 5 as highest grade). The programme was as follows:

Introduction
Welcome *by Hans Erhorn, Fraunhofer-IBP, WP4 leader*
Brief presentation of the ASIEPI project *by Hans Erhorn*
Introduction into thermal bridges as covered in ASIEPI by Hans Erhorn
Technical discussions
Overview on Member States approaches *by Marco Citterio, ENEA*
Impact of thermal bridges on the energy performance of buildings *by Heike Erhorn-Kluttig, Fraunhofer-IBP*
Software tools and thermal bridge atlases *by Antoine Tilmans, BBRI*
The industry point of view, expressed by an ASIEPI sponsor
Thermal breaks – challenges for hygro-thermal constructions to meet every requirement *by Piet Vitse, PCE*
Discussions
Questions
Conclusion and closure *by Hans Erhorn, Fraunhofer-IBP*

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2. On January 19, 2010 the second web event '*Good building practice to avoid thermal bridges*' concentrated on the remaining four tasks, namely the good practice guidance documents, the promotion means for good practice guidance, the execution quality control and the technical industry development connected to thermal bridges. It was attended by 76 persons and the total satisfaction was 4.3 (of maximum 5). Also here presenters from the industry have been invited. The programme is shown below:

Introduction
Welcome and introduction to ASIEPI *by Hans Erhorn, Fraunhofer-IBP, WP4 leader*
The ASIEPI work on thermal bridges *by Hans Erhorn*
Technical discussions
Good practice guidance: what should a guidance document contain and national examples for good guidance documents *by Peter Schild, SINTEF*
How is good building practice promoted in EU Member States *by Heike Erhorn-Kluttig, Fraunhofer-IBP*
Execution quality realised in some EU Member States and possibilities of how to check and improve it *by Kirsten Engelund Thomsen, SBi*
The industry point of view
Exemplary industry developments in the field of thermal bridge effect reduction: Isokorb and Novomur *by Ute Schroth, Schöck*
Exemplary industry developments in the field of thermal bridge effect reduction: Flex Systemwall *by Lars Baungaard Andersen, Rockwool*
Discussions
Questions
Conclusion and closure *by Hans Erhorn, Fraunhofer-IBP*

The presentations and the recordings are available on the project website www.asiepi.eu. (http://www.asiepi.eu/wp-4-thermal-bridges/web-events.html).

12.5 PRESENTATIONS ON DEMAND

The following presentations-on-demand are available:

- ASIEPI presentation-on-demand 3 '*Thermal bridges in the EBPD context: overview on MS approaches in regulations*', published in March 2009. It gives an overview on how the different Member States handle the thermal bridges issues in the context of their EPBD regulation. http://www.asiepi.eu/wp-4-thermal-bridges/presentation-on-demand.html

- ASIEPI presentation-on-demand 6 "*Main lessons learned and recommendations from the IEE SAVE ASIEPI project*", published in April 2010 in several different languages. It presents the results of the work on 6 different technical issues analysed in ASIEPI:

  - intercomparison of national energy performance requirements
  - impact compliance and control
  - thermal bridges
  - airtightness
  - innovative systems
  - summer comfort and cooling

12.6 WORKSHOPS

Within the EPBD Concerted Action platform the project ASIEPI presented and discussed its first results at a technical session of the Core Theme 'Procedures'. The session was called '*An effective handling of thermal bridges in the EPBD context*' and collected in workshop-style further information from the participating experts of the different EU Member States.

12.7 HANDLING OF THERMAL BRIDGE RELATED QUESTIONS ON TWO INTERNET PLATFORMS

The project foresaw to try to answer any thermal bridge related question on the Building Platform helpdesk and the BUILD UP portal. No specific questions to thermal bridges were received.

12.8 SUBMITTED THERMAL BRIDGE RELATED INFORMATION ON EXISTING DATABASES

ASIEPI submitted various information material such as the reports, the information papers, the conference papers, the software tools and thermal bridge atlases, relevant national standards, the list of best practice guidances, the available studies on the energy impact and the analysis of the execution quality, etc. on the BUILD UP portal and on the AIVC website.

12.9 THE INFORMATION PLATFORM ON THERMAL BRIDGES

The project started in May 2009 a community on BUILD UP dealing especially with thermal bridges related information: '*Thermal Bridges Forum*'. Members can discuss problems and questions, specific publications, news, events, tools and blogs can be found. All ASIEPI information related to thermal bridges is available in the community. http://www.buildup.eu/communities/thermalbridges

IEE SAVE ASIEPI

Part C. Information Papers

on

An effective Handling of Thermal Bridges in the EPBD Context

EPBD BUILDINGS PLATFORM

ASIEPI

Marco Citterio
Manuela Cocco
Italian National Agency for New Technologies, Energy and Environment – ENEA Italy
Heike Erhorn-Kluttig
Fraunhofer Institute of Building Physics – Germany

www.buildingsplatform.eu

Thermal bridges in the EBPD context: overview on MS approaches in regulations

Within the context of an energy performance regulation, it is essential to take transmission losses into account. If the building details are not well designed or carried out, thermal bridges can substantially increase the transmission losses. Additionally there is a risk of surface condensation and mould growth on the inner surfaces which can cause health and aesthetic problems. This document represents the status in the MS at the end of 2007.

1> Introduction

Thermal bridging increases the building energy demand for heating and cooling. For well insulated envelopes and buildings with an increased energy efficiency, the influence of thermal bridging on the energy consumption will be of a major importance. For such well insulated buildings, the ratio between the thermal bridging effect and the overall thermal losses increases compared to low or medium insulated buildings, and it is possible that the effect of thermal bridges on energy demand compensates or even overtakes, for instance, the energy gain provided by thermal solar collectors for domestic hot water [(1)]. The important impact of thermal bridging on the energy consumption is even more pronounced in the case of building retrofit, where solving thermal bridges often is an issue, especially where external insulation is not applicable because of architectural constraints[(2)] or not effective because of the presence of a lot of balconies.

Almost all MS building energy performance regulations deal with thermal bridges, but the approaches and, especially, minimum requirements may considerably differ.

This document summarizes the requisites and calculation procedures (detailed and simplified) in the MS participating in ASIEPI. In order to facilitate a correct comparison amongst MS regulations, the overview was splitted per geographical and climatic area: Northern, Central and Southern Europe.

2> The EBPD

The objective of the EPB Directive is to promote the improvement of the energy performance of buildings, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness.

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The EPBD articles impose:

- the general framework for a methodology of calculation of the integrated energy performance of buildings;
- the application of minimum requirements on the energy performance of new buildings;
- the application of minimum requirements on the energy performance of large existing buildings that are subject to major renovation;
- energy certification of buildings; and
- regular inspections of boilers and of air-conditioning systems in buildings, and in addition, an assessment of the heating installations where the boilers are more than 15 years old.

3> Thermal bridges approaches in Member States Regulations.

3.1> Northern Europe

Denmark

National regulations consider the influence of thermal bridges in new buildings and in the renovation of buildings, in both cases using a simplified approach.

Simple thermal bridges are typically assessed by hand calculation, complex thermal bridges are assessed by means of a detailed numerical analysis. As regards the complex thermal bridges however, all typical solutions are covered by tabulated values available in standards, atlases or in brochures provided by building materials producers.

Regulations set specific requirements for thermal bridges. For extensions there are specific requirements for the U-values and in addition some maximum values for Ψ_k (value of the linear thermal bridge) which goes from 0.03 W/mK for window fittings to 0.15 W/mK for foundations.

For new buildings the maximum energy performance requirement has to be fulfilled and in addition some maximum values for thermal bridges are imposed: Ψ_k may be at maximum, which goes from 0.06 W/mK for window fittings up to 0.40 W/mK for foundations.

The realisation of details is supervised by public authorities during the project and checked by an energy consultant (from certification scheme).

Norway

Regulations distinguish between thermal bridges of little significance, occurring in building sections due to the way of construction (e.g. insulation between wooden studs, rafter joist) and which should be taken into account in the U-value, and thermal bridges of higher significance (e.g. edges of concrete floor going partly through an insulated wall), which should be evaluated separately.

Both issues are taken into account by explicit calculation which is obligatory for both new and renovated buildings.

In Norway there are two possible ways of satisfying the energy performance requirements of buildings, the framework requirements (which set a maximum energy performance level for entire buildings, according to building type) or the energy measure requirements (which set requirement levels for building envelope sections, e.g. U-values of walls and roofs, and installations (e.g. heat recovery system).

In the energy measure requirement model, the normalised thermal bridge value NKV = $(\Sigma\Psi^*l)/A_{BRA}$ should not exceed 0.03 W/m²K in small buildings and 0.06 W/m²K in larger buildings, where Ψ is the linear thermal transmittance, l is the length of the thermal bridge and A_{BRA} is the available heated area (area within the exterior walls).The wall, roof, and floor U-value requirements are 0.18, 0.13, and 0.15 W/m²K, respectively. In additions there are also requirements related to the ventilation system, external shading, and setback of night time and weekend interior temperature.

For the framework requirements model there is no specific requirement related to the thermal bridges, but instead maximum thermal performance levels are specified for the whole building. Maximum U-value levels are however specified for the various building envelope parts.

Requirements regarding risks of surface condensation and mould growth on the inner surfaces will also limit the size of the thermal bridges. The execution of building details is not checked by authorities.

Finland

National regulations consider the influence of thermal bridges only for new buildings. The approach is a simplified one.

Simplified method 1: for a layer in a structure composed of different materials with different thermal conductivities parallel to the thermal flow: if the λ-ratio (the highest divided by the lowest thermal conductivity of two adjacent layers respectively) is smaller than 5, then the area weighted λ-value can be used as thermal conductivity of that layer. Insulation between wood studs is a typical example. This kind of layer is treated as an “averaged mixture” of two materials in U-value calculations

Simplified method 2: if the previously defined λ-ratio is higher than 5 the detail should be handled as thermal bridge. The effect of the presence of a poorly insulating material on the energy performance of the whole structure has to be modelled with an appropriate (e.g. 3D-calculation) method or with measurements in order to obtain the linear or point thermal transmittance of the thermal bridge. These thermal transmittances summed up over all thermal bridges are added to the U-value:

$$\Delta U_{\Psi X} = \Sigma\Psi_k\,(l_k / A) + \Sigma X_j\,(n_j / A)$$

The Finnish building code does not impose maximum values for thermal bridging, but the structures have to be designed in such a way that the overall heat transfer coefficient of the building design is lower than the reference design heat transfer coefficient calculated with the tabulated U-values from the building code and with the design ventilation rate. Structural details also have to be designed in order to avoid condensation within any part or on any surface of the structure.

The general realisation of details is not supervised by authorities, but an inspector may give guidelines for good practice.

3.2> Central Europe

Belgium

The 3 regions in Belgium are responsible for the implementation of the EPBD. The Flemish Region imposes EPBD requirements since 2006. The other regions are preparing similar regulations.

It is expected that in the near future the regulations will consider the influence of thermal bridges in new buildings applying explicit calculation and simplified approaches.

Five different approaches have already been set in the Flemish calculation method; however the implementation is postponed:

1. The overall transmission heat losses through the building envelope can be obtained from a 3D numerical simulation of the whole building according to the CEN/ISO standards.

2. Thermal bridging can be taken into account by adding the term $\Sigma\psi*l+\Sigma\chi$ to $\Sigma U*A$ in order to obtain the overall transmission heat transfer coefficient. Ψ and χ may be obtained by numerical simulation (CEN/ISO standards) or from tabulated values. User friendly software coupled to a database of details is developed for this approach

3. In case all details in a building are realized according to the regulations, it is allowed to apply to the overall insulation level (K-level) a default value accounting for the effect of thermal bridging on the transmission heat losses. For this approach a set of maximum ψ-values and reference details are developed. The default value will most likely correspond to about 5% of the present requirement for the overall insulation level of a new construction.

4. In case the details of possible thermal bridges correspond only partially to regulations, a separate 2D/3D determination of the ψ- or χ-values for those details is required.
    1. The following losses have to be added:
        a. The default value as specified in 3, which is covering the details according to the regulations;
        b. The influence of the building details which do not comply with the norms set by the authorities.

5. In case the effect of thermal bridges is not taken into account at all, a penalising default value of 10K-points for the extra transmission losses due to thermal bridging has to be added to the K-level (typical Belgian overall transmission heat loss indicator for the building envelope). 10K-points corresponds to more than 20% of the present requirements for new constructions.

Maximum values for thermal bridges are only used in methodology 3 but not as absolute limit values to the thermal bridges.

An energy performance certificate is required for all new buildings for which the energy performance has to be calculated, and for which a building permit has been requested. The drafting and delivery of this energy performance certificate is part of the procedure related to the *'EPB-declaration'* of the executed works after construction. Any aspect of the as-built declaration (thus including the thermal bridges in the future) can be subject to control (and sanctioning with administrative fines) by the public authorities.

The Netherlands

National regulations only consider the influence of thermal bridges in new buildings. This is done via the EP standardisation and an additional standard concerning thermal insulation of buildings [11], which contains an explicit calculation method as well as a simplified approach. This simplified method uses an addition to the U-value (with $\Delta U = 0.10\ W/m^2K$). The detailed method is devised according to CEN standards on thermal bridges: the value of linear thermal bridge (ψ-value) is calculated and added to energy losses by transmission.

The authorities set no maximum values concerning thermal bridges.

Officially the realisation of details is controlled by the authorities, but the realisation of the details is usually not checked.

Germany

With regard to structural thermal bridges, the national standards impose that the impact of thermal bridging must be kept as low as possible.

The remaining influence is taken into account in one of the following ways:

› Overall increase in the heat transfer of the building surface areas by ΔU_{WB} = 0.05...0.15 W/m^{2}K, according to DIN 4108 and DIN V 18599, with:
  - ΔU_{WB} = 0.10 W/m^{2}K as standard value for new constructions
  - ΔU_{WB} = 0.05 W/m^{2}K if realised at least as good as example details in DIN V 4108, supplementary sheet 2
  - ΔU_{WB} = 0.15 W/m^{2}K for existing buildings with internal insulation (DIN V 18599-2).

› Accurate analysis of thermal bridges in accordance with agreed European calculation standards (DIN EN ISO 10211-1/2) or example details with given ψ- or χ-values.

The standards consider the influence of thermal bridges in new buildings and in the renovation of buildings, applying in both cases explicit calculation methods and simplified approaches.

The dimensionless temperature factor f_{Rsi} should be higher than 0.7.

The realisation of details is usually not checked by the authorities.

France

Legal standards consider the influence of thermal bridges in new buildings.

Explicit calculation methods or thermal bridges atlas (Th-U) can be used to determine the linear thermal transmittances. The method used is based on the standards NF EN ISO 10211, NF EN ISO 13370, NF EN ISO 6946.

French standards regarding renovated buildings are under elaboration, and will be available in 2008 (the influence of thermal bridge will be considered).

With present requirements, the linear thermal transmittance may not exceed 0.65 W/mK for dwellings, 1 W/mK for apartment buildings and 1.2 W/mK for other buildings.
The realisation of details is not checked by the authorities.

Poland

Standards consider the influence of thermal bridges in new buildings and renovated buildings, both with simplified approach or explicit calculation.

Simplified method:
A correction factor is added to the U-value:

› exterior wall with openings for windows and doors: ΔU=0,05 W/m^{2}K,

› exterior walls with openings for windows and doors with balcony cantilever passing through the wall ΔU=0,15 W/m^{2}K

Detailed method: calculations according PN-EN ISO 14683

There are only limits for maximum U-values (that take into account

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thermal bridges).

The design is checked by another designer, both are responsible for the correctness of the design.

The building is checked administratively by the authorities before issuing building use permit. Checking is based on formal documentations, so no real test is performed.

Czech Republic

Regulations consider the influence of thermal bridges in new buildings and in the renovation of buildings, applying in both cases explicit calculation methods and simplified approaches.

Methods are described in standards CSN EN ISO 10211-1 Thermal bridges building constructions - Basic calculation methods CSN EN ISO 10211-1, CSN EN ISO 10211-2, CSN EN ISO 14683, CSN EN ISO 13370.

The different values required and recommended for linear and point thermal bridges are:

- Linear: $\Psi_{k,N}$ = 0,10 ...0,60 W/mK (required); $\Psi_{k,N}$ = 0,03 ...0,20 W/mK (recommended).
- Punctual: $\Psi_{k,N}$ = 0,90 W/K (req.); $\Psi_{k,N}$ = 0,30 W/K (rec.).

In special cases the building is checked by the authorities by means of infrared thermography.

3.3> Southern Europe

Greece

At the end of 2007 Greece was still in the process of setting up the EPBD regulation. The currently existing national regulation does not fulfill the EBPD requirements and does not yet consider the influence of thermal bridges in buildings.

Spain

Country standards [9,10] consider the influence of thermal bridges in new buildings and in buildings which are being renovated, applying in both cases explicit calculation methods and simplified approaches.

The simplified method consists of an addition to the U-value in order to take thermal bridging into account and of a proof that there is no condensation risk. The simplified method is based on the selection of the thermal bridge type from an atlas.
The general method consists in the assessment of the linear thermal transmittance (ψ-value) and indoor surface temperature, using a software like KOBRA.

The standards do not set a maximum value for thermal bridges, but there is a minimum value of the indoor surface temperature in order to avoid condensation risks.

When the constructive detail is not included in the atlas, the calculation of its linear thermal transmittance and indoor surface temperature must be included in the project.

Portugal

National authorities consider the influence of thermal bridges for new buildings and for the renovation of buildings. In both cases a simplified approach is used.

All thermal bridges are to be calculated individually, but losses are treated in a simplified manner by using tabulated values, no calculations are needed.

A maximum value for thermal bridges is not given for linear thermal bridges, but only for areas (e.g. a structural beam inserted within a wall): the U-value taking into account thermal bridging may not be higher than twice the U-value of the adjacent wall.

The control is carried out during design and realisation. During the design stage, the design must be submitted to the local authority with the request for a building permit. 1:50 scale drawings of typical situations of thermal bridges (e.g. joint of two vertical walls, verandas, contact with soil, structural beams within walls, etc.) should be included. The qualified expert checks if they meet the requirements of the regulations and if they are correctly accounted for in the thermal calculations.
During realisation, the builder is supposed to prove how the details of the thermal bridges were constructed (e.g. with pictures). In case of doubt, any other means can be used (e.g. thermography, at builders expense) to make sure that the thermal characteristics of the detail "as built" are according to design specifications.

Italy

The regulation considers the influence of thermal bridges only for new buildings, applying both a detailed calculation method and a simplified approach.

Detailed method: according to UNI EN ISO 10211 - 1/2.
Simplified approach: U-value increment according to walls typology and based on the standard UNI EN 14683.

The Italian regulation (DM 192/2005, DM 311/2006) does not impose a maximum value for thermal bridges. It considers a thermal bridge *acceptable* when its U-value - calculated considering it as a fictitious wall - does not exceed by more than 15% the transmittance of the closest wall: in this case the thermal bridge can be ignored; otherwise the weighted average transmittance of the wall and thermal bridge (considered as a fictitious wall) has to be considered and compared with maximum acceptable values for wall transmittance.

During the project, designers have to present a design report to the local authorities including an annex about the envelope characteristics in order to get a permit to build or refurbish. In principle controls on the building site are foreseen, but in practice each local administration has its own procedure.

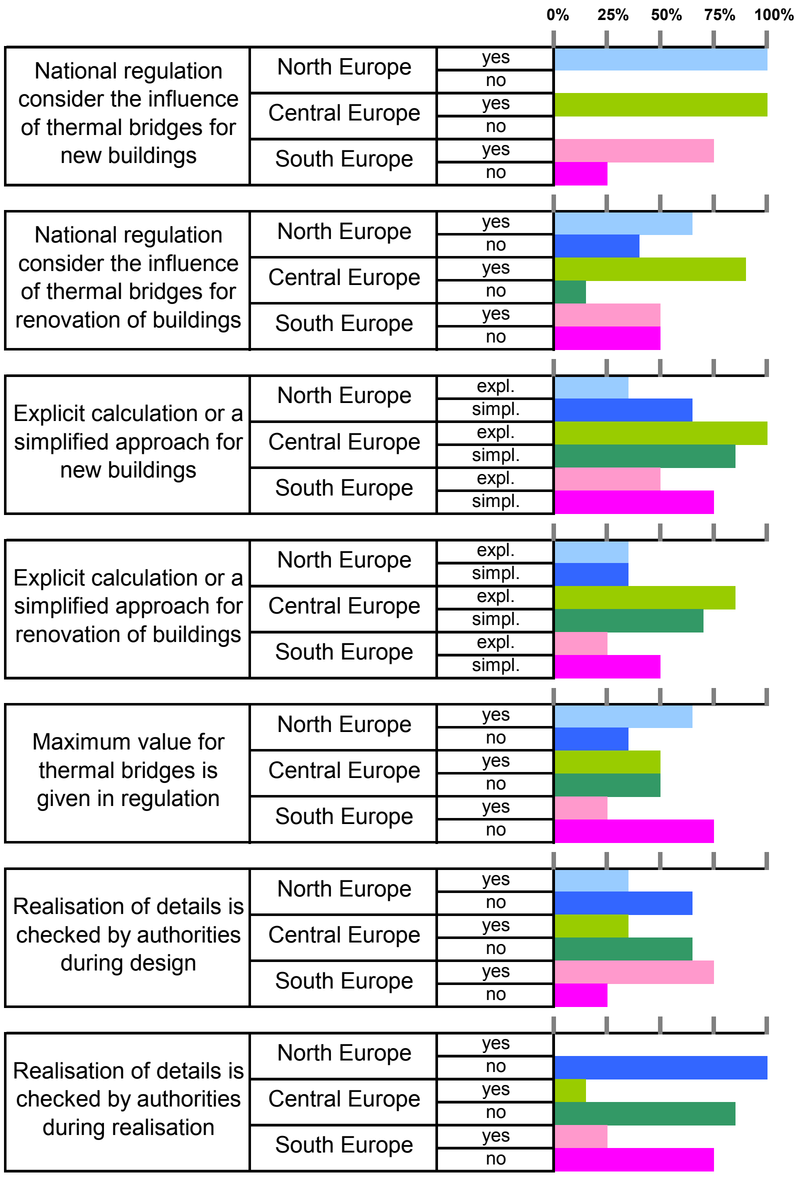
4> Conclusions

This paper analysed if and how Member States deal with thermal bridges in their calculation procedures.

The following table shows that all countries in Northern and Central Europe are dealing with the problem as far as new constructions are concerned. This is not the case for renovation projects.
Specific attention has been given to collecting information on simplified approaches: a simplified approach is most used in Northern and Southern Europe. Only Finland applies special assessment methods (dependent on the λ-ratio).

There are many methods to deal with the maximum value for thermal bridges in regulations: in Germany the dimensionless temperature factor f_{Rsi} is used, in Denmark and Czech Republic a ψ_{max} value is set depending on the type of join, in France the ψ_{max} depends on the type of building.

In addition, compliance and control issues were analyzed: the realisation of details is sometimes checked during the design phase, especially in Southern Europe.



5> References

1. Erhorn, H.; Gierga, M.; Erhorn-Kluttig, H.: „Demonstrationsvorhaben 3-Liter-Häuser in Celle. Proceedings Ziegel-Forum Professoren Tagung, Lindau, Germany. 14th July 2002.
2. Citterio, M et al.: "Reports on the concept development of the demonstration buildings in BRITA in PuBs". Deliverable no. 8, Design report of EU 6FP IP BRITA in PuBs

3. EPBD (2002). Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings, Official Journal of the European Communities, 04.01.2003.
4. EN ISO 10211-1:1995 Thermal bridges in building construction - Heat flows and surface temperatures - Part 1: General calculation methods.
5. EN ISO 10211-2:2002 Thermal bridges in building construction - Calculation of heat flows and surface temperatures - Part 2: Linear thermal bridges.
6. DIN 4108-2 DIN 4108-2:2003-07 Wärmeschutz und Energieeinsparung in Gebäuden, Teil 2: Mindestanforderungen an den Wärmeschutz.
7. DIN V 18599-2: Energetische Bewertung von Gebäuden – Berechnung des Nutz-, End- und Primärenergiebedarfs für Heizung, Kühlung, Lüftung, Trinkwarnwasser und Beleuchtung – Teil 2: Nutzenergiebedarf für Heizen und Kühlen von Gebäudezonen.
8. EN ISO 13370:1998 Thermal performance of buildings - Heat transfer via the ground - Calculation methods.
9. EN ISO 6946:1996 Building components and building elements - Thermal resistance and thermal transmittance - Calculation method.
10. EN ISO 14683:1999 Thermal bridges in building construction - Linear thermal transmittance - Simplified methods and default values
11. Decreto Legislativo 19 Agosto 2005, n. 192 - Attuazione della direttiva 2002/91/CE relativa al rendimento energetico nell'edilizia.
12. Decreto Legislativo 29 Dicembre 2006, n. 311 - Disposizioni correttive ed integrative al decreto legislativo 19 agosto 2005, n. 192, recante attuazione della direttiva 2002/91/CE, relativa al rendimento energetico nell'edilizia.
13. NEN 1068:2001 Thermische isolatie van gebouwen - rekenmethoden ('Thermal insulation of buildings – calculation methods')

Intelligent Energy Europe

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Impact of thermal bridges on the energy performance of buildings

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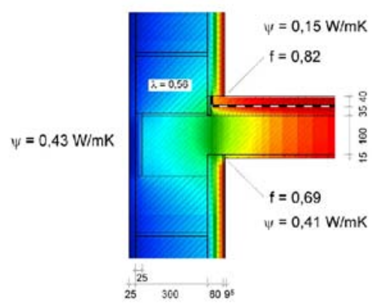

Example of a thermal bridge effect at a concrete ceiling embedded in the external wall.
Calculation of the thermal bridge loss coefficient and the dimensionless temperature coefficient. The colours illustrate the temperature distribution within the construction.
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Thermal bridges have influence on the surface temperature of building components, but also on the energy performance of buildings. The ratio of losses due to thermal bridges to the total transmission losses is small in existing, non-retrofitted buildings but can become quite considerable in new and especially in high performance buildings. This paper summarizes studies on the impact of thermal bridges on the energy performance of buildings in different European Member States and gives therefore an indication on the relevance of including detailed thermal bridge assessments in the EPBD calculation methods.

1 > Questions to be answered

Thermal bridges in building structures and component joints have impact on the surface temperature of the relevant building components. Due to the lower thermal resistance, the internal surface temperature on components with thermal bridges is reduced in winter and can in many cases lead to problems with moisture and mould. Additionally thermal bridges have an impact on the energy performance of buildings as they increase the heat transfer through the building envelope, meaning they cause additional transmission losses in summer and winter. Yet:

- How big are these transmission losses due to thermal bridge effects in absolute and relative values?
- What is the influence on the total final or primary energy consumption of a building?
- Should an energy performance assessment method for buildings include a possibility for a detailed calculation of the impact of thermal bridges?

The Intelligent Energy Europe project ASIEPI has collected studies dealing with the influence of thermal bridges on the energy performance of buildings which have been performed in different European Member States. They are summarised here and a conclusion concerning the importance of a detailed assessment method within the energy performance calculation of buildings is drawn.

2 > International studies on the quantification of thermal bridge effect on the energy performance

As presented in Information Paper 64 “Thermal bridges in the EPBD context: overview on MS approaches in regulations” [1] not all analysed countries consider the influence of thermal bridges in their regulations for

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new buildings and even less for the renovation of existing buildings. In the case of new buildings an explicit calculation of thermal bridges is used in 35 % of the countries in North Europe, 100 % in Central Europe and 50 % in South Europe. Most countries use a simplified approach, e.g. default values for including the increased thermal losses due to thermal bridges. Even in countries where a detailed calculation method for thermal bridges is part of the energy performance calculation standard, a simplified alternative method is often offered. Then the simplified method is applied more frequently than the detailed method.

In some Member States studies on the influence of thermal bridges have been carried out, often in order to see if this impact can be either neglected or substituted by default values. The ASIEPI project has collected studies from the following countries: Germany, France, Denmark, The Netherlands, Czech Republic, Poland, Belgium and Greece. The studies were either made with typical buildings, with a collection of up to 200 buildings, or with pilot projects for high performance buildings. Also the results are expressed in different ways: as additional transmission losses, as additional net heat energy demand or as additional primary energy demand.

Photo of the double house used for the German study on the impact of thermal bridges on the energy performance of buildings.

Main results of the German study on the impact of thermal bridges:

- Improved joints can reduce the energy need for heating by 11.4 kWh/m^{2}a (compared to standard constructions) and 4.4 kWh/m^{2}a (compared to state of the art constructions)
- At high performance buildings the primary energy for heating can be reduced by 4 to 5 kWh/m^{2}a. This is 15 % of the allowed demand for a 3-liter house.
- Thermal bridges can have the same influence as solar thermal hot water generation.

Germany: Demonstration project 3-liter-houses Celle – Thermal bridge influence on the energy performance of the Ziegel-Aktiv-Haus [2]

In this demonstration project concepts for high performance houses have been developed and some of the concepts have been built. The aim was to achieve a primary energy demand of less than 34 kWh/m^{2}a which can be recalculated to less than 3 liter oil per m^2 and year for space heating, ventilation and auxiliary energy. The concepts included different technologies and strategies, one of them being the reduction of energy losses due to thermal bridges. To this end, not only have advanced building joints been developed, but also a study on the comparison of the default values for thermal bridges that are used in the German energy performance code with the explicitly calculated values has been carried out. The German standard DIN V 4108-6 foresees default values for standard joints (ΔU=0,10 W/m^{2}K) and for state of the art joints (ΔU=0,05 W/m^{2}K) according to a leaflet with example joints.

The double house consists of an advanced brick construction with low thermal conductivity of the bricks, highly insulated roof and basement slabs and triple glazed low-E-coated windows. The heating system of each unit is a gas condensing boiler combined with solar collectors feeding into the heat storage and ventilation by window opening in one, and a mechanical ventilation system with heat recovery in the other.

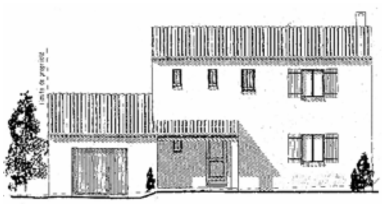
There have been 16 linear joints analysed and improved starting from the external wall corners, window and door frame connections, roof-wall joints, dormer constructions, to connections between wall and slab. The results of the study are presented in the following table:

Savings of Ziegel-Aktiv-Haus compared to	Standard	State of the art
ΔU [W/m^{2}K]	- 0.081	-0.031
Energy need for heating [kWh/m^{2}a]	-11.4	-4.4
Primary energy for heating [kWh/m^{2}a]	-9.9 / -12.6*	-3.8 / 4.8*

* two different heating systems in the double house units.

Compared to the standard values for joints the net energy demand for heating can be reduced by 11.4 kWh/m^{2}a if all joints are well designed and explicitly calculated. Compared to state of the art joints 4.4 kWh/m^{2}a can be saved. For the building systems used in the two units of the double house, the primary energy for heating can be reduced by 9.9 kWh/m^{2}a respectively 12.6 kWh/m^{2}a referred to standard constructions and still about 4 to 5 kWh/m^{2}a referred to state of the art constructions. As 34 kWh/m^{2}a primary energy for heating and ventilation is the limit for such a high performance building, a reduction of 5 kWh/m^{2}a (=15 %) is an important part of the energy concept. The necessary reduction of the wall U-value compared to state of the art to compensate for not improved joints would be 0.1 W/m^{2}K (with a 90 m^2 wall). Thermal bridges (and airtightness) have the same influence as solar thermal hot water generation if compared with standard joints (>10 kWh/m^{2}a primary energy reduction).

France: Thermal bridge influence on the primary energy [3]



Example building used for the French study on the impact of thermal bridges on the energy consumption of buildings.

The French project partners have conducted a study for a new single family house with concrete construction and a gas condensing boiler as heat generator. The house has a suspended ground floor and attic. The climate zone H1A (Paris) was chosen for the study. Nine different thermal bridges were analysed in detail including the connections of basement slab to walls, of ceilings to walls, doors, etc. Then followed an analysis of corrective techniques such as thermal bridge rupture as an isolated measure or in combination with other measures such as the insulation of ceiling and floor.

The results are presented in the following table for the mean U-value of the building ($U_{bât}$ in W/m^{2}K), the difference to the original mean U-value of the buildings and the primary energy demand for heating. The standard realisation resulted in a mean U-value of 0.56 W/m^{2}K, an energy use for heating of 75.92 kWh/m^{2}a and a primary energy for heating of 117.76 kWh/m^{2}a.

Main results of the French study on the impact of thermal bridges:

- Improved joints can reduce the primary energy for heating by more than 18 kWh/m^{2}a (compared to standard constructions)
- This is a reduction of 15% of the primary energy for heating.

Corrective technique	$U_{bât}$ [W/m^{2}K]	Δ $U_{bât}$ [W/m^{2}K]	Saved primary energy for heating [kWh_{PE}/m^2/a]
Thermal bridge rupture	0.50	-0.06	-8.45
Thermal bridge rupture + insulated drop ceiling	0.48	-0.08	-11.34
Thermal bridge rupture + floating screed	0.45	-0.11	-15.37
Thermal bridge rupture + insulated drop ceiling + floating screed	0.43	-0.13	-18.14
External insulation	0.45	-0.11	-15.37

The French study showed that the improvement of joints can result in a primary energy saving of more than 18 kWh/m^{2}a, that is more than 15 % of the primary energy for heating.

Denmark: Low energy class 1 typehouses according to the Danish building regulations [4]

Example building used for the Danish study on the impact of thermal bridges on the energy consumption of buildings.

The low energy class 1 type house is a new highly insulated building with lightweight wooden external walls with a brick facing, a wooden roof construction, a concrete slab floor and joints optimised to reduce thermal bridge effects. The three analysed thermal bridges are those that have specific demands (standard requirements) in the Danish building code. The Danish building code contains stricter requirements for thermal bridges at extensions to an existing house than for new buildings. The following table shows the thermal bridge loss coefficients for the optimised building and the requirements in the building code:

Main results of the Danish study on the impact of thermal bridges:

- The saved primary energy compared to new buildings according to the requirements in the building code is 5.2 kWh/m²a.
- To compensate for this the original U-value of the low energy building of 0.105 W/m²K had to be improved by 0.03 W/m²K.

Type of detail	Thermal bridge loss coefficient [W/mK]		
	Requirement for new buildings	Requirement for additions to a house	Calculated for the low energy class 1 type house
Slab with floor heating - external wall	0.20	0.12	0.063
Slab with floor heating - doors/high windows	0.20	0.12	0.093
Window reveal including window wall joint	0.06	0.03	0.059

The saved primary energy due to improved joints compared to the requirements for new buildings is 5.2 kWh/m²a; compared to an addition to an existing house 1.6 kWh/m²a. If instead of improved joints the same impact should have been reached by a higher insulation of the 154 m² wall, the reduction of the U-value had to be 0.03 W/m²K for the new building. With an original wall U-value of 0.105 W/m²K this is not easy to achieve.

Main result of the Dutch study on the impact of thermal bridges:

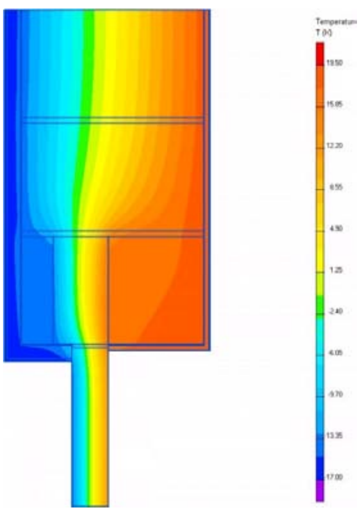
- The detailed calculation of thermal bridges compared to the nationally used default values can lead to reductions in the EP value between 3.75% and 11.25 % depending on the house type.

The Netherlands: Effects of using default values for thermal bridges in the EP calculation versus using detailed calculations [5]

A consulting office was contracted by an insulation manufacturer in 2005 to perform a study to compare the effect of using the Dutch default values for thermal bridges in the energy performance calculation with detailed calculations. The exemplary buildings used for this study were 5 reference new residential buildings with brick construction: an end house, a terrace house, a semi-detached house, a gallery flat and a detached house. For all the houses the lengths and the thermal bridge loss coefficients of all joints have been calculated. The result of the study was the difference in the energy performance between the calculation based on the default value for thermal bridges (U-value + 0.1 W/m²K) and based on detailed calculations which resulted in a lower energy performance value EP:

Reference house	Δ EP/EP value of 0.8 [%]
End house	7.5
Terraced house	3.75
Semi-detached house	7.5
Gallery flat	3.75
Detached house	11.25

The study showed that a detailed calculation of the thermal bridge effect can lead to up to an 11% lower EP value.



Exemplary result of the detailed calculation of thermal bridges in the Czech study. Here: window lintel.

Czech Republic: Influence of thermal bridge details on the energy performance of houses with different energy quality [6]

This study analysed the growing impact of thermal bridges with the improved energy quality of houses. The example building used for this study was a residential building with brick construction and wooden frame windows. The following graphic presents the impact of the thermal bridges on the energy need balance of 4 similar houses. At typical houses of the 1970s (bar on the left) the relative impact of thermal bridges is 7 % while with improving quality, the impact can get as high as 28 % (bar on the right for the currently recommended technical standard).

Main result of the Czech study on the impact of thermal bridges:

- With an improved technical standard of the house, the relative influence of thermal bridges on the energy need balance increases from 7% (regular house of the 1970s) to 28% (currently recommended standard).

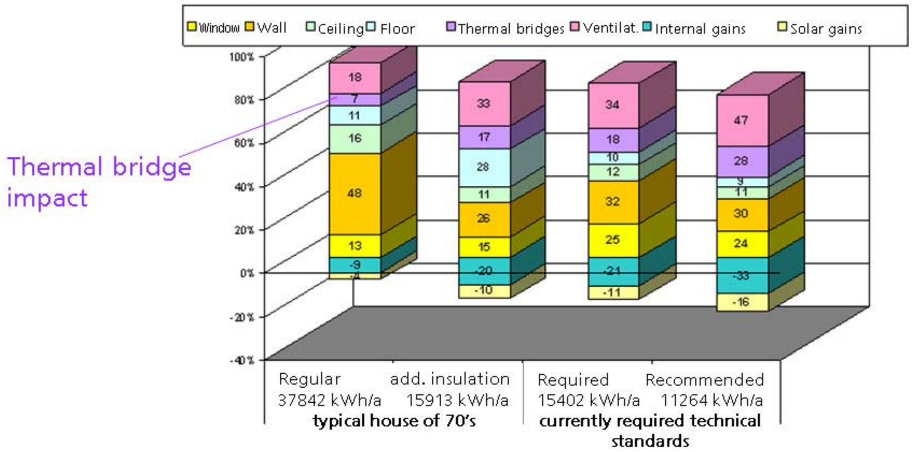


Photo of the example building used for the Polish study on the impact of thermal bridges on the energy performance of buildlings.

Poland: Quantitative study of thermal bridges in residential buildings [7]

A typical design of a two-storey single-family house with aerated concrete construction and a wooden roof was analysed by the Polish partners in ASIEPI. Thirteen different thermal bridges were calculated in detail. The main result was the difference between the default value for the impact of thermal bridges on the energy performance and the detailed calculation expressed by an addition to the thermal transmittance losses (Δ U * building surface area). The Δ U-value according to the detailed calculation was 0.036 W/m²K, whereas the standard Δ U-value for thermal bridges is 0.1 W/m²K and the value for state of the art joints 0.05 W/m²K. When calculating with the detailed results, the thermal bridges are responsible for 5.9 % of the thermal loss through the building envelope (transmission and ventilation).

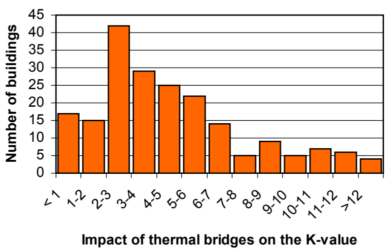


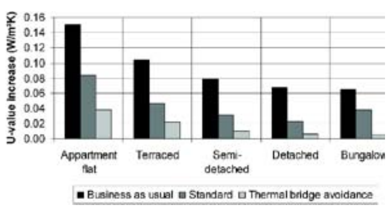
Diagram showing the impact of thermal bridges on the K-value of 200 different houses in Flanders.

Belgium: Study of the energy aspects of new dwellings in Flanders: insulation, ventilation, heating [8]

200 residential buildings that were constructed between 1990 and 1996 have been analysed in a simplified manner concerning various thermal bridges. In Flanders, the thermal quality of the building envelope is expressed through a so-called K-value: a dimensionless area-weighted average thermal transmittance value. The current requirement for the building envelope is K45. According to the study the average impact of the thermal bridges is approximately 5 K-points. With 45 K-points as the maximum, the thermal bridges have about 10 % impact on this value. The study only analysed the impact on the thermal transmittance. The Belgian partners in ASIEPI estimated the average energy impact of the thermal bridges (compared to zero net thermal bridges) based on the energy performance calculation method as:

- ~ 8 kWh/m²a energy needs for space heating
- ~ 11 kWh/m²a energy use
- ~ 10 kWh/m²a primary energy

The reduced primary energy compared to the energy use is due to increased consumption for (fictitious) cooling.

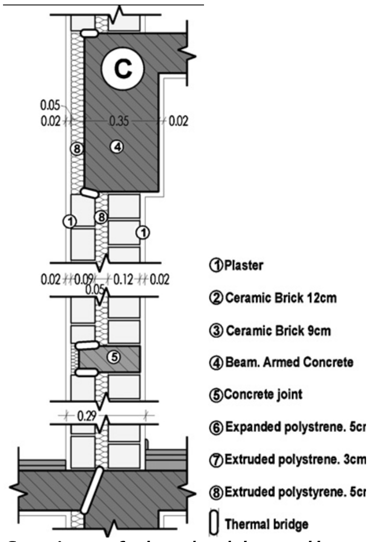


U-value increase due to the impact of thermal bridges in different types of cavity wall dwellings in the 2nd Belgian study.

In another Belgian study [9], cavity wall dwellings with 20 cm wall insulation have been analysed. Three scenarios (little attention to thermal bridges, standard attention and thermal bridge avoidance) have been compared regarding the increase of the U-value based on the thermal bridge effects of 23 different joints. The main results were:

- When insufficient attention is paid to the avoidance of thermal bridges the increase of the average thermal transmittance can be as high as 0.06 - 0.15 W/m²K.
- When attention is paid to thermal bridge avoidance the increase of the

average thermal transmittance can be as low as 0.01 – 0.04 W/m²K.



Section of the double wall construction analysed in the Greek study.

Greece: The impact of thermal bridges on the energy demand of buildings with double brick wall constructions [10]

The paper presents a study on representative configurations of thermal insulation at external walls in order to investigate the impact of the thermal bridges on the energy consumption in both summer and winter conditions. A three-storey apartment building equipped with heating and cooling systems was calculated with a dynamic simulation program under the climate of Thessaloniki. While the study assesses 4 different insulation scenarios from typical application to external insulation it also calculates the (total) impact of thermal bridges on the heating and cooling demand. For this information paper the results of the thermal insulation scenario according to the minimum requirements for the coldest zone in Greece (5 cm insulation thickness) are summarised in the following table.

Characteristic value	Unit	Excluding thermal bridges	Including thermal bridges
Specific annual energy use for heating	kWh/m²a	71	92
Maximum heating load	kW	24.8	30.4
Specific annual energy use for cooling	kWh/m²a	30	31
Maximum cooling load	kW	15.4	17

The impact of the thermal bridges on the annual energy need for heating is 30 % or 21 kWh/m²a. The specific energy need for cooling difference is much lower with 1 kWh/m²a or 3 %. On the other hand, the calculations show that also the summer influence of thermal bridges shouldn't be neglected as the difference of the maximum cooling load is more than 10 %. It can be assumed that if the climate region would have been warmer, the impact on the cooling load and cooling energy need would have been higher.

3 > Summary and conclusions

It is advised to read the presented results of national studies regarding the impact of thermal bridges on the energy demand of buildings with care. Most of the studies compare existing default values for thermal bridge impacts in national standards with detailed thermal bridge calculations of improved joints such as the German, the French, the Danish, the Dutch and the Polish study. Other analyses including the Czech, Belgian and Greek studies presented here have as results the (total) impact of the thermal bridges on the energy performance without comparing it to default values. Also the amount of analysed joints, the building geometry, the climate, etc. vary between the studies. Still the results can be summarised as follows:

- The total impact of thermal bridges on the heating energy need is in general considerable and can be as high as 30 %.
- The impact on the cooling energy need is significantly lower. There is however still a significant summer influence regarding the maximum cooling load.
- Countries with national default values for thermal bridges have mostly set those values in order to be on the "safe side" meaning that they result in slightly higher impact than if the joints are analysed in detail with 3D-simulation programs.
- If national default values are compared with improved joints regarding the energy quality, the difference of the heating energy can be as high as 11 kWh/m²a energy need or 13 kWh/m²a primary energy. Another study showed an influence of 18 kWh/m²a primary energy.
- The relative impact of improved joints compared to national default

values on the primary energy for heating can amount to 15 %.

The following conclusions can be drawn:

- The impact of thermal bridges in both winter (heating energy demand and heating load) and summer performance of buildings (cooling load) can't be neglected and should be included in the national calculation methods by default values and/or detailed calculations.
- In order to motivate for improvements of joints it should be offered to use lower values than the default value for thermal bridges according to the result of detailed calculations. Due to that improved joints can be used as method to improve the energy performance of buildings similar to better insulation, more efficient systems, etc.
- Better joints do not only reduce thermal bridge losses but also improve the airtightness of the building.

4 > References

1. Citterio, M.; Cocco; M., Erhorn-Kluttig, H.: "Thermal bridges in the EPBD context: overview on MS approaches in regulations. Information Paper P64 of the EPBD Buildings Platform (2008).
2. Erhorn, H.; Gierga, M.; Erhorn-Kluttig, H.: „Demonstrationsvorhaben 3-Liter-Häuser in Celle". Proceedings Ziegel-Forum Professoren Tagung, Lindau, Germany, 14th July 2002.
3. Lahmidi, H.; Leguillon, F.: „Study for the ASIEPI project: Thermal bridges influence on the primary energy consumption." Summary report of ASIEPI WP4. *
4. Rose, J.; Kragh, J.; Svendsen, S.: „Low energy class 1 typehouses according to the Danish building regulations". Proceedings of the 8th Symposium of Building Physics in the Nordic Countries, June 16.-18., Copenhagen, Denmark.
5. Spiekman, M.: Contribution to the ASIEPI project: "Summary of a Dutch study on the quantification of thermal bridge effects on the energy performance". Summary report of ASIEPI WP4. *
6. Šubrt, R.: "České Budějovice: Detalil nadpraži okna". (2007)
7. Wojnar, S.; Firlag, S.; Panek, A.: "Quantitative study of thermal bridges in residential buildings." Summary report of ASIEPI WP4. *
8. BBRI: "Insulation, ventilation and heating in new dwellings". Results of a survey. BBRI-report #4, 1999 (available in Dutch and French).
9. Janssens, A. et al: "Development of limits for the linear thermal transmittance of thermal bridges in buildings". Thermal performance of the exterior envelopes of whole buildings X. International conference, Clearwater, Florida. ASHRAE (2007).
10. Theodosiou, T.G.; Papadopoulous, A.M.: "The impact of thermal bridges on the energy demand of buildings with double brick wall constructions." Energy and Buildings 40 (2008), p. 2083-2089.

* to be available at the end of the project.

Intelligent Energy Europe

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Software and atlases for evaluating thermal bridges

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More information can be found at the ASIEPI project website: *www.asiepi.eu*

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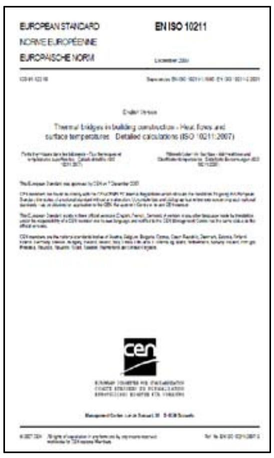
Note: This version P198 of this paper replaces previous versions P152 and P197. The (small) changes of content are:

- The table on calculation programmes has been updated.
- The meaning of the validation column has been clarified.

All other changes (limited in number) concern minor rephrasing and reformatting.


EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM
EN ISO 10211

The front page of EN ISO 10211:2007.

Different tools are available for evaluating thermal bridges. This paper provides information on software and atlases that are frequently used in the Member States. The European/International standard EN ISO 10211 is also briefly presented: it establishes the conventions to be followed when modelling thermal bridges, and provides for the validation of software.

1 > Objectives of the paper

As described in Information Paper P064, thermal bridges must be taken into account in the EPB-regulations of most European Member States (MS). The detailed evaluation of the linear thermal transmittance ψ [W/(mK)] or the point thermal transmittance χ [W/K] is one of the options to do this. Specific tools are needed to determine the ψ or χ values. There are two kinds of tools: numerical calculation software and thermal bridge atlases. Numerical calculation should be carried out using validated software and following rules that are usually given in a standard, which in the framework of EPB-regulations is usually the European/International standard EN ISO 10211 *[1]*. In a first section, the present paper will summarize the content of this standard and the rules to be followed for the modelling of thermal bridges. The validation test cases of this standard will then be described. In a second section, a survey of software tools for thermal bridge calculations will be given. Finally, the available atlases used in the different MS will be presented.

This paper is based on an internal ASIEPI survey of the following countries: Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Lithuania, Netherlands, Norway, Poland, Romania, Spain and the United Kingdom.

2 > The EN ISO 10211 standard for the calculation of thermal bridges and other transmission standards

As mentioned above, most of the EPB-regulations of the MS refer to the standard EN ISO 10211 for the detailed numerical calculation of the linear thermal transmittance of thermal bridges. In this section, we present two aspects of this standard: the modelling rules and the validation test cases. It should be noted that the description given below is only a short summary of the standard and is not intended to be comprehensive. The goal is to outline the procedure for the modelling of a thermal bridge detail in software and to emphasize the need for software validation.

Modelling rules

The first set of important rules are those that concern the dimension of the numerical model. As the goal is to model a part of the whole building including the thermal bridge, cut-off planes must be defined so that the

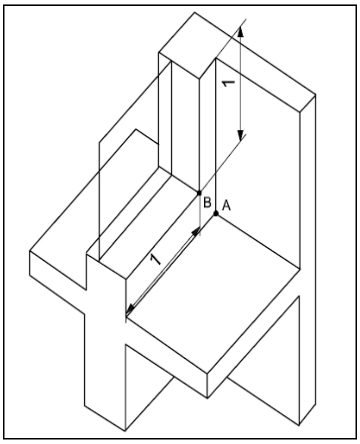
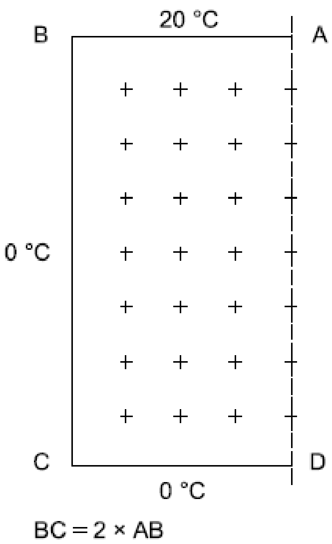


Illustration of the distances of the cut-off planes from the thermal bridge in point B (EN ISO 10211).



Analytical solution at grid nodes (°C)			
9,7	13,4	14,7	15,1
5,3	8,6	10,3	10,8
3,2	5,6	7,0	7,5
2,0	3,6	4,7	5,0
1,3	2,3	3,0	3,2
0,7	1,4	1,8	1,9
0,3	0,6	0,8	0,9

Test reference case 1 of the annex 1 of the EN ISO 10211.

impact of the thermal bridge is the same as if the entire building was to be directly calculated. EN ISO 10211 *[1]* defines minimum distances between the cut-off planes and the investigated thermal bridge. These distances depend on the particular detail investigated. Generally speaking, a distance of 1 meter from the thermal bridge is required, but for example, when a symmetry plane is present at a closer distance, this symmetry plane is used as the cut-off plane. In case of the presence of ground, a larger zone around the thermal bridge in the ground is modelled. Another aspect related to the geometry of the model concerns the simplifications that are allowed. These simplifications mainly concern thin layers, the use of quasi homogeneous layers that incorporate minor thermal bridges, and changes related to the external or internal surface positions or interfaces.

Another set of rules concerns the conditions that should be applied at the boundaries of the model and the thermal conductivities or thermal resistances that should be used. The thermal conductivity of the building materials should be determined according to the standard EN ISO 10456 *[2]* or national conventions. For air layers and cavities, the thermal resistances can be determined according to different standards (EN ISO 6946 *[3]*, EN 673 *[4]* and EN ISO 10077-2 *[5]*), depending on the particular building element modelled. The boundary conditions consist of the temperatures and the surface resistances, or the heat fluxes. Temperatures can generally be freely chosen (but should be realistic in relation to radiative heat transfer), whereas surface resistances depend on the direction of the heat flux and on the purpose of the thermal bridge calculation. For surface resistances for the calculation of the linear thermal transmittance, reference is made to the EN ISO 6946 *[3]*, but simplification rules are given in addition. It should be noted that for the evaluation of the risk of superficial condensation, specific surface resistances are to be used, which are given in the standard EN ISO 13788 *[6]*.

While many other rules are described in the standard EN ISO 10211 *[1]*, it is beyond the scope of this paper to mention all of them.

Test cases for software validation

Annex A of EN ISO 10211:2007 *[1] defines* four different test cases for the validation of software. Two of them are two-dimensional (2D) models; the other two are three-dimensional (3D) models.

In order for software to be classified as a 2D steady-state high precision method, it should be able to calculate test cases 1 and 2 (2D test cases) and to fulfil the requirements associated with these.

In order for software to be classified as a 3D steady-state high precision method, it should be able to calculate all four test cases (2D and 3D test cases) and to fulfil the requirements associated with these.

Unfortunately, a couple of small but annoying errors with respect to the sign conventions have slipped into case 3[i] and case 4[ii] of Annex A of EN ISO 10211:2007 (see footnotes at the end of this paper for details). Even though the corrections are self-evident, so as to avoid any further confusion and officially remove any doubts, it seems warranted to publish a corrigendum in the short term (which should also include the correction of other small mistakes elsewhere in the text).

This practical example is illustrative of easily avoidable errors, which regrettably occur more often in definitive versions of standards. Generally speaking, the authors themselves make great efforts and sacrifices, often in difficult working conditions, so as to deliver texts as good as reasonably achievable. In order to reduce the occurrence of such type of evident errors in future standards/revisions, structural improvements in the standardisation process seem therefore called for. These may include such things as the structural and systematic provision of sufficient means and financing allowing for the development of professional, high quality standards, and the institution of systematic final quality checking procedures (e.g. by remunerated third persons, not previously involved in the drafting process).

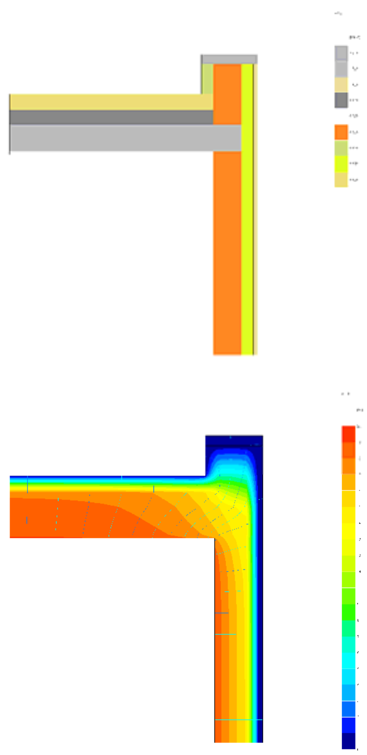
In the framework of EPB-regulations, it seems highly desirable that all MS explicitly require that software used for thermal bridge calculations fulfils at least these test cases. From the survey, it appears that this is actually already the case in the Czech Republic and in Spain, and it is planned in Belgium.

While the validation according to the EN ISO 10211 *[1]* gives a first indication of the quality of the calculation software, it appears that these test cases are not sufficient to ensure that the software will correctly calculate all situations encountered. Indeed, the four test cases are all based on rectangular geometries, so that errors or imprecisions related to non-rectangular situations are not addressed. Nor do the test cases cover any kind of air layers, losses through the ground or more complex boundary conditions.

Often, software capable of doing thermal bridge calculations can also calculate heat transfer through window frames. For this type of calculation, a set of ten test cases is given in Annex D of the European/International standard EN ISO 10077-2:2003 *[5]*. The successful validation of software according to this standard widens the scope of applicability of the software and increases the degree of confidence about the general quality of the software.

Other European/International transmission standards

EN ISO 10211:2007 *[1]* is part of a larger suite of standards that together should deal with all the aspects of thermal transmission calculations. It concerns among others EN ISO 13789 *[7]*, EN ISO 6946 *[3]*, EN ISO 13370 *[8]* and EN ISO 10077-1 *[9]* and -2 *[5]*. However, when systematically and rigorously applying the standards, a number of issues remain unanswered, or it is unclear how the recent changes in another standard affect thermal bridge calculations. This is for instance the case for slightly ventilated air layers. Different readers have different interpretations for the application to thermal bridges. Additional specifications or examples in the standard could clarify such issues.



Example of a model and the associated results from a numerical calculation.

Although in past revisions great strides have already been made to better adjust the different transmission standards among each other, some voids and inconsistencies still remain. Therefore, in order to achieve a fully streamlined set of transmission calculation rules, it appears desirable that at the time of the next revision of these standards, they are merged into one single standard, with unified definitions, terminology and symbols. This may better guarantee that the total coherence among all different aspects is fully thought through in the published text. The present standards of the transmission suite could then form the basis for different parts of such a fully adjusted, unique standard.

3 > Software tools

Over the past 2-3 decades, dedicated software for the numerical calculation of thermal bridges has been developed, in pace with the astounding advance of computer technology. From experimental research tools for specialists on basic computing machines in the early days, these tools have become ever more powerful and user-friendly, lowering the threshold for more generalised use. Their present features are already impressive, and there is no reason to assume this evolution will cease.

The table below gives an overview of a selection of current software, with the characteristics and abbreviations as explained below. All the software is available in an English language version, except when otherwise indicated.

Name	Type	2D/3D	SS/TR	FF/RECT	ψ-value	License	Validation
Heat transfer software							
AnTherm [36]	H-T (1)	3D	SS	R	Y	commercial	EN ISO 10211:2007 EN ISO 10077-2:2003
Argos (2) [37]	H-T	2D	SS	FF	Y	commercial	
Bisco / Bistra [38] / [39]	H-T	2D	SS / TR	FF	Y	commercial	EN ISO 10211:2007 EN ISO 10077-2:2003
Champs-bes [40]	HAM-T	2D	TR	R		free	EN ISO 10211:2007
David32 [41]	H-T	3D	SS	R		free	EN ISO 10211:2007
Delphin [42]	HAM-T	2D	TR	R		commercial	EN ISO 10211:2007 HAMSTAD Benchmarks 1 to 5 EN 15026:2007
Flixo [43]	H-T	2D	SS	FF	Y	commercial	EN ISO 10211:2007 EN ISO 10077-2:2003
FramePlus [44]	H-T					commercial	
HAMLab [45]	HAM-T	3D	TR	FF		free	(3)
Heat2 [46]	H-T	2D	TR	R	Y	commercial	EN ISO 10211:2007 EN ISO 10077-2:2003
Heat3 [47]	H-T	3D	TR	R	Y	commercial	EN ISO 10211:2007
KOBRA v3.0w (4) [48]	H-T	3D	SS	R	Y	free (5)	EN ISO 10211:2007
KOBRU86 / Sectra [49] / [50]	H-T	2D	SS / TR	R	Y	commercial	EN ISO 10211:2007
RadTherm [51]	H-T	3D	TR	FF		commercial	
Solido [52]	H-T	3D	SS	FF		commercial	EN ISO 10211:2007
TAS ambiens [53]	H-T	2D	TR	FF		commercial	EN ISO 10211:2007
Therm [54]	H-T	2D	SS	FF		free	EN ISO 10211:2007 (6)
Trisco / Voltra [55] / [56]	H-T	3D	SS / TR	R	Y	commercial	EN ISO 10211:2007
UNorm [57]	H-T	3D	SS	R	Y	free	EN ISO 10211:2007 EN ISO 10077-2:2003
WUFI 2D 3.2 [58]	HAM-T	2D	TR	FF		commercial	EN ISO 10211:2007
General purpose software							
Ansys multiphysics [59]	M-Phys	3D	TR	FF		commercial	
Ansys CFX [60]	M-Phys	3D	TR	FF		commercial	
Fluent [61]	M-Phys	3D	TR	FF		commercial	
Phoenics [62]	M-Phys	3D	TR	FF		commercial	
Comsol multiphysics [63]	M-Phys	3D	TR	FF		commercial	EN ISO 10211:2007
SAMCEF thermal [64]	H-T	3D	TR	FF		commercial	

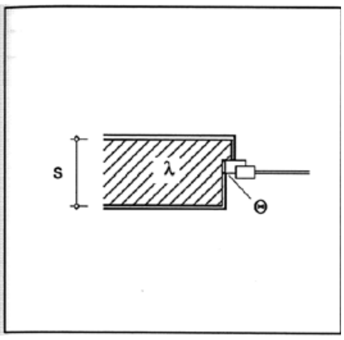
(1) Vapour diffusion can also be calculated
(2) Only available in German
(3) Not directly validated, but uses Comsol multiphysics as calculation core
(4) Only available in Dutch and French
(5) At present only for construction projects on Belgian territory
(6) Not yet validated by the developer itself, but the validation files are available on the website of the Flemish Passive House Platform [65]

- Capabilities of the software : Heat Tranfer only / Heat, Air and Moisture transfer / general, MultiPhysics (H-T, HAM-T or M-Phys): The physical models included in software can vary. Some of them are able to model heat and moisture transfer through building components, while others are limited to heat transfer or can model a wide range of physical phenomena (fluid flow, heat conduction, radiative heat transfer, etc.).
- 2D/3D: Some software has only the capability of calculating 2D models. Note that usually, 3D software can also be used to calculate 2D models.
- Steady-state or transient (SS or TR): Some software can only calculate equilibrium temperatures and heat fluxes in a model (steady-state simulations). While transient simulations are usually not required for thermal bridge calculations within the framework of EPB-regulations, they can be useful for example for calculations of heat losses through the ground with periodic variation of external conditions (see § 10.5 of EN ISO 10211 *[1]*). Note that software capable of calculating transient cases can usually also calculate steady-state solutions.

- Free-form/rectangular model (FF or R): Some software is limited to rectangular models while others can calculate free-form models.
- Automatic calculation of the linear thermal transmittance (ψ - value: Y): In some software, the linear thermal transmittance according to EN ISO 10211 is calculated automatically.
- Free/commercial: Some software is distributed free of charge, other under an open source license, and still other is commercially licensed.
- Validations: The last column mentions which validation test cases are made available on the supplier company's website as program input files (possibly in combination with a written report that discusses the calculation results). By downloading the test files, the user of a given program can readily verify by himself/herself whether that program satisfies the criteria defined in the standards. **Note that in the framework of the ASIEPI project NO independent check has been performed of the test cases of the different programs.** The claims on the websites of the companies remain the sole responsibility of these companies. But on the other hand, not a single report has been received at present that any of the test files would not comply with the validation criteria.

4 > Thermal bridge atlases

While the evaluation of linear thermal transmittance can be done using software as explained above, for standard details it may be easier and faster to make use of an atlas of thermal bridge details. The main advantage of using such atlases is that no calculations are needed, so the information can be obtained rapidly and with less preliminary knowledge. The main disadvantages are that the number of details necessary to cover the many situations encountered in reality is quite large, and the flexibility is usually lower. Moreover, when using an atlas, one must make sure that the conventions used for obtaining the values of the atlas are in accordance with the conventions set by the national EPB-regulations. Atlases that aren't general enough may therefore not be applicable in all countries. This is less of a problem with software though, as it is more flexible.



S [cm]	λ = 0,21		λ = 0,56		λ = 0,99	
	WBV	Θ	WBV	Θ	WBV	Θ
24	0,04	0,75	0,07	0,69	0,11	0,62
30	0,05	0,74	0,10	0,67	0,14	0,60
36,5	0,07	0,73	0,12	0,66	0,18	0,60

Example of data given in a thermal bridge atlas (taken from [18]).

There are different kinds of thermal bridge atlases. Many exist as stand-alone documents, originally developed independently of the EPB-regulation. But in some Member States, thermal bridge atlases have been developed specifically for the EPB-regulation. Such atlases can be of the ordinary type, i.e. a simple collection of building details with corresponding values of interest (e.g. linear thermal transmittance, temperature factor, ...). Or it can be a set of details that are considered as good-practice details in the framework of the EPB-regulations. The latter approach is an important evolution in the way of dealing with thermal bridges. This change started about a decade ago. Focus has been shifting from ever more systematic and detailed analysis of thermal bridges to their avoidance as much as reasonably possible. A detailed quantification of thermal bridges is then usually considered as no longer necessary, and the designer is dispensed with this time-consuming task, a task that by itself does not solve the thermal bridge. This important new development will be presented in a future ASIEPI Information Paper.

Finally, values of linear thermal transmittances are also given in the European/International standard EN ISO 14683 *[10]*. But the number of details in this standard is small, they are rather simplistic, and the values are on the safe side, which makes it quite difficult to use it in practice to obtain precise evaluations of the thermal bridges.

The table below summarizes the main atlases that are used in the surveyed countries. A special case of an atlas is the highly flexible electronic atlas

Flexibility of an atlas is to be understood as follows:

<u>Y</u>: a number of variations of parameters (dimensions, thermal conductivities,…) is taken into account for each detail

<u>N</u>: no variations of the parameters

"KOBRA", initially developed as a DOS programme in the framework of the European project "Eurokobra" and more recently made compatible with the Windows operating system. In this atlas, the dimensions, the thermal conductivities and the boundary conditions of predefined topologies can be changed and the value of the linear thermal transmittance is accurately recalculated for the precise case. It is thus in effect a combination of an atlas and a numerical calculation programme, but it requires no specific modelling knowledge of the user.
While in most of the surveyed countries thermal bridges atlases are reported in common circulation, they don't appear to be widely used in Greece, Italy, the Netherlands and Finland.

Name	Language	Number of details	Types of buildings	Flexibility	Integral Part of EP-reg	In use in MS...
EN ISO 14683 : Thermal bridges in building construction - Linear thermal transmittance - Simplified methods and default values (ISO 14683:2007) [10]	English	76	Residential	N	N	Europe
KOBRA v3.0w [11]	French and Dutch	3000+	All types	Y	N	Belgium
Construction details – Thermal Bridges [12]	Czech	56	All types	Y	N	Czech Republic
U-values 2003 [13]	Danish	2000+	All types	N	N	Denmark
Danish Standard 418. Calculation of heat loss from buildings [14]	Danish	275+	All types	N	Y	Denmark
2005 thermal regulation, Th-U 5/5 Thermal bridges for new building [15]	French	10000+	New building	Y	Y	France
Th-U 5/5 Thermal bridges for existing building [16]	French	3000+	Existing building	Y	Y	France
Thermal bridge atlas for wooden constructions [17]	German	3000+	Wooden constructions wall, ceiling, roof	Y	N	Germany
Thermal bridge atlas for brick constructions [18]	German	8000+	Brick constructions with/without insulation, ceiling, roof	Y	N	Germany
Building Research Design Sheet 471.017, Thermal bridges - Tables with ψ values [19]	Norwegian	23	All types	Y	N	Norway
Electronic atlas of thermal bridges ("Kuldebroatlas") [20]	Norwegian	23+	All types	Y	N	Norway
Thermal bridges - Calculation, ψ values, and influence on energy consumption. Project report 25-2008 [21]	Norwegian	31	All types	Y	N	Norway
Thermal Bridges Catalogue Traditional Buildings [22]	Polish	100+		N	N	Poland
Thermal bridges. Basics, simple formulaes, heat loss, condensation, 100 calculated building details. [23]	German	100	All types	N	N	Austria
Thermal Bridges in Constructive Elements Catalog for Building Technical Code [24]	Spanish	300+	All types	Y	Y	Spain
Building regulation STR 2.05.01:2005 "Thermal technique of the building envelope", Annex 7 [25]	Lithuanian	200	All types	Y	Y	Lithuania
Thermal bridges catalog [26]	German	200+	All types	Y	N	Switzerland
Code for thermal energy performance calculation of building's elements C107/3-2005 [27]	Romanian	1500+	All types	N	Y	Romania
Limiting Thermal Bridging and Air Infiltration Acceptable Construction Details [28]	English	150	All types	Y	Y	Ireland
Accredited construction details [29]	English	150	Dwellings	N	Y	United Kingdom
Accredited construction details (Scotland) [30]	English	130	Dwellings	N	Y	United Kingdom
Enhanced Construction Details [31]	English	47	Dwellings	N	N	United Kingdom
Thermal bridge catalog [32]	German	323	All types	Y	N	Germany
BuildDesk (1) [33]	Polish	100+	All types	N	N	Poland
CERTO (1) [34]	Polish	100+	Traditional and concrete panel	N	N	Poland
Thermal bridge catalogue for renovation and retrofit measures to prevent mould [35]	German	92	All types, renovation	Y	N	Germany

(1) Certification software that also contains a thermal bridge atlas

5 > Conclusions and recommendations

From the survey summarised in this paper, it can be seen that many tools exist for the evaluation of thermal bridges.

Concerning the software, the main problem encountered at the start of the enquiry was the lack of systematic and up-to-date proof of validation. At the time of publication of this paper, some software still did not have documented validation. There lingers a certain degree of doubt over the calculation results of such non-validated software. Their use in the framework of EPB-regulations of MS should therefore better be avoided.

Concerning the thermal bridge atlases, it appears that a whole collection of such documents is available. Most of them are written in the language of their original country and are not translated. Of course, this may be one of the main reasons that render the use of such documents difficult in other countries.

Overall, the following practical recommendations can be formulated to the different main actors:

- Member States:
    - They can be advised to explicitly require that software used in the context of their EPB-regulation at least satisfies the validation cases of the most recent version of EN ISO 10211. At present this is the publication of 2007.
- CEN/ISO:
    - It seems highly desirable to publish in the short term a corrigendum for the errors in cases 3 and 4 of annex A (and elsewhere in the text) of EN ISO 10211:2007.
    - In order to avoid repetition of such type of errors in future standards/revisions, structural improvements and systematic quality checks in the process of establishing standards might be indicated. This may require additional funding.
    - In a future revision of the EN ISO 10211, a more comprehensive set of validation test cases seems warranted, e.g. also encompassing more complex boundary conditions, non-rectangular geometries and air layers.
    - Further improvement, streamlining and clarification of the EN ISO transmission standards appear desirable: this can probably best be achieved by merging all present standards from the transmission suite into (different parts of) one single, fully coherent standard, with unified definitions, terminology and symbols.
- Software developers:
    - Validate systematically and continuously all thermal bridge software according to the latest versions of European and International standards and other benchmarking methods, and publish any proof of validation (including calculation files) on the internet.
    - Continue the further improvement of the capabilities and user friendliness of thermal bridge software.
- Translation of the available atlases in English, in order to allow a wider use. This may in particular be relevant for the new generation of atlases with solutions to avoid/minimise thermal bridges. In this way the Member States can profit from the efforts of each other and of common European developments. The topic of such solution-oriented atlases will be discussed in more detail in a future Information Paper.

6 > References

1. EN ISO 10211: Thermal bridges in building construction – Heat flows and surface temperatures – detailed calculations (ISO 10211:2007), CEN, 2007
2. EN ISO 10456: Building materials and products - Hygrothermal properties - Tabulated design values and procedures for determining declared and design thermal values (ISO 10456:2007), CEN, 2007
3. EN ISO 6946: Building components and building elements – Thermal resistance and thermal transmittance – Calculation method (ISO 6946:2007), CEN, 2007
4. EN 673: Glass in building – Determination of thermal transmittance (U value) – Calculation method, CEN, 1997
5. EN ISO 10077-2: Thermal performance of windows, doors and shutters – Calculation of thermal transmittance – Part 2: Numerical method for frames (ISO 10077-2:2003), CEN, 2003
6. EN ISO 13788: Hygrothermal performance of building components and building elements – Internal surface temperature to avoid critical surface humidity and interstitial condensation – Calculation methods (ISO 13788:2001), CEN, 2001
7. EN ISO 13789: Thermal performance of buildings - Transmission and ventilation heat transfer coefficients - Calculation method (ISO 13789:2007), CEN, 2007
8. EN ISO 13370: Thermal performance of buildings - Heat transfer via the ground - Calculation methods (ISO 13370:2007), CEN, 2007
9. EN ISO 10077-1: Thermal performance of windows, doors and shutters - Calculation of thermal transmittance - Part 1: General (ISO 10077-1:2006), CEN, 2006
10. EN ISO 14683: Thermal bridges in building construction – Linear thermal transmittance – Simplified methods and default values (ISO 14683:2007), CEN, 2007
11. Physibel n.v., KOBRA v3.0w, 2008.
    www.cstc.be/go/kobra (French) or
    www.wtcb.be/go/kobra (Dutch)
12. Roman Šubrt and Michal Volf, Stavební detaily -Tepelné mosty, Grada Publishing, 2003.
    www.grada.cz
13. Varmeisolerings-foreningen, U-værdi 2003, 2003
14. Dansk Standard, Dansk Standard 418. Beregning af bygningers varmetab, 2002
15. Réglementation thermique 2005, Th-U 5/5 Ponts Thermiques, CSTB, 2006
16. Th-U existant 5/5 ponts thermiques, CSTB, 2008
17. Gerd Hauser and Horst Stiegel, Wärmebrückenatlas für den Holzbau, Bauverlag GmbH, 1992.
    http://www.zub-kassel.de/downloads
18. Gerd Hauser and Horst Stiegel, Wärmebrückenatlas für den Mauerwerksbau, Bauverlag GmbH, 1990/1996.
    http://www.zub-kassel.de/downloads
19. Arild Gustavsen, Byggdetaljer 471.017 "Kuldebroer. Tabeller med kuldebroverdier", SINTEF Building & Infrastructure, 2008.
    http://bks.byggforsk.no/DocumentView.aspx?sectionId=2&docNumber=4710
20. Kuldebroatlas, SINTEF Building & Infrastructure, 2009.
    http://bks.byggforsk.no/Tools.aspx?sectionId=2&toolType=25
21. A.Gustavsen, J.V.Thue, P.Blom, A.Dalehaug, T.Aurlien, S.Grynning, S.Uvsløkk, Kuldebroverdier - Beregning, kuldebroverdier pg innvirkning på energibruk - Prosjektrapport 25-2008, SINTEF Building & Infrastructure, 2008
22. Jerzy Pogorzelski and J.A. Awksientjuk, Katalog mostow cieplnych. Budownictwo tradycyjne, Wydawnictwa ITB, 2003.
    www.itb.pl
23. Walter Heindl, Klaus Krec, Erich Panzhauser and Alfred Sigmund, Wärmebrücken. Grundlagen, Einfache Formeln, Wärmeverluste, Kondensation, 100 durchgerechnete Baudetails, Springer, 1987
24. S. Álvarez and J.M. Salmerón, Catálogo de Elementos Constructivos de CTE. Puentes térmicos, IETCC, 2008.
    http://www.codigotecnico.org/fileadmin/Ficheros_CTE/Documentos/CTEFeb08/CAT-EC-v05.0_MAYO08.pdf

25. Statybos techninis reglamentas Pastatų atitvarų šiluminė technika, 7 priedas, Ministry of Environment, 2005
26. Infomind SàRL, Catalogue des ponts thermique, Office fédéral de l'énergie, 2003. *http://www.vd.ch/fileadmin/user_upload/themes/environnement/energie/fichiers_pdf/calcul_pont_thermiques.pdf*
27. I.P.C.T, Normativ privind calculul performantelor termoenergetice ale elementelor de constructie ale cladirilor C107/3 - 2005, M.T.C.T-2055/29.11.05, 1997/2005
28. Department of the Environment, Heritage and Local Government, Limiting Thermal Bridging and Air Infiltration Acceptable Construction Details, 2008. *http://www.environ.ie/en/TGD/*
29. Department for communities and local government, Accredited construction details, Crown, 2007. *http://www.planningportal.gov.uk/england/professionals/en/1115314255826.html*
30. The Scottish Building Standards Agency, Accredited construction details (Scotland). *http://www.sbsa.gov.uk/tech_handbooks/accred_detail.htm*
31. Energy Saving Trust, Enhanced Construction Details, 2008. *http://www.energysavingtrust.org.uk/business/Business/Building-Professionals/Helpful-Tools/Enhanced-Construction-Details*
32. ZUB Kassel, Wärmebrückenkatalog, 2005. *http://www.zub-kassel.de*
33. Piotr Pawlak, BuildDesk, BuildDesk Polska. *http://bdec.builddesk.pl*
34. Jerzy Żurawski, CERTO, Dolnośląska Agencja Energii i Środowiska, 2008. *www.cieplej.pl*
35. Horst Stiegel, Gerd Hauser, Wärmebrückenkatalog für Modernisierungs- und Sanierungsmaßnahmen zur Vermeidung von Schimmelpilzen, Fraunhofer IRB Verlag, 2004
36. AnTherm, *http://www.kornicki.de/antherm/index.htm*
37. Argos, *http://www.zub-kassel.de/software/argos*
38. Bisco, *www.physibel.be*
39. Bistra, *www.physibel.be*
40. Champs-bes, *http://beesl.syr.edu//champs.htm*
41. David32, *http://www.gadbyggnadsfysik.se*
42. Delphin, *http://bauklimatik-dresden.de/delphin/index.php*
43. Flixo, *http://www.infomind.ch/bph/en/services/*
44. FramePlus, *http://www.enermodal.com/*
45. HAMLab, *http://sts.bwk.tue.nl/hamlab/*
46. Heat2, *http://www.buildingphysics.com/index-filer/heat2.htm*
47. Heat3, *http://www.buildingphysics.com/index-filer/Page691.htm*
48. KOBRA v3.0w, *www.cstc.be/go/kobra* (French) or *www.wtcb.be/go/kobra* (Dutch)
49. KOBRU86, *www.physibel.be*
50. Sectra, *www.physibel.be*
51. RadTherm, *http://www.thermoanalytics.com/products/radtherm/*
52. Solido, *www.physibel.be*
53. TAS ambiens, *http://www.edsl.net/*
54. Therm, *http://windows.lbl.gov/software/therm/therm.html*
55. Trisco, *www.physibel.be*
56. Voltra, *www.physibel.be*
57. UNorm, *http://www.gadbyggnadsfysik.se*
58. WUFI 2D 3.2, *http://www.hoki.ibp.fraunhofer.de/wufi/wufi_frame_e.html*
59. Ansys multiphysics, *http://www.ansys.com/products/multiphysics.asp*
60. Ansys CFX, *http://www.ansys.com/products/cfx.asp*
61. Fluent, *http://www.fluent.com/software/fluent/index.htm*

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62. Phoenics, *http://www.cham.co.uk/*
63. Comsol multiphysics, *http://www.comsol.com/*
64. SAMCEF thermal, *http://www.samcef.com/en/pss.php?ID=7&W=products*
65. Passiefhuis-Platform vzw, *http://www.passiefhuisplatform.be/index.php?col=-welkom&lng=en&doc=THERM*

[i] Practically speaking, it concerns the following points:

- figure A.3.b: the boundary condition between A and C should be γ
- equation A.5 should read: $\Phi_{\beta,\alpha}$ = ...= 2,094 x (15-20) = -10,47 W
- equation A.7 should read: $\Phi_{\beta,\gamma} + \Phi_{\alpha,\gamma}$ = 24,36 + 35,62 = 59,98 W
- equation A.8 should read: $\Phi_{\beta,\gamma} + \Phi_{\beta,\alpha}$ = 24,36 - 10,47 = 13,89 W
- equation A.9 should read: $\Phi_{\alpha,\gamma} + \Phi_{\alpha,\beta}$ = 35,62 + 10,47 = 46,09 W

[ii] Second paragraph of the section A.1.5 Case 4 : “lowest internal surface temperatures” should be replaced by “highest surface temperature on the external side”

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More information can be found at the ASIEPI project website:
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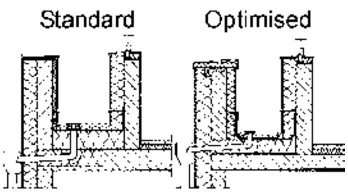


Sample from German study. Component joint of a roof terrace in standard (left) and optimised (right) design.

Analysis of Execution Quality Related to Thermal Bridges

Execution quality can have a significant effect on the energy consumption of buildings. The occurrence of thermal bridges due to faulty execution can increase heat losses dramatically and in the worst case even result in moisture problems and have a drastic impact on the indoor climate. At present, there is little or no information available on this topic. Therefore, a study has been set up within the framework of the ASIEPI project funded by the Community's Intelligent Energy Europe programme, to collect information from each of the participating Member States (MS) concerning execution quality. This paper presents the results of that study along with a proposal for stimulating and checking execution quality.

1 > Effect of thermal bridges due to faulty execution

It is a well-known fact that thermal bridges can increase the transmission heat loss of buildings significantly, especially as we move towards higher and higher insulation levels in both our new and existing buildings. Thermal bridges have been the focus of many studies in Europe over the last decades and today we have at our disposal highly developed calculation tools along with thermal bridge atlases for assessing their effect. This presents an opportunity to minimise thermal bridge effects during the design phase of a building project; however, in the transition from theory to practice there is a risk of introducing thermal bridges due to faulty execution.

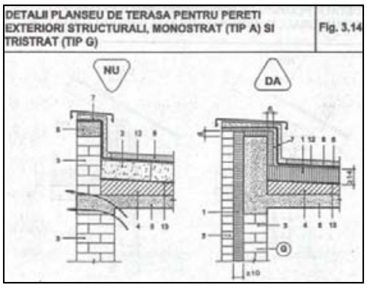
This paper does not include thermal bridges occurring due to air movement inside constructions (convection), air tightness etc. The latter are dealt with in a separate work package of the ASIEPI project.

A study was set up to quantify the effect of thermal bridges due to faulty execution. The study encompasses two different analyses: 1) a survey among the participating MS concerning previous individual national studies on the influence of execution quality and 2) a questionnaire containing questions pertaining to methods for assessing and stimulating execution quality, i.e. an attempt to quantify what affects the execution quality.

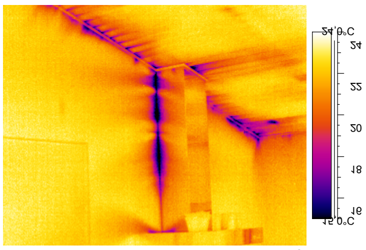
2 > Summary of existing studies concerning execution quality related to thermal bridges

Only a few studies exist on execution quality with regard to thermal bridges among the participating MS.

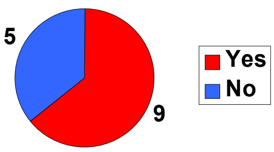
In Germany, a study was made on Burgholzhof in Stuttgart where approximately 800 low energy accommodation units were built [1]. The building process of 39 multi-family houses was monitored and the purpose of the study was to supervise 3 parts of the building process, i.e. 1) energy



Sample from Romanian study. Detail of the connection between external wall and terrace, bad (NU) and good (DA) solution.



Determining positions of thermal bridges in building constructions by infrared thermography.



Is infrared thermography used on new buildings in your country?

performance certification, 2) check of building joints in both the design and realisation phases and 3) check of building materials used on the construction site. The study showed that there were on average 2.8 critical design details per building that needed to be corrected. On-site visits resulted in more than 100 protocols concerning both material choices and execution of building details. All in all execution quality was good; however, the recommendation was to have building inspections during execution in future buildings to avoid defects and increased energy losses.

Romania reports three studies that were performed nationally; two studies deal with experiences from existing buildings (retrofitting) and one deals with experiences from new buildings. The first study [2] contains general solutions for increasing the energy performance of existing buildings by renovating especially construction joints (thermal bridges). The study focuses on 37 details that are critical parts of the construction. The second study [3] shows typical building details for 23 cases that are relevant for new buildings. This study shows both good and bad solutions in order to emphasise the importance of correct execution. The third study [4] from Romania is a normative reference concerning methods for assessing the execution quality in existing buildings. Among others, infrared thermography is suggested as a method to assess execution quality.

The England and Wales 2010 proposals include inclusion of so-called safety factors for claimed thermal bridge heat losses that are not accredited and well-tried details. These safety factors are introduced because they might cause problems with regard to execution quality (i.e. since builders have not used them before they are more likely to make mistakes), and furthermore hence their values (linear thermal transmittances or point thermal transmittances) are uncertain. Evidence for theoretical values will be required - in principle - so that uncertainty should not be any greater than for accredited details. Execution quality is certainly a concern for unfamiliar/untested details.

3 > Summary of questionnaire concerning assessment and stimulation of improved execution quality

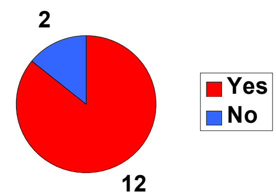
A questionnaire was distributed among the participating MS in the ASIEPI project, in order to establish the state of assessing and improving the execution quality. The results are summarised in the following.

Infrared thermography

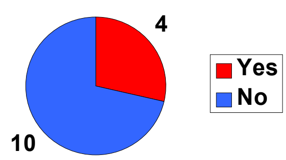
Infrared thermography is the most powerful technique for determining position and to some extent magnitude of thermal bridges in existing buildings. The technology has developed a lot over the last decades, and today everyone can operate FLIR (Forward Looking InfraRed) cameras. Prices have also plummeted, and today cameras can be purchased at prices below €3,000, making it a cheap and easily accessible technology.

Infrared thermography is not a legal requirement in any of the participating Member States. Infrared thermography is in general not used extensively anywhere and is primarily used in connection with low energy buildings, research or education projects or under circumstances where there are judicial disputes concerning building execution quality. Either infrared thermography is used by itself to locate thermal bridges -or it is used in connection with blower door tests to establish the location of air leakages.

In Denmark, infrared thermography is used on some new buildings. There is a legal requirement in the Danish Building Regulations stipulating that at least 5 % of new buildings should be tested for airtightness by blower door,



Are inspections carried out during and/or after the building process of new buildings in your country?



Do you have any other specific methods for assessing execution quality in your country?

and that this test should always be accompanied by infrared thermography in order to pinpoint the location of any leakages. It is the responsibility of the local authorities to ensure that this part of the Building Regulations is fulfilled.

Finland lists infrared thermography as part of the normal quality control for new buildings; however, there is still no legal requirement to perform the analysis and it is up to the future building owner to request a test.

Building inspections (during and after the building process)

Building inspections with focus on energy during and after the building process of new buildings is a method for ensuring that the building is realised as originally planned. In opposition to infrared thermography, building inspections can be carried out during the building process, making it possible to pinpoint and correct any faulty execution before the building is finished.

In the MS, there is a general tendency towards the use of inspections during and after the building process – especially for larger buildings. In most countries, there are legal requirements for inspections; however, these inspections seldom/never focus on energy consumption and thermal bridges, but rather on health, safety, structural elements and load-bearing capabilities. In some MS, the inspections also serve the purpose of ensuring that the realised building follows the design specifications used for obtaining the building permit.

In Italy there is a legal requirement for inspections during the building process and it is the responsibility of the local authorities that they are performed. In practice, however, inspections are rarely carried out due to limited resources (financial and human) of the local authorities/provinces.

Romania has mandatory inspections during the most important phases of the building process, but they do not include focus on energy use or thermal bridges. At the end of the building process, the local authorities and the Government Building Inspectorate will perform inspections to ensure that the realised building is as originally planned.

Norway has recently drafted new rules, proposing compulsory independent third party inspections after the building process. The rules are expected to be introduced in 2010.

Denmark uses a third party energy certification scheme for all new buildings. The certification covers all energy-related installations/parts of the building that can be inspected visually (pipe insulation, boiler characteristics, fan power usage etc.).

Alternative methods for assessing and stimulating execution quality

The participating MS were asked to list any alternative methods used in their individual countries for assessing and stimulating execution quality.

Finland mentions that a few specialised consultants have equipment for performing gas-concentration measurements of gas-filled windows.

In Germany, visual checks (inspections) are performed with specific focus on checking for thermal bridges if requested by the building owner. Comparing details on the construction site with design drawings makes this task easier.

For some building projects, Norway uses especially trained people to investigate the building design before the building process is initiated. This investigation focuses on weeding out details that may cause problems. Any problematic details found through the investigation can then be redesigned. The investigation will typically also result in a series of suggestions concerning specific inspections or measurements that should be carried out during the building process.

Incentives or penalties to stimulate/ensure good execution quality

A method for stimulating/ensuring good execution quality is to have incentives and/or penalties. The participating MS were asked in the questionnaire to list any incentives/penalties used in their respective countries.

All countries penalise bad execution quality and most have penalties that have direct (fines) or indirect (halting the building process or prohibiting building use) economic consequences for the building contractor. In the most serious cases, the responsible executive manager and/or technical supervisor may loose their certificates/licenses.

Only a few countries have incentives for stimulating good execution quality. Typical incentives come in the form of governmental funding or reduced taxes for building low-energy buildings or passive houses. The incentives are typically connected with time-limited programmes.

4 > Proposal for stimulating and assessing execution quality

The final question of the questionnaire asked the participating MS to list any suggestions they had for stimulating and assessing execution quality. Based on their answers we have drawn up a proposal for stimulating and assessing good execution quality.

Sticks:

- Inspections by energy specialists before, during and after the building process (photos, measurements)
- Increase number of mandatory blower door (IR thermography) tests (e.g. to 15% of all new buildings), and utilise the IR results.
- Possibility of withdrawing license of designer/contractor
- Bad examples done by building contractors should be published

Having inspections before, during and after the building process would be the best solution; however, for economical reasons this will not be viable for all new buildings. The extent of the inspections should be adjusted for each building project, yet energy specialists should always be included.

Building contractors will be forced to focus on execution quality by increasing the number of mandatory blower door tests and at the same time use IR thermography for thermal bridges rather than just air tightness.

Introducing the possibility of withdrawing the license of a designer/-contractor for repeatedly providing poor execution quality could centre their focus on this issue significantly. However, it is a question whether this could function in practice (maybe in some MS). Instead, making information publicly available concerning a contractor's level of execution quality – both good and bad – could have a more positive effect on execution quality.

Carrots:

- Funding programmes
- Reduction of green taxes and interest rates for low energy buildings/passive houses
- Good examples done by building contractors should be published

Funding programmes are powerful incentives for increasing focus on execution quality, and previous experience has clearly shown that economic incentives work well. The reduction of green taxes and/or interest rates for low energy/passive houses will reduce the operational cost of the houses further. This will increase the demand for this type of houses and thereby decrease their price, meaning that construction companies can cover the extra expenses associated with low energy buildings.

Other:

- Courses for designers and construction company staff or craftsmen on how to design and realise building joints with focus on air tightness and thermal bridges
- Good practice guidelines. In general passing on expert knowledge concerning the understanding of the key elements of low energy building and good workmanship
- Introduction of U-Values that take into account the installation of windows. This would motivate the window manufacturers to have stronger guidelines for installation, and thereby more training for installers

The continued education of designers, construction company staff and craftsmen with respect to execution quality will help realise future goals concerning the further reduction of building energy consumption. In addition to education, good practice guidelines will be helpful in passing on the latest expert knowledge from theory to practice. A specific information paper on good practice guidelines for preventing thermal bridges written by IEE ASIEPI will soon be available.

5 > Conclusion

This IP deals with execution quality and in particular with methods for assessing thermal bridge effects due to faulty/poor execution quality, and methods for stimulating improved execution quality to avoid/reduce thermal bridge effects.

A questionnaire distributed among the participating MS shows that only a few studies have been carried out concerning the relationship between execution quality and thermal bridge effects. These studies indicate that there is a need for increased focus on execution quality.

The questionnaire also shows that the MS use more or less similar methods for assessing and stimulating improved execution quality. Infrared thermography is used to some extent, but is not yet a legal requirement anywhere. Inspections during and after the building process are used quite extensively in all MS, especially for large buildings. Most MS have legal requirements regulating inspections; however, these do not focus on energy consumption or thermal bridges. There are only very few alternatives to inspections and infrared thermography and they include gas concentration measurements on windows and pre-building process inspections of drawings by specialists. Finally, the questionnaire shows that most MS use sanctions rather than incentives to ensure good execution quality.

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Original text language: English

Based on suggestions from the participating MS, the IP presents a "proposal for stimulating and assessing execution quality". The proposal contains different measures described as sticks and carrots, which contribute to better quality. The proposed measures are aimed at different target groups but for most of them, it is the policy makers, who will be responsible. Establishing requirements for a specific amount of inspections and for mandatory blower door test, for the possibility of withdrawing a license; all this is something that requires rules. Furthermore, reduction of green taxes and interest rates for low energy buildings/passive houses and funding programmes are also the responsibility of policy makers. Then the standardisation bodies have to follow up and prepare the standards. The building industry and the building practitioners have to arrange courses for designers and construction company staff or craftsmen on how to design and realise building joints with focus on air tightness and thermal bridges. In addition to education, good practice guidelines will be helpful in passing the newest expert knowledge from theory to practice and this is the responsibility of building industry.

6 > References

1. "Erhorn, H.; Kluttig, H.: „Baumaßnahme Burgholzhof Stuttgart mit ca. 800 Wohneinheiten in Niedrigenergiebauweise – Ergebnisse des wissenschaftlichen Begleitprojekts." (Building project Burgholzhof in Stuttgart with about 800 accommodation units in low energy design – results of the scientific evaluation project). IBP report WB 115/2002. Fraunhofer Institute for Building Physics, Stuttgart, Germany (2002).
2. Solutii cadru pentru reabilitarea termo-higro-energetica a anvelopei cladirilor de locuit existente" SC 007 – 2002 (General solutions for existing residential building's thermo – hygro- energy renovation, SC 007 – 2002) – BC, vol 18-2003, pag. 4 – 150.
3. "Ghid privind optimizarea nivelului de protectie termica la cladirile de locuit noi" GP 058 – 2000 (Guide concerning new residential building's thermal insulation, GP 058 – 2000), IPCT S.A – 2000, pag. 1 – 111.
4. "Normativ privind stabilirea performantelor termo-higro-energetice ale anvelopei cladirilor de locuit existente in vederea reabilitarii" NP 060 – 2002 (Norms to settle down thermo-energy performance of existing residential buildings, NP 060 – 2002) – BC, vol 18 – 2003, pag. 151 – 280.

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Good practice guidance should contain:

- Well illustrated introduction to what thermal bridges are, their effects, and the main principles of avoiding them
- Well-illustrated examples of serious thermal bridges, and their solutions
- Routes to compliance:

Routes to compliance should also be supported by:

- Established clearly-defined simple quantitative levels of good practice (e.g. minimum thickness of thermal breaks)
- Collections of detailed drawings showing good solutions, together with their thermal bridge values
- Calculation methods for alternative details

Good practice guidance on thermal bridges & construction details, *Part I: Principles*

Most areas of Europe need good thermal insulation in order to conserve energy and to improve indoor climate. Minimizing thermal bridges is an important part of achieving this. However, even in well-insulated buildings, thermal bridges are often neglected.

This paper suggests topics that should covered in 'good practice' guidance, how it can be structured and presented, and how it can be related to building regulations and standardization. Part II of the paper shows a selection of good examples from different countries.

This paper is published together with an electronic archive (file *thermal_bridge_good_practice.ZIP*) containing over 60 reference documents. This paper has clickable hyperlinks for opening the individual documents. The ZIP file contents should be extracted to the same directory as this PDF for the hyperlinks to work.

The target readership for this paper is organizations planning to publish or update their own construction details and guidance on thermal bridges & airtightness. It is also aimed at building authorities, standardization bodies, and energy agencies.

1 > HOW TO STRUCTURE & DISSEMINATE GUIDANCE, AND INTEGRATE IT INTO REGULATIONS & STANDARDS

Widespread dissemination, and tight integration with building regulations & standardization, are crucial to successful adoption of higher building standards. Guidelines on thermal bridges should therefore be:

- …available in both paper & electronic media (free or low cost on Internet), both as a complete handbook and as separate construction details. Comprehensive examples of are UK [*UK01*] and Ireland [*IE01*].
- …referenced from the national building regulations and the national energy performance calculation standard. In conjunction with this, the country should establish the following:
  - The national energy performance regulations should require/assume a minimum or 'default' standard of thermal bridge heat loss (e.g. ΔU or Ψ'', W/m²K per unit façade area or floor area). This can be supported by a collection of 'preaccepted' construction details that achieve this standard. An example of this is UK's *Accredited Construction Details* [*UK01*]. The same can be done for optional higher standards, such as the UK's *Enhanced Construction Details* [*UK02*, *UK03*], or passive house standard details [*AT01*, *AT02*,

Intelligent Energy Europe

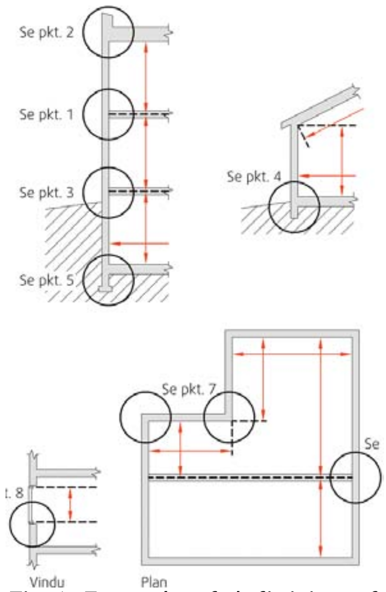

Fig.1 Example of definition of internal dimensions. Thermal bridges are circled [© SINTEF]

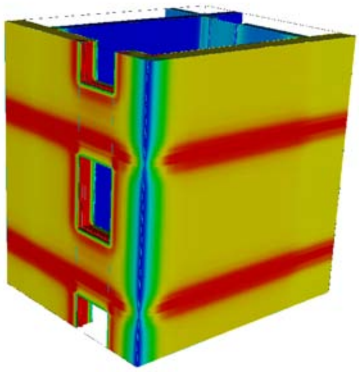

Fig.2 3D finite-element model calculation of heat loss. Red is highest heat flux.

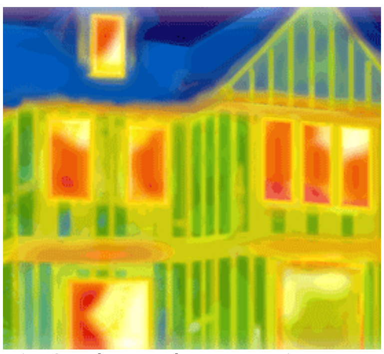

Fig.3 Thermal camera image of timber frame walls.

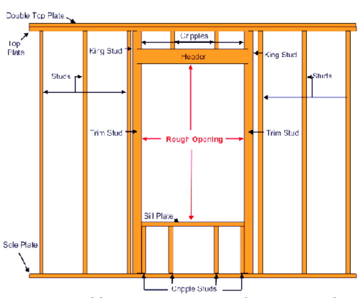

Fig.4 Illustration of typical wood framework with window.

[BE02]. Minimum standards should also be defined to limit, for example, condensation risk.

— A national standard defining:
(a) …calculation of areas for thermal transmission (Fig.1). The two main alternatives are *internal* or *external* areas. Both are acknowledged in the International Standard for calculation of thermal bridges [EN ISO 10211]. This has consequences for the numerical values of geometric thermal bridges. Using *external areas* is a safer (more conservative) approach because it leads to smaller linear thermal transmittances for external edges than if internal dimensions are used (Fig.10b), hence less error if the thermal bridges were ignored. However, *internal areas* are more practical, and easier to calculate. For example, it avoids the uncertainty in outer area for e.g. ventilated cavities, double facades, complex external geometry and sloped roofs. Furthermore, most thermal bridges are not purely geometric, so the benefit of using external areas is not so great.
(b) …which types of thermal bridges should be aggregated into normal U-values for facades, and which should be kept separate as thermal bridge Ψ-values. There is international consensus on this issue:

- All framework (studs and top & sole plates) and extra framework around window & door frames (sill plate, king & trim studs, and headers; see Figs 4 & 5) and other repeating thermal bridges in the facade, should generally be aggregated into *U*-values. Thus, *U*-values should reflect the true amount of framework (i.e. length of framework per m^2 opaque wall), which can vary greatly depending on window geometry and area.
- This leaves only geometric thermal bridges (e.g corners), and non-repeating thermal bridges (e.g. around ground slab) that should be evaluated with separate thermal bridge calculations.

— Examples of standards are Danish DS 418 [DK01 summarized in DK02], German DIN 4108 [DE01], and Dutch NEN 1068 [NL01] & NPR 2068 [NL02].

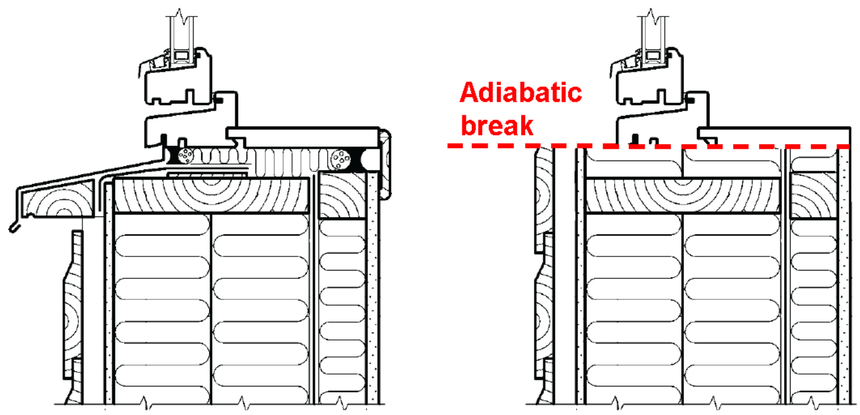

Fig.5 The magnitude of the window/wall thermal bridge is the difference in heat loss between these two pictures. Wall framework is accounted for in the wall's U-value, but heat loss through it increases when it is in thermal contact with the window frame (left) [source: SINTEF]

2 > TOPICS TO COVERED BY GUIDANCE HANDBOOKS

(a) Concise introduction to thermal bridges, and their avoidance

> *What functions must façade details fulfil?*: The reader should first be made aware of the functional requirements to take into consideration when designing construction details. See Fig.9 below. The most important are weatherproofing, airtightness, thermal insulation and

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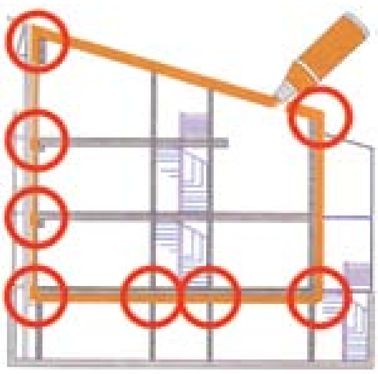

Fig.6 Aim for continuous thermal insulation. Imagine drawing an unbroken line around the building envelope. Red circles indicate thermal bridges [source: PHI]

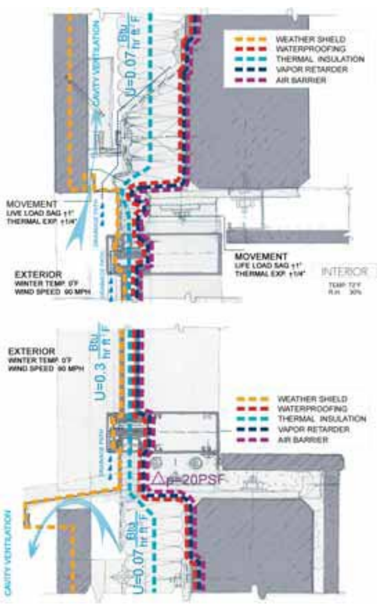

Fig.7 The principle of ensuring continuity of layering past windows, incl. thermal insulation. [source CA01]

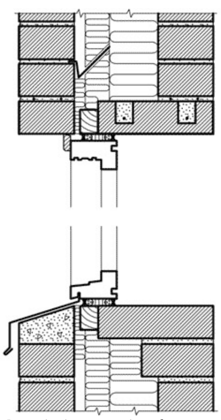

Fig.8 Position windows in line with the insulation layer, and the upturned edge of the windowsill flashing should be just outside insulation layer. [© SINTEF]

vapour barrier. The ordering of the different layers is important. This is well described in [*CA01* page 20-23].

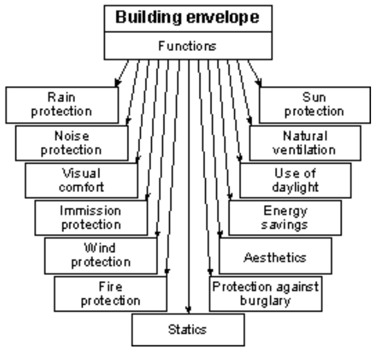

Fig.9 Functional requirements of building envelopes [source: IBP]

- *What is a thermal bridge?*: Generally it is part of a building façade where heat-conducting materials come in contact, creating a 'short-circuit' heat flow path though the facade. Thermal bridges are characterized by multi-dimensional heat flow such that the local heat loss deviates from the façade's assumed U-value.
- *Types of thermal bridges*:
  (**a**) **Repeating**, e.g. wall studs and ties, which can be accounted for in U-values (Fig.3 & 4), (**b**) **Non-repeating**, e.g. details around windows & doors, cantilevered balconies, or junctions between façade areas (Fig.10a & red areas of Fig.2), (**c**) **Geometric**, i.e. angled intersection of two planes, which leads to a difference in area of the outside and inside surfaces of the façade (e.g. Fig.10b & blue corner of Fig.2)

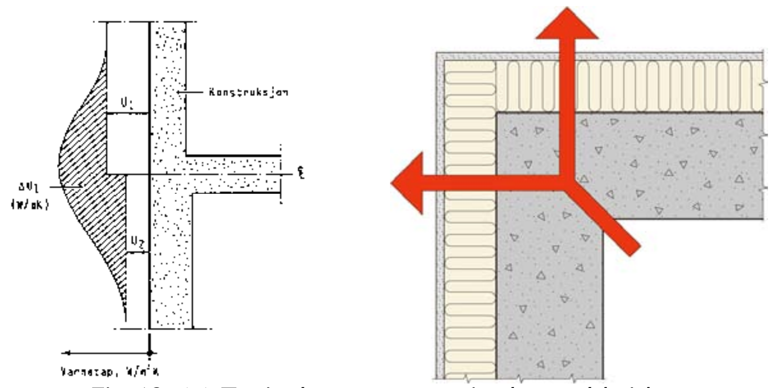

Fig.10 (a) Typical non-geometric thermal bridge, (b) geometric thermal bridge at an external corner. The thermal bridge value Ψ (W/mK) is negative if the heat loss calculation (U•A) is based on external area, and is positive if A is internal area [figs © SINTEF]

- *Principles for avoiding thermal bridges*: (**a**) **Aim for an unbroken thermal insulation envelope** around the entire building; see Figs 6-8. This means that at building element junctions (e.g. roof/wall), their insulating layers should join without gaps or misalignment. If penetrations are unavoidable (e.g. balcony or wall/foundation), try to insert thermal breaks should that join to the insulation layers in the adjacent construction. Many documents [*UK01*, *IE01*, *DE07*] give a good coverage of the application of this principle. (**b**) **Keep façade geometry simple**. Further principles are given in [*UK01*].
- *Airtightness principles*: The above principles should ideally be presented together with the principles for achieving good airtightness, as these often have the same solution principles. See [*UK01* page 13, *IE01* page 15].

(b) Illustrate the effects of thermal bridges

In order to encourage better insulation practice, the negative effects of thermal bridges should be well explained [*NO02*]:

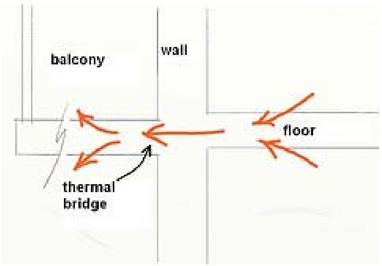

Fig. 11 Simple illustration of balcony thermal bridge

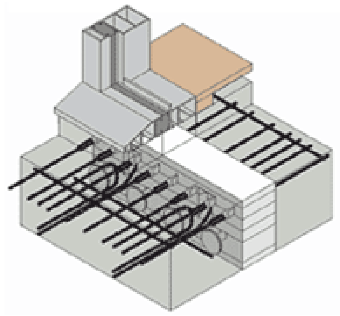

Fig. 12 Detail of wall/floor junction, a typical point for thermal bridging

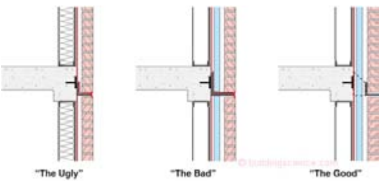

Fig. 13. Examples of two poor and good details for metal lintels for supporting a cavity brick wall.

Fig. 14 Foto of modern lintel bracket that permits unbroken layer of insulation to pass behind, before the brick wall facing is put up.

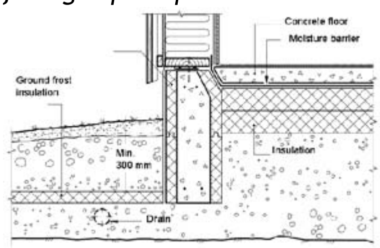

Fig. 15 Detail avoiding thermal bridge and air leakage at the wall/slab-on-ground junction [© SINTEF]

- *Increased heat transfer* through thermal bridges. The consequence of heat loss through normal thermal bridges should be explicitly quantified (both in terms of energy and money). Also, it is important to explain the calculation of the heat loss, and the fact that the thermal bridge value (ψ) increases with increasing insulation thickness of the materials surrounding the thermal bridge. Thus the heat loss through thermal bridges will become increasingly important as member states tighten their insulation requirements. In warm climates, the effect of thermal bridges on cooling load should be highlighted.
- *Low surface temperatures*. This can lead to local condensation or eventually local blackening (aerosol condensation) on inside surfaces. Another consequence is reduced thermal comfort, such as cold floors or cold downdraught. Numerical evaluation is described in [*UK06*, & *EN ISO 10211*].
- *Low temperatures inside the construction*. This may lead to material stresses due to temperature variation, and possibly also interstitial condensation with resulting moisture damage.

(c) Well-illustrated examples of serious thermal bridges

It is important to present details from normal, local building practices that often incur serious thermal bridges. The UK & Irish Accredited Construction Details guides are a good example of this [*UK01* page 14, *IE01* page 18+]. Other useful guides are [*DE05*, *DE06*, *DE07*, *CA01*]. As a rule, the following building elements are critical:

- Balconies (e.g. Figs 11 & 12)
- Brick wall lintels (e.g. Figs 13 & 14)
- Wall/slab-on-ground junctions (e.g. Fig. 15)
- Window/wall junctions (e.g. Figs 5, 7, 8)
- Steel pillars, studs and sills integrated in the building elements

(d) Establish clearly-defined levels of 'good practice'

Each country should establish a quantitative level of good practice. This depends on local climate and insulation standards. In general:

- Introduce a recommended minimum thermal break dimension (mm) at critical details.
- Define minimum insulation thickness (mm) to avoid condensation.
- Define acceptable values of linear thermal bridges for various critical details, together with associated construction details.
- Other *qualitative* measures for good practice might include a Compliance Checklist; see for example page 8 of [*UK01*].

(e) Calculation methods

Explain how thermal bridges are to be calculated with reference to the national standards for area/heat transfer calculation and energy performance calculation. Ideally, show at least one example of a calculation for a whole building. Examples: [*NO08* page 48].

3 > CONSTRUCTION DETAILS

(a) Collections of 'good practice' details

It is extremely useful to establish a collection of construction drawings that show how thermal bridges can be avoided. Some good examples are [*UK01*, *UK02*, *IE01*, *NL03*]. Examples of higher performance details are

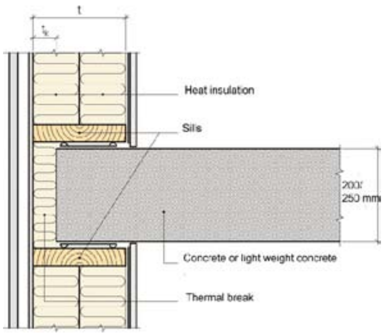

Fig.16 Detail of wall/floor junction, a typical point for thermal bridging

t	t_k	Floor material and –thickness (mm)					
		Concrete		Cellular concrete		Light weight concrete	
	mm	200	250	200	250	200	250
98	50	0,07	0,08	0,00	0,00	0,02	0,02
148	50	0,11	0,12	0,01	0,01	0,04	0,04
198	50	0,13	0,15	0,02	0,02	0,05	0,06
198	100	0,05	0,06	0,01	0,01	0,02	0,02
148 + 98	50	0,15	0,16	0,02	0,02	0,05	0,06
148 + 98	100	0,07	0,08	0,01	0,01	0,03	0,03
148 + 148	50	0,16	0,18	0,02	0,03	0,05	0,06
148 + 148	100	0,08	0,09	0,01	0,01	0,03	0,03
148 + 148	150	0,04	0,05	0,01	0,01	0,02	0,02

Table of thermal bridge values- for Fig.17, ψ [W/(mK)]

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[UK03]. Examples for passive house standards are [AT01/AT02] and [BE01/BE02]. General guidelines are given here:

- Show rich details, not only showing thermal bridge measures, but also protection against driving rain, and airtightness features.
- Describe or illustrate the construction sequence for each detail. Ideally this should be in a form that can be accessible at the building site. For example, Norway has a pocket sized book of details intended for use on site [NO09].
- Take climate variations into account. Some countries have regions with different climates, and where different details may be needed.
- Establish a logical grouping/numbering system for the drawings. Many countries have such a system [notably UK01 & NL03], some of which seem too complex.
- Ideally, detail annotations should be in a language-neutral form, such as numbers or letters, to allow easier adoption by other countries.

Countries can establish their own collections of accredited details by adopting good practice details from other countries with similar climate. Furthermore, the country should consider establishing a national procedure to enable new details to be quality controlled and adopted in the future. Un the UK, new details are assessed for compliance in accordance with the BRE IP1/06 [UK07] and BRE BR 497 [UK08] by a third party certification body. There should also be a feedback form for suggestions, e.g. [IE01 last page].

(b) Calculated thermal bridge values

An atlas of thermal bridge values of the most common constructions should be established, giving values for the ‘good practice’ construction details described above, possibly supplemented with more details. See ASIEPI WP4 IP3. The calculation of heat loss through thermal bridges should follow the rules in EN ISO 10211. The atlas should include geometrical and non-repeating thermal bridges. The calculations should consider:

- Which thermal bridges can be neglected?
- Which thermal bridges can be calculated with the simpler method described in EN ISO 6946?
- The calculation of geometrical thermal bridges must be done according to national area definitions (use of external or internal measures).

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More information can be found at the ASIEPI project website: *www.asiepi.eu*

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Good practice guidance on thermal bridges & construction details, *Part II: Good examples*

A third of EU Member States have no real 'good-practice' guidance on thermal bridges in the framework of their building energy regulations. The quality of guidance in the remaining States is very varied. This paper presents selected examples of good-practice guidance on thermal bridges and associated construction details from around Europe, in the hope that this will inspire organizations that are planning to publish or improve their own construction details and guidance on thermal bridges & airtightness.

This paper is published together with an electronic archive (file *thermal_bridge_good_practice.ZIP*) containing over 60 reference documents. This paper has clickable hyperlinks for opening the individual documents. The ZIP file contents should be extracted to the same directory as this PDF for the hyperlinks to work.

1 > UK

UK has possibly the most complete solution for dealing with thermal bridges in the framework of its building regulations. The main publication is called the Accredited Construction Details (ACDs) for Part L of the Building Regulations for England & Wales [*UK01*]. The ACD guide is freely available from Internet (*www.planningportal.gov.uk*) and is intended to assist the construction industry to comply with the energy performance standards in the regulations. Usefully, it focuses on both insulation continuity and airtightness. The details are for dwellings, but can be used for other buildings with similar construction. Using these details ensures a total thermal bridge coefficient of 0.08 W/m²K for the building envelope as a whole, whilst using non-accredited details is penalized with 0.15 W/m²K. Similarly, use of the ACDs should result in an airtightness of no less than 10 (m³/h)/m² @50 Pa. The guide has two sections:

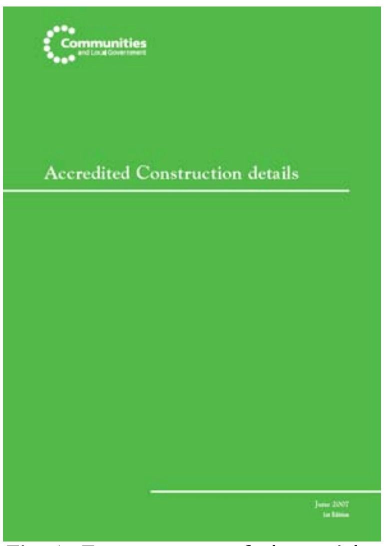

Fig.1 Front cover of the guide to Accredited Construction Details for England & Wales [UK01]

- **Section 1** is a 16 page guide discussing general theory of insulation continuity and airtightness. Practical tips are given for the design stage, construction, an control methodology. The use of Accredited Details, with their associated Compliance Checklists as a route to compliance, is explained. It gives a brief summary of the consequences of poor thermal bridges and air leakage, included energy costs, illustrated with photos of common problems (Fig.1). Further, it gives advice on how to improve the thermal performance of critical details. It refers to the 6-page BRE IP 1/06 [*UK07*] if one wishes to calculation of heat transfer coefficient for non-standard details.
- **Section 2** is a collection of 146 details, each of 1 A4 page. The details clearly show thermal insulation and the air barrier in red and blue

Fig.2 Photos of critical details in UK's ACD guide

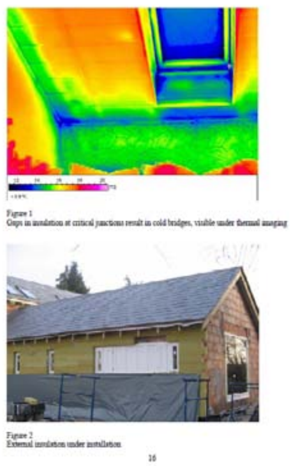

Fig.3 Photos of critical details in Ireland's ACD guide

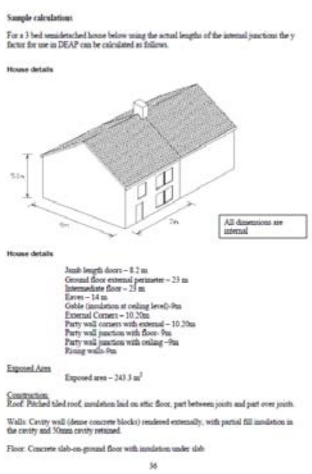

Fig.4 Calculated example house in Ireland's guide

respectively, which is very useful. Each sheet also has check-boxes for on-site quality control of detail execution. Completed forms are meant to be forwarded to the state Building Control Body (BCB) during construction. The details are grouped into 5 separate PDF documents according to construction type. Within each group, the details are sorted according to junction type, i.e. where the detail occurs in the building envelope – There are 8 such junction types. See fig.XX Each detail has a version number, and a specific ID code built up as follows: (*Construction type*)–(*Junction type*)–(*Reference number*), e.g. "MEI-WD-01" is the detail for Window/Door lintels in Masonry Walls with External Insulation. This coding system is very practical.

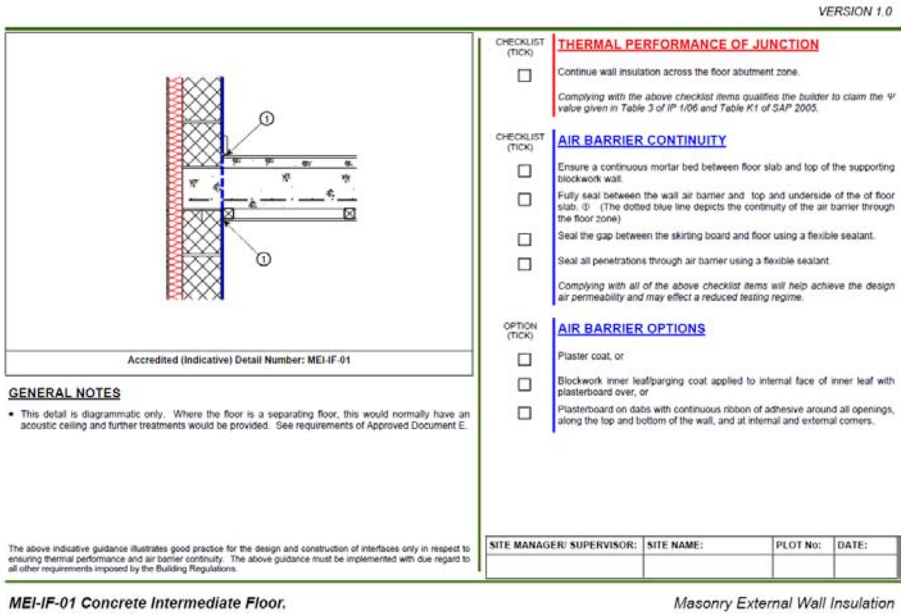

Fig.5 Example detail from UK's ACD

Although Scotland is part of the UK, it has its own regulations, which are similar to England's. Scotland's ACDs have a far simpler guide, though the details are similar, yet more clearly drawn and annotated [*UK02*]. These have roughly the same heat loss as the England & Wales details.

If optional higher standards of insulation are sought, one can use the freely available 'Enhanced Construction Details' (ECD) [*UK03*], which have half of the thermal bridge heat loss of ACDs, i.e. 0.04 W/m²K. These have been published by the UK's Energy Savings Trust. Similarly to the ACD, the details are accompanied by a 11-page introductory guide. Unlike ACDs, the thermal bridge coefficient (ψ) is declared on each detail sheet. The ID code system is different to that of ACD.

49 Section 2 of this publication provides a series of ACDs illustrating typical junction interfaces for various construction types. The details are indexed in accordance with their construction and junction type in the form **Construction Type – Junction Type – Reference Number** (e.g. MCI-GF-01). The table below outlines the section codes:

Construction Type		Junction Type	
MEI	Masonry External Insulation	EW	External Wall
MCI	Masonry Cavity Insulation	GF	Ground Floor
MII	Masonry Internal Insulation	IF	Intermediate Floor
TFW	Timber Frame	IW	Internal Wall
SFW	Steel Frame	RE	Roof Eaves
		RF	Flat Roof
		RG	Roof Gable
		WD	Windows and Doors

Fig.6 Codes for different construction types and junction types

Fig.7 Irish feedback form.

Fig.8 Norwegian design sheet

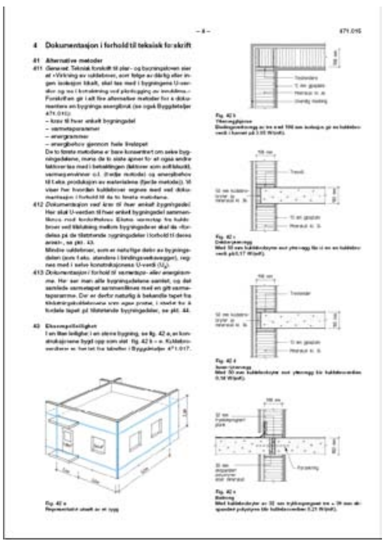

Fig.9 Norwegian design sheet

2 > Republic of Ireland

Ireland's 'Acceptable Construction Details' (ACDs) [*IE01*] are intended to help achieve the performance standards in its 2008 Technical Guidance Documents (TGD) Part L. It is largely based on UK's ACD, and is freely available (*www.environ.ie/en/TGD/*). The 46-page introductory guide seems to be further-developed from UK's guide, and includes a useful calculation example using the Irish DEAP spreadsheet method for summating the thermal bridges for any specific building. Another interesting feature is a feedback form for new & amended details. Ireland's ACD numbers 136 details, with a different categorization than UK ACDs, using number IDs.

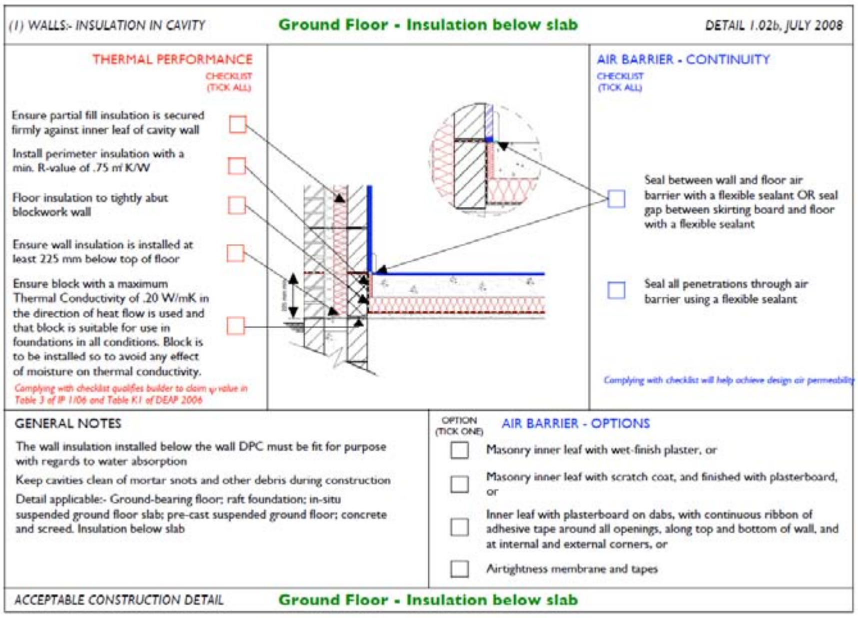

Fig.7 Example detail from Ireland's ACD

3 > Norway

SINTEF Building and Infrastructure, which is the national building research foundation, has over 60 years built up a series of good- practice guides [*NO01*]. The series presently numbers 760 guides, each of 6~8 pages, provides concrete solutions and advice on a wide range of specialist building issues, richly illustrated and with clear text. It is updated monthly and available online (*bks.byggforsk.no*, also CD-ROM and printed). All drawings can be downloaded electronically in high detail. The guidelines are regarded as the national reference for good building practice. Almost all companies in the Norwegian building industry subscribe. Presently, 4 of the guides are in English and Polish.

Five of the booklets deal with thermal bridges specifically [*NO02*, *NO03*, *NO04*, *NO05*, *NO06*]. These explain consequences, calculation of energy use, improvement, and a small atlas of details with thermal bridge values. However, more importantly many of the remaining guides in the series contain details, with how to avoid thermal bridges as just one aspect. See examples in fig. 2 and 3. There is also a handy pocket book of details of wooden constructions, for use on building sites [*NO09*].

In 2007, a freely available national report was published to support the treatment of thermal bridges in the building regulations and EP calculation method [*NO08*]. It is equivalent to UK's guide, but is much more detailed.

As a result of this project, the national EP calculation standard now tabulates 'typical' values of total thermal bridge coefficient [$W/m^2_{floor}K$] depending on construction type (i.e. steel frame, wood frame,

Fig.10 *Protokollblad #24 [PHI] [DE06]*

Fig.11 *Protokollblad #35 [PHI] [DE07]*

Fig.12 *Guide on building energy regulations, with 3 pages on thermal bridges [DE02]*

concrete/brick) and on the minimal thickness of thermal breaks (i.e. 5 cm or 10 cm). This is a simple and practical means of combining good practice together with EP calculations, without the bother of summating all the linear thermal bridge ψ-values for all the details that are used in a specific building.

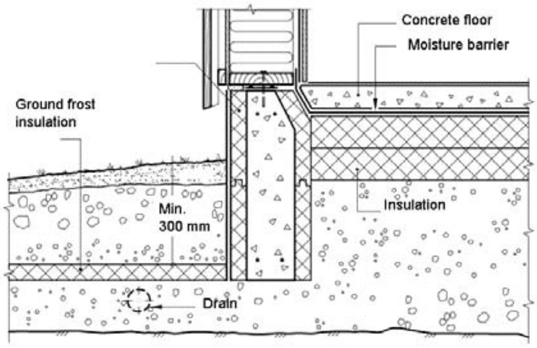

Fig.13 This figure shows how to avoid thermal bridging and air leakage at a wall / slab-on-ground junction.

4 > Germany

Numerous reports covering the topic of thermal bridges have been published in Germany. However, there is no equivalent to UK's ACD guide & details. Those publications that are freely available generally cover thermal bridges rather superficially [e.g. *DE12*, *DE14*, *DE15*] or as part of a general documentation of an energy efficient concept [e.g. *DE02*, *DE11*].More substantial publications on thermal bridges have been published by the Passivhaus Institut, in particular '*Protokollband #14*' on passive house windows [*DE04*], '*Protokollband #16*' on thermal-bridge free constructions [*DE05*], '*Protokollband #24*' on energy-efficient modernization, especially of multifamily housing for which thermal bridges are an important aspect [*DE06*], and '*Protokollband #35*' focusing on two critical thermal bridges: basements and balconies [*DE07*].

5 > Belgium

'Good practice' guidance is still under development in Belgium. One project, called 'Koudebrug-IDEE', has established a free on-line catalogue [*BE04*] with some 150 details for joints commonly found in Belgium. The quality of these drawings is very basic. However another project has published some very appealing and clear passive house details (*www.bouwdetails.be*) [*BE01*, *BE02*]. It is a free website with interactive step-by-step 3D illustrations showing how to construct passive house details, and downloadable 2D details with step-by-step description of construction. These details have a unique pedagogic quality.

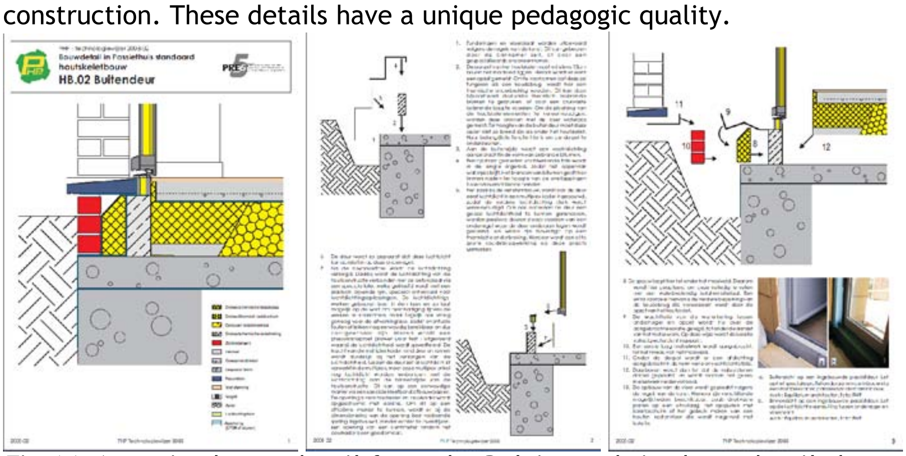

Fig.14 A passive house detail from the Belgian website bouwdetails.be

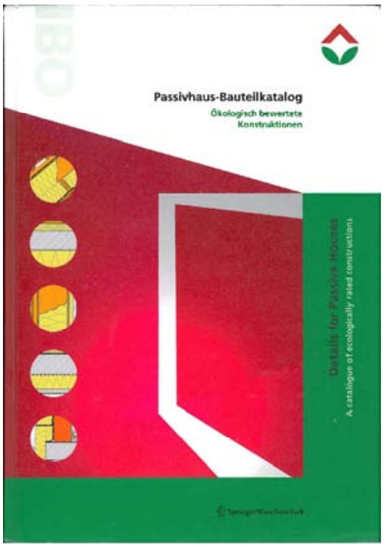

Fig.15 Frond cover of 'Passivhaus-Bauteilkatalog' with ecologically-rated details [*AT02*]

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Link: www.asiepi.eu

Original text language: English

6 > Austria

IBO 'Passivhaus-Bauteilkatalog' is a 347-page bilingual German/English 'bible' of passive house details [*AT01*, *AT02*]. There are 310 illustrations. Each detail has a description together with suitability criteria, performance parameters (incl. thermal bridge ψ-values), LCA evaluation, and cost assessment.

7 > Netherlands

SBR-Refentiedetails [*NL03*] is a highly professional subscription service providing a large collection of constantly updated details together with thermal bridge ψ-values and other data. They are available for different construction types, both residential and commercial buildings, and renovation, new, or passive house. In practice they are mostly used for residential buildings. The details are available in paper, online and electronic files (DWG, DXF) for import to CAD. The draw-back of this service is that it is not explicitly connected to the building regulations. There is, however, software available to enable summation of the thermal bridges for all the details in a specific building.

Each SBR detail has a unique ID code, which conveys much useful information. However, the code is a tad complicated, and since it consists only of digits, it is less self-explanatory than, for example, the UK's code system.

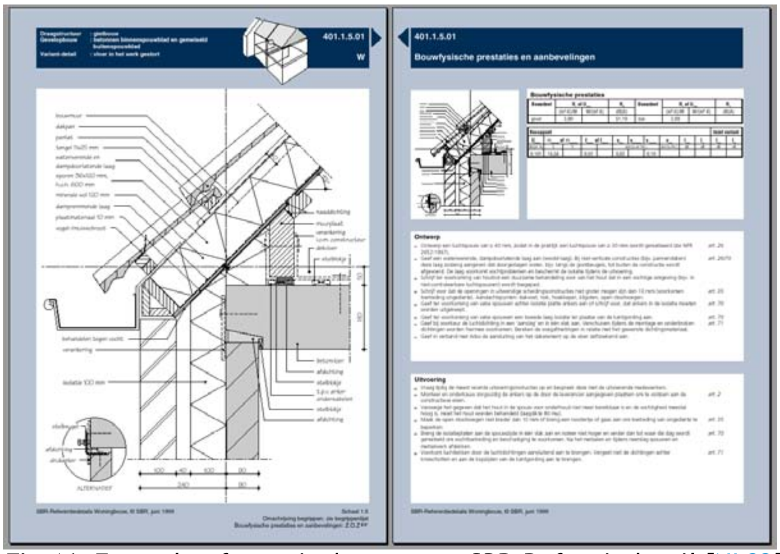

Fig.16 Example of a typical two-page SBR-Refentiedetail [NL03]

8 > Romania

Romania has guides with common construction details, with provisions and examples of correct and incorrect insulation. The guides/standards are not free, but are available electronically via *www.matrixrom.ro*.

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Advanced thermal bridge driven technical developments

Hans Erhorn
Heike Erhorn-Kluttig
Fraunhofer Institute for Building Physics (IBP), Germany

More information can be found at the ASIEPI project website: *www.asiepi.eu*

Similar Information Papers on ASIEPI and/or other European projects can be found at the individual project websites and in the publications database of the BUILD UP Portal: *www.buildup.eu*

Section drawing showing how an Isokorb is forming a thermal break between the building and the balcony [Copyright Schöck Bauteile GmbH].

In order to inform about actual technical developments to reduce the thermal bridge impact in buildings, the Intelligent Energy Europe project ASIEPI has worked closely together with the building industry via the associated industry partners. Good examples for industry developments have been gathered and are presented in this information paper. Though the paper does not provide a full market survey it gives and idea of the variety of the different currently available developments.

1 > Examples for industry developments regarding the reduction of thermal bridges

Only few industry companies are focusing their products on thermal bridge avoidance. Other industry companies do not focus on thermal bridge issues but manufacture products like general insulation and then improve the thermal quality of these products by further developing solutions that are reducing the thermal bridge impact.

1.1 Thermal breaks for external building components

Structural elements that go undisturbed from the inside of a building through the insulation layers to the outside result in major thermal bridges. An example for this situation is a balcony slab, which is directly connected to the room ceiling. In the following, products of two different industry companies are presented that allow for reduced thermal bridge impact at external building components. Alternative solutions include balcony designs that have separate pillars and are only connected to the external wall by point anchors.

<u>SchöckIsokorb®: Thermally efficient load-bearing connections</u>

The SchöckIsokorb® product provides a so-called thermal break between external components such as balconies and the building. It is available as reinforced concrete-to-concrete application, as reinforced concrete-to-steel application and as steel-to-steel application. There are also solutions for wood-concrete connections.

The Isokorb system consists of insulation, stainless steel and a pressure module made of micro fibre high performance fine concrete and can form a thermal break whilst transferring load and maintaining full structural integrity. For example, the linear thermal transmittance can be reduced from about 0.94 W/mK to 0.20 W/mK for a balcony slab extending through the wall from the inside ceiling to the exterior. Further information on the system (in various languages) can be found at [1] and [2].

Intelligent Energy Europe

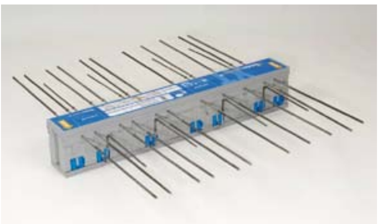
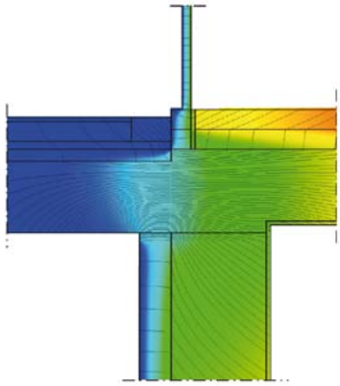
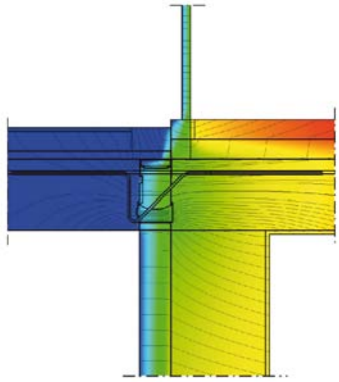


Photo of a SchöckIsokorb® [Copyright Schöck Bauteile GmbH].

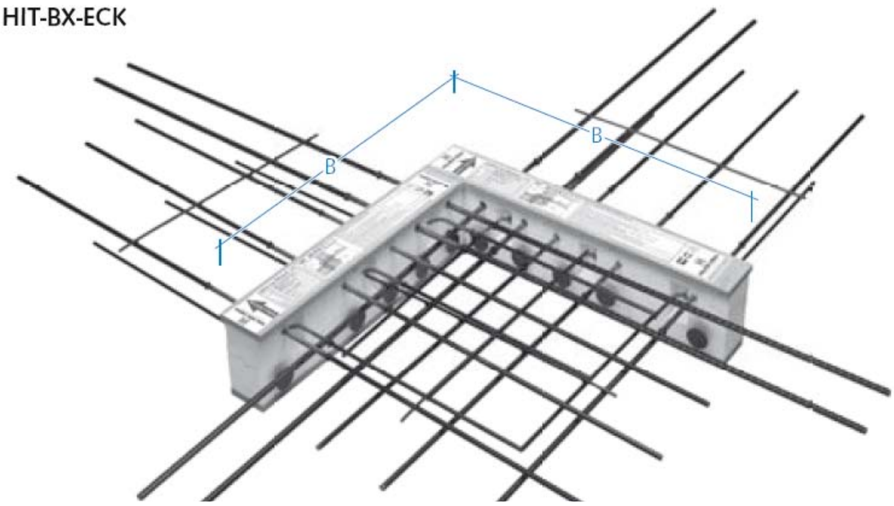
	
ψ_e = 0.94 W/mK	**ψ_e = 0.20 W/mK**
Balcony slab going through the wall from the inside ceiling to the exterior with insulation on top of the balcony.	Balcony with SchöckIsokorb®.

Graphic showing the coloured temperature distribution, the isoflux lines and the external linear thermal transmittance coefficient of two different solutions for fixing a balcony to a building [Copyright Schöck Bauteile GmbH].

<u>Halfen HIT balcony connections</u>

Also Halfen produces a load bearing thermal insulation unit for the thermal separation of concrete components from the main building structures. Due to a separation of exterior concrete components from main structures with Halfen-Iso-Elements [3] heat losses and CO_2-emissions can be reduced, and condensation and mould growth can be avoided. One special feature of the Halfen-Iso-Element is a combination of metre-units and 200 mm modules to form any length. Through a combination of these units and modules cuttings at the construction site can be avoided and a high economy grade can be achieved.

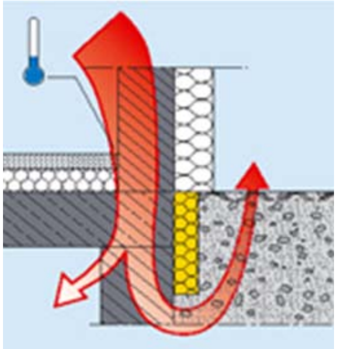
HIT-BX-ECK



Thermal break element for a balcony at a wall corner [Copyright Halfen GmbH].

1.2 Thermal break elements for basement joints

Walls above cellar ceilings often cause thermal bridges as presented in the graphic on the left. Heat is lost via the connection of the external wall to the cellar ceiling and from there to the unheated cellar and the ground. Therefore the cellar walls and ceiling either have to be insulated on both

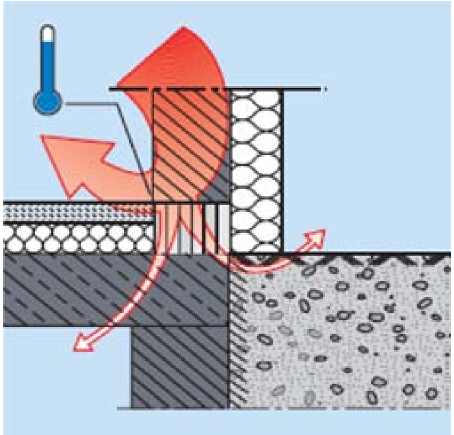


Scheme visualizing possible heat losses through the joint cellar ceiling/external wall [Copyright Schöck Bauteile GmbH].

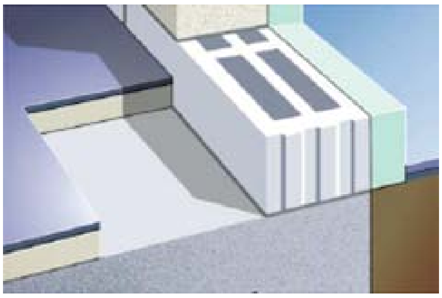
sides (at least in the areas of the external and internal walls), or a thermal break needs to be included at the level of the ceiling insulation. ASIEPI has found two industry companies that produce these kinds of thermal breaks:

<u>SchöckNovomur</u>

A second product reducing thermal bridges from Schöck Bauteile GmbH is a hydrophobic thermal break element called Novomur [1], [2]. It is used as first masonry row at ground floor level in order to reduce the thermal losses from the exterior wall via the cellar ceiling to the cellar and the ground (see figures below).



Schematic drawing of the function of a thermal break element as first row of stones at the ground floor.



Scheme showing a Novomur element used as thermal break on top of the cellar ceiling

[Copyright Schöck Bauteile GmbH].

The element is produced in two different stone strength classes: 20 N/mm² (Novomur for multi-family houses) or 6 N/mm² (Novomur light for detached or terraced houses). It consists of light-weight concrete and polystyrene foam.

Puren insulation bridge under the first row of masonry to reduce the thermal bridge impact [Copyright Puren GmbH].

<u>Puren Insulation Bridge</u>

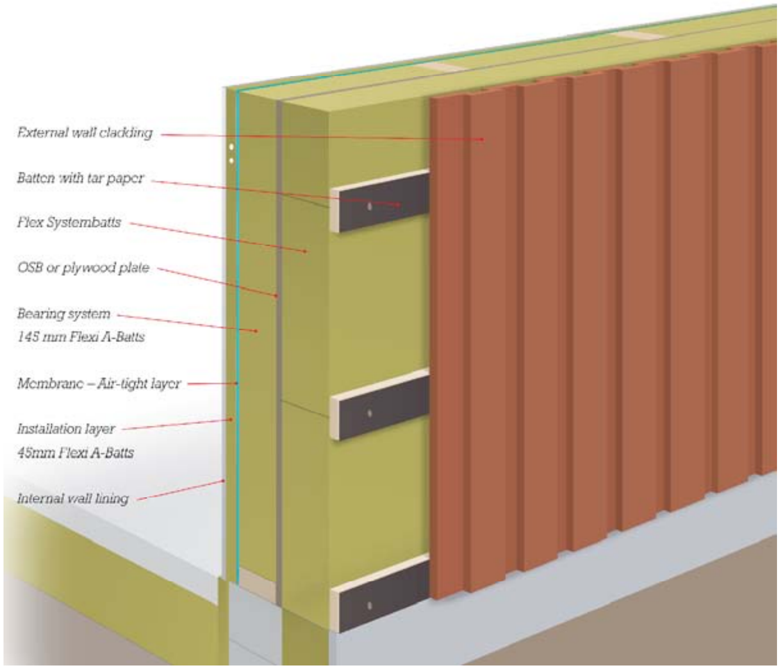
Similar to the previous product, the Puren insulation bridge is used below the first masonry row in order to avoid thermal bridging into or from wall connections. It is a rigid-foam based purenit construction material with a high thermal insulation value, capable of bearing a maximum continuous load of up to 1.8 MPa. Further information in five different languages is available at [4].

1.3 Products for mounting insulation material to the wall with reduced thermal bridge impact

Usually, insulation material is mounted to external walls by means of anchors or rails. The anchors connect the outside surface of the insulation directly with the warm wall behind the insulation. They are made of metall and cause point thermal bridges, which have to be included in the U-value calculation of the insulation system. More anchors are necessary if not only the insulation material, but also a curtain wall has to be mounted. For external composite thermal insulation systems the insulation can be glued to the wall, thus avoiding thermal bridges created by anchors, but this is realised very rarely and can only be done up to a certain wall height. One industry company has now developed a system for an insulated curtain wall that results in less thermal bridge impact.

Rockwool Flex Systemwall

Flex Systemwall is an external wall insulation system that significantly reduces thermal bridges compared to regular mounting on rails. The system can be used for heavy and light-weight walls for both new construction and renovation.



Graphic showing the fixture of the cladding system into the battens. [Copyright Rockwool].

The backing wall construction receives an effective insulation coat. Subsequently, the optional cladding is fastened. Flex Systembatts are used as external wall insulation. Their flex zones ensure the tightness of the joints and the result is an external wall insulation without thermal bridges. The weight of the facade cladding and underlay boards is carried by the roof structure. Underlay boards are attached to the back wall, whereby the insulation is maintained. More information can be found at [5] and [6].

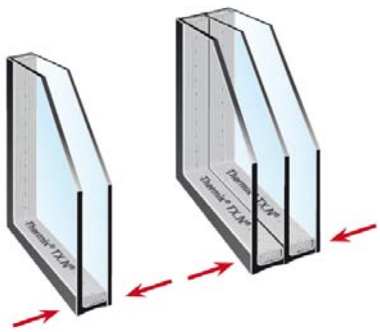
1.4 Thermal bridge solutions for window/wall joints

In most cases, the problematic joint between window frames and the surrounding wall is mostly solved by providing an overlap of the insulation material on part of the frame. Dealing with thick insulation layers this method can change a buildings's appearance and lead to the so-called arrow-slit architecture, with the windows being hidden behind 200 mm of insulation or more. A German company offers a solution to this problem.

KnaufGips KG Lichtkeile (light wedges)

Photo of a Lichtkeil (light wedge) within an externally insulated wall [Copyright KnaufGips KG].

As a result of increasing insulation thicknesses, KnaufGips KG (Marmorit) has developed special solutions for the wall/window joint to avoid the so-called arrow-slit architecture and to increase the amount of daylight coming in through the windows. “Light wedges”, that are opening up towards the external surface of the insulation system, allow for a higher yield of daylight. At the same time, they meet the thermal bridge challenge at the wall/window joint. They are available as diagonal or rounded elements. Further information is available at [7].



Schematic drawing of warm-edge spacers between a double and a triple glazing [Copyright Thermix®].

Photo of the Swisspacer product [Copyright SGG Swisspacer®].

1.5 Warm-edge spacers for double-glazed and triple-glazed windows

The evolution of high performance windows has resulted in low-e-coated double and even triple glazing filled with rare gases such as argon, xenon or krypton or even vacuum glazings. Nowadays, the glazing usually has a lower U-value than the window frame, even if the latter is made of wood. For a long time, there used to be a weak spot in the glazing: the edge bond. Still, most spacers that separate the two glass panels from one another are made of aluminium which acts like a thermal bridge at the glazing/frame joint. Compared to aluminium spacers, stainless steel spacers only slightly reduce the thermal bridge impact. New developments for spacers have combined stainless steel and insulating plastic. Two examples of these products are given below.

<u>Thermix® warm-edge spacers for insulating glass</u>

The Thermix® warm-edge spacers produced by the company Ensinger can be used in combination with all regular types of glazing and frame products. The combination of stainless steel and highly insulating plastic ensures that the respective material properties are optimally used. Besides achieving considerable heat savings, the risk of condensation and mould formation is minimized. For instance, the ψ-value of the glass edge in a wooden frame can be reduced from 0.08 W/mK (aluminium spacer according EN ISO 10077-1) to 0.041 W/mK by using the Thermix spacer. Further information can be found at [8].

<u>Swisspacer - Warm-Edge Spacer Systems</u>

Swisspacer is a thermally improved, or warm-edge, spacer bar for insulating glazing. It is manufactured from special fibreglass, composite material. Swisspacer is available in two versions:

- Swisspacer - the composite material is covered by an ultra thin foil of aluminium
- Swisspacer V - with an extremely thin stainless steel foil for maximum possible insulation.

The heat transmission coefficient of the window is at least 0.1 W/m²K lower than that of a window with conventional aluminium spacer bars. Reductions of the window U-value of up to 0.4 W/m²K can be attained depending on the frame/glazing configuration and the window size. For further information have a look at [9].

2 > Conclusions

ASIEPI has collected examples for thermal bridge driven industrial developments in the building sector. Though there are many examples for high quality building joints published in different good practice guidances that are based on good (architectural/engineering) design, it has to be concluded that not that many products exist that were especially developed to reduce thermal bridges in buildings.

ASIEPI therefore recommends to:

- **the building industry:**
  - to increase their developments regarding thermal bridge driven details. Improved solutions should be developed for fixing external loads like balconies, for mounting insulation and/or cladding and for solving re-occuring problematic component joints. A simple application of the products should also be in the focus of the developments.
- **the building practitioners:**
  - to keep up with high quality industrial solutions concerning thermal bridges and other building problems, e.g. airtightness.

The following additional information papers on thermal bridge topics can be found on the ASIEPI website:

- Thermal bridges in the EPBD context: Overview of MS approaches in regulations
- Impact of thermal bridges on the energy performance of buildings
- Software and atlases for evaluating thermal bridges
- Analysis of execution quality related to thermal bridges
- Good practice guidance on thermal bridges & construction details. Part I: Principles
- Good practice guidance on thermal bridges & construction details. Part II: Good examples.

The recordings of an Internet information session on advanced thermal bridge driven technical developments are available at: *http://www.asiepi.eu/wp-4-thermal-bridges/web-events.html*

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Kaunas University (LT), University of Budapest (HU), University of Bucharest (RO), BRE (UK), UCD (IE)

Link: www.asiepi.eu

Original text language: English

› **the regulators:**
- to create a clear regulatory framework that gives a fair assessment of improved product solutions, compared to poor solutions with a strong thermal bridge effect.

A possibility to stay informed, but also to inform others on new technical developments regarding the avoidance of thermal bridges is the community "Thermal Bridges Forum" on the EU portal for energy efficiency in buildings BUILD UP [10].

3 > References

1. Schöck: Innovative Baulösungen. Website including the products Isokorb and Novomur in various languages: *http://www.schoeck.de*.
2. Schroth, U.: Exemplary industry developments in the field of thermal bridge effect reduction: Isokorb and Novomur. ASIEPI web event 8: Good Building Practice to avoid Thermal Bridges. *http://www.asiepi.eu/wp-4-thermal-bridges/web-events.html*.
3. Halfen GmbH: Halfen HIT Balcony Connections. *http://www.halfen.com/?id=9907&id_lc=25*
4. Puren GmbH: Website including the product Puren Insulation Bridge in five different languages: *http://www.puren.com*.
5. Rockwool: Firesafe insulation. English website with information on products: *http://www.rockwool.com*.

   The Flex Systemwall can currently be found at the Danish website only: *http://www.rockwool.dk/systemer/flex+systemv%C3%A6g/fordele+ved+systemet*
6. Baungaard Andersen, L.: Exemplary industry developments in the field of thermal bridge effect reduction: Flex Systemwall. ASIEPI web event 8: Good Building Practice to avoid Thermal Bridges. *http://www.asiepi.eu/wp-4-thermal-bridges/web-events.html*.
7. KnaufGips KG: Broschüre Warm-Wand-Systeme (PuFa22). *http://www.knauf.de/content/de/tools_downloads/downloads/broschueren/broschueren_puf/br_warmwand_systeme/warmwand_systeme_1.php*
8. ENSINGER GmbH: Thermix® - Warm-edge spacers for insulating glass. *http://www.thermix.de/t-en/index.php*
9. SGG SWISSPACER® - What is a warm edge: *http://www.swisspacer.com/en/products/what-is-a-warm-edge.html*
10. BUILD UP: Energy solutions for better buildings. Community "Thermal Bridges Forum". *http://www.buildup.eu/communities/thermalbridges*.

Disclaimer: ASIEPI has received funding from the Community's Intelligent Energy Europe programme under the contract EIE/07/169/SI2.466278.

I E E S A V E   A S I E P I

ASIEPI

Part D. Web events

on

An effective Handling of Thermal Bridges in the EPBD Context

ASIEPI web event 4: An effective handling of thermal bridges in the EPBD context

ASIEPI web event 8: Good Building Practice to avoid Thermal Bridges

ASIEPI web event 4

An effective handling of thermal bridges in the EPBD context

4 March 2009, 10:00-12:00 GMT+1 (Paris time)

Thermal bridges increase the building energy demand for heating and cooling. This energy loss can be even higher than for example the energy benefit provided by thermal solar collectors for domestic hot water. The public awareness of this fact is however very low.

Therefore, the national EP calculation procedures should include the impact of thermal bridges (as they include the effect of thermal solar collectors!). Moreover, best practice examples of advances solutions or technologies should be widely presented, in order to promote the advantages of a detailed planning of component joints in new and renovated buildings.

This ASIEPI web event has given an overview of the approaches in place in different Member States for assessing thermal bridges as part of the energy performance of buildings. The real impact of thermal bridges on the energy performance and information on software tools and thermal bridge atlases are presented as well. Additionally there was a presentation on the point of view of the industry, by one of the ASIEPI sponsors.

Event page: http://www.asiepi.eu/wp-4-thermal-bridges/web-events/web-event-4.html

An effective handling of thermal bridges in the EPBD context
Welcome *by Hans Erhorn, Fraunhofer-IBP, WP4 leader*
Brief presentation of the ASIEPI project *by Hans Erhorn*
Introduction into thermal bridges as covered in ASIEPI *by Hans Erhorn*
Technical discussions
Overview on Member States approaches *by Marco Citterio, ENEA*
Impact of thermal bridges on the energy performance of buildings *by Heike Erhorn-Kluttig, Fraunhofer-IBP*
Software tools and thermal bridge atlases *by Antoine Tilmans, BBRI*
The industry point of view, expressed by an ASIEPI sponsor
Thermal breaks – challenges for hygro-thermal constructions to meet every requirement *by Piet Vitse, PCE*
Discussions
Questions
Conclusion and closure *by Hans Erhorn, Fraunhofer-IBP*

ASIEPI web event 8

Good Building Practice to avoid Thermal Bridges

19 January 2010, 10:00-12:00 GMT+1 (Brussels time)

The work in IEE ASIEPI on thermal bridges started with an overview on national energy performance regulations concerning if and how thermal bridges can be assessed by the national standards. This information together with the possible impact on the energy performance and the available software and thermal bridge atlases have been presented and discussed in the first internet information session "An effective handling of thermal bridges in the EPBD context".

This time we inform about the following topics:

- Good practice guidance
- Promotion of good building practice
- Execution quality
- Advanced technical developments

ASIEPI has collected examples and experiences from several European countries. We look forward to share the knowledge, initiate discussions and raise questions during the second web event on thermal bridges.

Event page: http://www.asiepi.eu/wp-4-thermal-bridges/web-events.html

Good Building Practice to avoid Thermal Bridges
Welcome and introduction to ASIEPI *by Hans Erhorn, Fraunhofer-IBP*
The ASIEPI work on thermal briges *by Hans Erhorn, Fraunhofer-IBP*
Technical discussions
Good practice guidance: what should a guidance document contain and national examples for good guidance documents *by Peter Schild, SINTEF*
How is good building practice promoted in EU Member States *by Heike Erhorn-Kluttig, Fraunhofer-IBP*
Execution quality realised in some EU Member States and possibilities of how to check and improve it *by Kirsten Engelund Thomsen, SBi*
The industry point of view
Exemplary industry developments in the field of thermal bridge effect reduction: Isokorb and Novomur *by Ute Schroth, Schöck*
Exemplary industry developments in the field of thermal bridge effect reduction: Flex Systemwall *by Lars Baundgaard Andersen, Rockwool*
Discussions
Questions
Conclusion and closure *by Hans Erhorn, Fraunhofer-IBP*

IEE SAVE ASIEPI

Stimulation of good building and ductwork airtightness through EPBD

Summary report

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SUMMARY

Building and ductwork leakage are detrimental to energy conservation, comfort, hygiene. They can cause building damage and it can prevent proper control of the ventilation airflow rates. Today, more than ever, with the objective of all new constructions being "nearly zero energy buildings" in 2020, **policy makers** need to know how better airtightness can be stimulated. Within ASIEPI, we have come to the following recommendations, which are developed in part A of this summary report.

To the question "How to promote a market transformation of envelope airtightness ?" the following 3 main recommendations can be formulated:

- to include airtightness with fair reward in the EP calculation methods of the member states, combined with compulsory measurements and/or quality management approaches for claiming such reward in the EP-calculation, in labels and in subsidies;
- to promote cooperation with building professionals through development of practical tools and through pilot and research projects;
- to roll out a global dissemination strategy specifically tailored to each of the target groups as owners, builders, designers, craftsmen, and measurement technicians.

To the question "How to support a market transformation of ductwork airtightness ?" Based on the Scandinavian success stories the following 3 main recommendations can be formulated:

- *Market pull*: Improve the competence of building professionals (especially HVAC professionals) on the benefits of good ductwork airtightness, to convince them that airtight round duct systems with prefitted seals have many additional benefits (lower costs, space efficiency, etc.) over both rectangular duct systems and round ducts without pre-fitted seals;
- *Technology push*: Support industrial development of efficient products because a technology push was clearly observed in Scandinavia where 90-95% of ductwork installed are spiral-seam steel circular ducts with factory-fitted sealing gaskets;
- *Regulatory push*: Include requirements on airtightness (and possibly also pressure testing) in national regulations, with penalties for non compliance, and to develop well-explained technical guidelines and/or building standards.

Major contributions of ASIEPI on the "building and ductwork airtightness" issue are described in part B of this summary report. They include :

- A review of regulations requirements, partly based on a questionnaire submitted to experts with the 13 countries represented in the consortium, and summarised in one conference paper;
- A focus on 5 countries where a market transformation is underway, with 2- to 4-page reports that analyse the market transformation mechanisms;
- A focus on technical issues, with a series of information and conference papers on very-low energy buildings, calculation and measurement methods;

- Awareness raising, namely through several national and international workshops, internet sessions, and presentations in conferences.

Part C is a collection of all the Information Papers produced on this topic.

Finally, Part D presents the related organised web events.

Part A: Final recommendations

1. INTRODUCTION

Today, more than ever, with the objective of all new constructions being “nearly zero energy buildings” in 2020, **policy makers** need to know how better airtightness can be stimulated.

Building and ductwork leakage are detrimental to energy conservation, comfort, hygiene and can cause building damage. Good envelope and ductwork airtightness allows one to better control ventilation airflow rates. Therefore, it makes it possible to minimize energy use while maintaining a good indoor environment.

To provide a rough idea, studies report that envelope leakage can increase the heating needs by 5 to 20 kWh/m²/year in a moderate climate (2500 to 3000 degree-days) given today’s levels of airtightness.

Regarding ductwork, the SAVE-DUCT project has shown on a sample of 42 systems in Belgium and France that on average 20% of the air flowing through these systems was leaking out of the ducts.

One objective of ASIEPI was also to give a clear picture to policy makers regarding the way better envelope and ductwork airtightness had been or could be stimulated in the member states, including indications - where available - on the impact of the measures taken to transform the market.

2. WHY PROMOTE DUCTWORK AND ENVELOPE AIRTIGHTNESS ?

2.1 IMPACTS ON ENERGY LOSSES AND INTEREST IN VERY LOW ENERGY BUILDINGS

Impact of envelope and ductwork airtightness on energy losses is recognized as being significant (16): in Belgium and in Germany, it is estimated that envelope airtightness accounts for about 10% of the current energy performance level, a similarly gain as the installation of solar collectors; in France, the impact of envelope airtightness is estimated at 2 to 5 kWh/m²/year per unit of n50 for the heating needs, the impact of ductwork airtightness is estimated at 0 to 5 kWh/m²/year for the heating needs; in Scandinavia the impact might be around 10 kWh/m2/year per unit of n50.

In the case of low energy buildings (10)(11) (12), comparisons between envelope airtightness and insulation thickness have been made and as a result, infiltration losses is identified as a significant factor (Figure 1). In such buildings, airtightness measurement results show what can be achieved in practice.

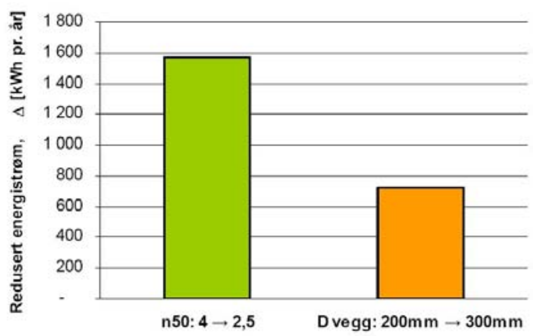

Figure 1 . Relative energy saving from building more airtight (green) compared with the energy saving from building according to the new standard for wall insulation in Norway, for a normal single family dwelling. Source : (15)

2.2 OTHERS IMPACTS ON VENTILATION, INDOOR AIR QUALITY AND BUILDINGS PATHOLOGY

It is also known (14)(15)(18) that poor envelope and ductwork airtightness may have consequences on ventilation systems efficacy, leading to increased energy use, poor indoor air quality, and buildings pathologies.

Some systems like ventilation with heat recovery systems are especially sensitive to bad quality of envelope and ductwork airtightness.

2.3 OVERVIEW IN EUROPE

Through the ASIEPI project, we have identified that while some key elements for a market transformation on envelope airtightness are under development in many countries, status quo seems to prevail for the duct market.

3. HOW TO PROMOTE A MARKET TRANSFORMATION OF ENVELOPE AIRTIGHTNESS ?

Through this work, we have identified 3 practical recommendations to promote better envelope airtightness through a combination of measures that push and pull the market:

Figure 2 . Three components for a market transformation of envelope airtightness, according to Rennings approach (2005)

3.1 FAIR REWARD IN THE EP REGULATION AND MEASUREMENT AND/OR QUALITY MANAGEMENT APPROACH AS A PRECONDITION FOR CLAIMING REWARDS, LABELS OR SUBISIDIES

Airtightness has been included and can be rewarded in the EP calculation method of the majority of the states investigated (Figure 3) as it represents both a key element to achieve low-energy buildings (even in some Southern climates) and a cost-effective measure to reduce energy use. Combined with compulsory airtightness measurements at commissioning for claiming a reward in the EP-calculation, this has been identified as a major push for an airtightness market transformation. Recent experience (France, Finland) with the implementation of quality management approaches as proof of compliance including measurement of random samples is also promising.

This also applies to labels or subsidies.

In Germany, success stories regarding the airtightness market can be mostly explained by over two decades of regulatory push including: taking into account airtightness in EP regulation, developing standards, developing low energy-labels with a requirement on the envelope airtightness and subsidies (15).

Focusing on the label issue, the German experience with the PassivHaus label, and more recently, the French experience with the regulation-based BBC-Effinergie label are interesting examples that illustrate this recommendation. The number of companies offering measurement services in France grew from about 10 in 2007 to over 100 in 2009. The BBC-Effinergie label became operational in 2008.

A side-effect of the pre-requisites for claiming benefits is that some craftsmen in Germany, Norway or France for instance have bought their own device to control airtightness during construction. In Germany, practical experience in achieving extremely airtight envelopes has been demonstrated. Estimates on the number of passive houses around the world range from 15,000 to 20,000 (15).

Concerning the subsidies, one example comes from Norway where the governmental House Bank gives economic incentives to low energy buildings, with a condition for payments: energy relevant characteristics must be documented. Airtightness measurement is also regarded as a way of documenting this property (15).

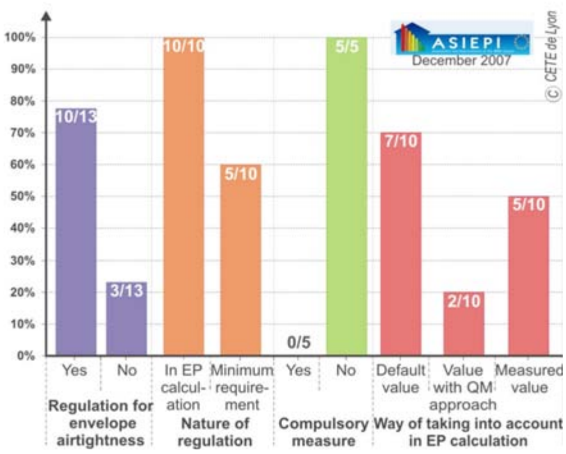

Figure 3. Envelope airtightness : results of a questionnaire of 13 Europeans experts involved in the ASIEPI project

3.2 PROMOTE COOPERATION WITH BUILDING PROFESSIONALS AND INDUSTRY, THROUGH PILOT AND RESEARCH PROJECTS & PRACTICAL TOOLS

In the member states we observed a multiplication of low energy buildings pilot projects arousing the attention of actors on envelope airtightness issues (6). Often supported by regional and national bodies, they significantly drove the market. Among those, there are passive houses pilot projects in Germany, Belgium, France, Czech republic, Poland, etc… Nine experts (of the 13 questioned) consider that those pilot and research projects are significant drivers for a market transformation. Those projects, showing very concrete and practical experience, are of interest to a large scope of building professionals, including designers, builders, craftsmen, and industries.

Some pilot projects were coupled with measurement campaigns (Norway, Germany, France) and such campaigns are also performed to characterise the quality of the building stock (Belgium, Finland). In Belgium, such a large study carried out in 1995-1997, including an envelope airtightness measurement on 50 dwellings, is considered as a very important step to what became the EPB regulation (15).

There is also a common concern regarding the help building professionals need for an effective market transformation and the lack of practical local tools (e.g., catalogues of construction details) with relevant recommendations to build airtight starting at the design stage. To remedy this problem, the German association for airtightness FliB published recommendations in 2001. There is a strong interest for such guidelines in other countries such as Belgium, France, or Norway for instance. The draft recommendations developed in the framework of the PREBAT-MININFIL project in France (Figure 4) experience a great success among professionals.

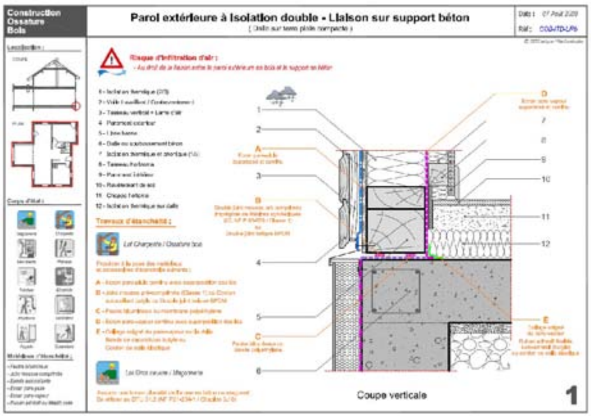

Figure 4. Buildings details, airtight materials and coordination of craftsmen. Source: CETE de Lyon, PREBAT Project MININFIL

3.3 PROMOTE A GLOBAL DISSEMINATION STRATEGY

The dissemination strategy can include trainings, communication and events regarding pilot and research projects, practical tools, very-low energy labels, or the EP regulations. The dissemination material and actions should be specifically tailored towards each of the target groups such as owners, builders, designers, craftsmen and measurement technicians.

In Germany (15), through dissemination and training (and thanks to the availability of measuring companies and sealing products), nearly everybody who is working in the building sector has heard about air tightness measurement, has seen a measuring procedure, has also a basic knowledge about the fault-prone building details like the joints of construction elements.

In this member state, the Blower Door Symposium is organized since 1993 and there are well-organised trainings and certification processes for planners, craftsmen and measurers. It also shows that it is important to develop a dissemination strategy firstly to initiate, and secondly to go with the market transformation.

3.4 SOME PITFALLS UNDERLINED

Thanks to our focus on 5 countries - Norway, Finland, Germany, Belgium and France (15) – some pitfalls were underlined as barriers to a good development of the envelope airtightness market.

The main pitfall to avoid is to underestimate the challenge.

Standardising good envelope and ductwork airtightness for every construction is a tremendous challenge that calls into question traditions in the design and erection of buildings. It requires the need to revisit trainings of architects, engineers and craftsmen, quality assurance processes, regulations (calculation methods and requirements), and to develop specific regulation or certification frameworks for example, for rewarding quality management approaches, or for performing reliable measurements.

Most countries are just starting to realize the challenge they have to overcome.

The second pitfall lies in the barriers to a social and economic acceptance of airtight envelopes

In Norway (15), it was observed that some builders would like to avoid measurement due to the costly repairs needed when a measurement shows that airtightness does not meet the initial requirements.

Erroneous or misleading statements such as “who would live in a plastic bag ?” by influential persons have great potential for slowing down, stalling, or even reversing a market transformation. This problem has been clearly identified in Finland and Norway.

While airtightness is favourable to the overall building quality, bad designs or workmanship (for example, absence of natural or mechanical ventilation system, inadequate strategy concerning combustion devices, absence of capillary breaks, or water leaks) can worsen damage.

Clear information must be given at every stage (decisions makers, owners, builders, designers, craftsmen, measurement technicians) to avoid mistrust or misunderstandings of these kinds.

A third pitfall concerns the technical difficulties associated with the measurement protocol

There exist two very similar standards covering envelope airtightness measurement with fan pressurisation (EN 13829 and ISO 9972). However, there remain many unanswered questions regarding the way a test should be performed (5). For example, the intentional openings to be sealed during the test depending on the calculation method, or in case of large or multi-family buildings. This could distort competition between measurement technicians, designers and builders. Within ASIEPI, we have written a draft position paper (4) for the revision of standard ISO 9972 based on existing technical documents from Belgium, France, and Germany which was presented at the 2009 AIVC/BUILDAIR conference.

Promoting a global dissemination strategy would also help to avoid those both pitfalls.

4. HOW TO PROMOTE A MARKET TRANSFORMATION OF DUCTWORK AIRTIGHTNESS ?

Regarding ductwork airtightness, we got most of following information from a previous SAVE project called SAVE-DUCT (1) and from the ASIEPI information paper "Duct System Air Leakage - How Scandinavia tackled the problem (18)". Except in Scandinavia, many European countries have very leaky ventilation systems. Figure 6 shows that while Swedish systems typically comply with class B on the sample analysed, they are 5 to 10 times leakier in Belgium and in France.

Airtightness class	Limiting leakage (ℓ/s)/m²
A - worst	< 1.32
B	< 0.44
C	< 0.15
D - best	< 0.05

Figure 5. Duct airtightness classes, measured at a test pressure of 400 Pa. Area is calculated according to EN 14239. Source : (18)

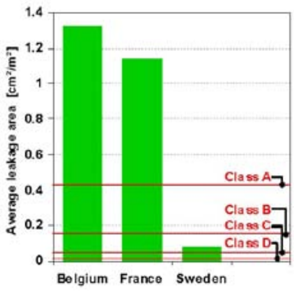

Figure 6. Comparison of average measured duct system leakage in Belgium, France & Sweden (1999). Source : (1)

A focus on the Scandinavian success stories allowed us to propose 3 recommendations to support a market transformation of ductwork airtightness.

Figure 7. Three components for a market transformation of ductwork airtightness, according to Rennings approach (2005)

4.1 DEVELOP DISSEMINATION ON BENEFITS CONNECTED TO GOOD DUCTWORK AIRTIGHTNESS TO THE BUILDING AND INDUSTRY PROFESSIONAL COMMUNITIES

Increased awareness of the building and the industry professional communities about duct leakage impacts is an important step for a market transformation.

The building community should be more informed about the impacts of poor ductwork airtightness on energy efficiency, but also about other impacts, namely on comfort, indoor air quality, ventilation efficiency, fire protection. In Scandinavia good ductwork airtightness has largely been promoted together with indoor air quality benefits. Note that the Swedish VVS AMA guideline not only deals with energy issues related to duct airtightness but also with safety and indoor environment.

Another crucial point is to inform industries and after that to convince them that airtight round duct systems have many additional benefits (low costs, space efficiency) over both rectangular duct systems and round ducts without pre-fitted seals.

4.2 SUPPORT INDUSTRIAL DEVELOPMENT OF EFFICIENT PRODUCTS

A technology push was clearly observed in Scandinavia where 90-95% of ductwork installed are spiral-seam steel circular ducts with factory-fitted sealing gaskets, which have a better quality of tightness (Figure 8).

In Norway, while the minimum requirement is normally class B, 90% of installed ductworks is class C or better, because it is what ductwork suppliers deliver. What are the reasons behind this? It is quite simple : such ductwork are known to have many other benefits over rectangular ductwork, including space efficiency and cost !

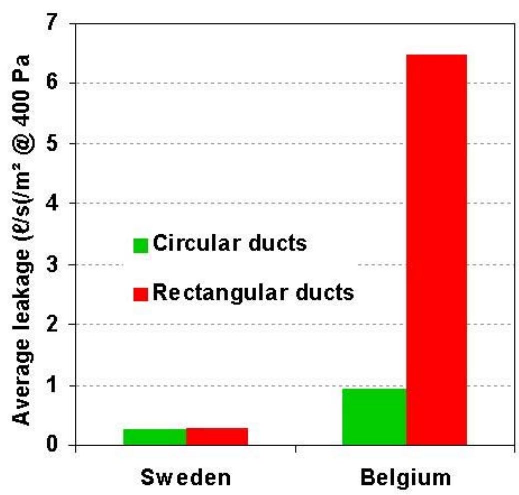

Figure 8. Rectangular versus circular ductwork in Sweden and Belgium. Source : (1)

4.3 INCLUDE REQUIREMENTS IN NATIONAL REGULATION, WITH PENALTIES FOR NON COMPLIANCE.

In Finland (15), the ductwork air tightness requirement has been in the EP regulatory framework since the 1980's. Swedish and Finnish regulations require minimum class C ductwork. These requirements are also connected to regular inspections (except single family dwellings in Finland). Guidelines and Standards are also necessary to be considered as references with technical information and precisions. Such technical guidelines and/or standards exist in every Scandinavian country. There is the VVS AMA in Sweden; the national standard NS 3420 in Norway; the Danish code DS 447.

As a result, requirements and references to guidelines are commonly included in building contracts, it is practically always the case in Sweden, and great attention is paid to commission all ventilation and air conditioning systems.

Penalties on the building energy label, for instance in case of higher leakage, are also one way to encourage building professionals to pay attention to duct leakage.

4.4 BARRIERS IN MIDDLE AND SOUTHERN EUROPE

The five short country reports (15) give also some information about barriers in France and Germany. In France and in Germany, despite some pilot projects and the fact that ductwork airtightness is now explicitly taken into account in the EP-regulation, little has changed with regard to the interest paid by professionals on this issue. Reasons identified behind this status quo might be : the poor reward given to ductwork airtightness; the lack of pilot projects and dissemination on this issue over the past 5 years, as opposed to envelope airtightness; the little use of round steel components pre-fitted with seals which may be encouraged by the lack of attention given to ductwork and ventilation system design. It is estimated that half of the ventilation ducts assembled in Germany are not being installed according to the current standards.

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5. REFERENCES

(1) Andersson, J.; Carrié, F.R. and Wouters, P. Improving Ductwork - A Time for Tighter Air Distribution Systems, Report, EU Project SAVE-DUCT, Brussels 1999. ISBN 1902177104

(2) Aurlien T., Rosenthal B., International comparison of envelope airtightness requirements and success stories that could inspire the EC and other MS, Information Paper n°P147, September 2008, 6p., http://www.buildup.eu/publications/1208, http://www.asiepi.eu/wp-5-airtightness/information-papers.html

(3) Caillou S., Van den Bossche P., Delmotte C., Van Orshoven D., Vandaele L., Measurement of building airtightness in the EPB Context : specific procedure and sources of uncertainties, Conference paper, Building Physics Symposium, Leuven, Belgium, 2008, 6p., http://www.asiepi.eu/wp-5-airtightness/related-papers.html

(4) Caillou S., Van Orshoven D., ISO 9972: Position paper for propositions of revision, Brainstorming document presented at AIVC conference 2009, Berlin, Germany, 12p., http://www.asiepi.eu/wp-5-airtightness/available-reports.html

(5) Caillou S., Van Orshoven D., Report on the building airtightness measurement method in EU countries, Report, February 2010, 33p., http://www.asiepi.eu/wp-5-airtightness/available-reports.html

(6) Carrié F.R, Fleury M., Voisin G., Aurlien T., Stimulating better envelope and ductwork airtightness with the Energy Performance of buildings directive, Conference paper,

AIVC conference, Kyoto, Japan, 2008, 6p., http://www.asiepi.eu/wp-5-airtightness/related-papers.html

(7) Carrié, F.R., Guyot, G., Envelope and ductwork airtightness in the revision of the French energy regulation: calculation principles and potential impacts, Abstract submitted at AIVC Conference, Seoul, South Korea, 2010, http://www.asiepi.eu/wp-5-airtightness/related-papers.html

(8) Carrié F.R, Wouters P., Heijmans N., Rosenthal B., Aurlien T., Guyot G., Ways to stimulate a market transformation of envelope airtightness. Analysis of on-going developments and success stories in 4 European countries, Web event, 12th December 2008, http://www.asiepi.eu/wp-5-airtightness/web-events/web-event-1.html

(9) Carrié F. R., Rosenthal B., An overview of national trends in envelope and ductwork airtightness, AIVC Information Paper VIP 29, August 2008, 6 pp., http://www.aivc.org/medias/pdf/Free_VIPs/VIP29_Airtightness.pdf, http://www.asiepi.eu/wp-5-airtightness/information-papers.html

(10) Erhorn H., Erhorn-Kluttig H., Carrié F.R., Airtightness requirements for high-performance buildings, Conference paper, AIVC, Kyoto, Japan, 2008, 6 p., http://www.asiepi.eu/wp-5-airtightness/related-papers.html

(11) Erhorn-Kluttig H., Erhorn H., Lahmidi H., Airtightness requirements for high performance buildings, Information Paper n°P157, March 2009, 5p., http://www.buildup.eu/publications/5656, http://www.asiepi.eu/wp-5-airtightness/information-papers.html

(12) Erhorn H., Erhorn-Kluttig H., Lahmidi, H., Anderson, R.: Airtightness requirements for high-performance buildings, Conference paper, AIVC, Berlin, Germany, 2009, 6 p., http://www.asiepi.eu/wp-5-airtightness/related-papers.html

(13) Fleury M., Guyot G., Carrié F.R, Synthèse du questionnaire ASIEPI : État des pratiques européennes concernant l'étanchéité à l'air de l'enveloppe et des réseaux, (in French), Synthesis of ASIEPI's questionnaire : Practices about envelope and ductwork airtightness in Europe, Août 2008, 28p., http://www.asiepi.eu/wp-5-airtightness/available-reports.html

(14) Guyot G., Carrié F.R, Envelope airtightness: how stimulate a market transformation? On-going developments, Presentation on demand, March 2009, http://www.asiepi.eu/wp-5-airtightness/presentation-on-demand.html

(15) Guyot G., Carrié F.R, Fleury M. (FR), Rosenthal B., Walther W. (DE), Shemeikka J. (FI), Heijmans N., Van den Bossche P. (BE), Tormod A., Schild P.(NO), An overview of the market transformation on envelope and ductwork airtightness in 5 European countries, Report, March 2010, 28p., http://www.asiepi.eu/wp-5-airtightness/available-reports.html

(16) Guyot G., Carrié F.R, Schild P., ASIEPI Project : Stimulation of good building and ductwork airtightness through EPBD, Final technical report, 50 p., http://www.asiepi.eu/wp-5-airtightness/available-reports.html

(17) Papaglastra M., Leivada I., Sfakianaki K., Carrié F.R, Santamouris M., International comparison of envelope airtightness measurements, Conference Paper, 3rd European BlowerDoor Symposium, E-U-[Z], Kassel, Germany, 2008, pp. 3-11, http://www.asiepi.eu/wp-5-airtightness/related-papers.html

(18) Schild P. G., Railio J., Duct System Air Leakage - How Scandinavia tackled the problem, Information Paper n°P187 March 2010, 6 p., http://www.buildup.eu/publications/8105, http://www.asiepi.eu/wp-5-airtightness/information-papers.html

(19) Schild P., Caillou S., Millet J-R., Mattsson L. Å., Railio J., Carrié F.R., How to improve ductwork airtightness - Ongoing developments and success stories in Europe, Web event, 16th December 2009, http://www.asiepi.eu/wp-5-airtightness/web-events.html

(20) Tilmans A., Van Orshoven D., D'Herdt P., Wouters P., Carrié F.-R., Guyot G., Spiekman M.E., Treatment of envelope airtightness in the EPB-regulations: some results of surveys of the IEE-ASIEPI project, Conference paper, Buildair conference, Berlin, 2009, 8p., http://www.asiepi.eu/wp-5-airtightness/related-papers.html

(21) Van Orshoven D., Tilmans A., Methods in the national EPB-calculation procedures to determine the ventilation heat transfer coefficient, Report, 2010, http://www.asiepi.eu/wp-5-airtightness/available-reports.html

(22) Walther W., Testing the airtightness of large or multiple-storey-buildings in an EU-Regulation Context, Conference Paper, Blowerdoor conference, 3rd European BlowerDoor Symposium, E-U-[Z], Kassel, Germany, 2008, pp. 12-19, http://www.asiepi.eu/wp-5-airtightness/related-papers.html

(23) Wouters P., Heijmans N., Carrié F.R., Implementation of energy performance regulations : opportunities and challenges related to building airtightness, Information Paper n°P072, May 2008, 10 p., http://www.buildup.eu/publications/1450, http://www.asiepi.eu/wp-5-airtightness/information-papers.html

(24) Walther W., Rosenthal B., Airtightness Testing of Large and Multi-family Buildings in an Energy Performance Regulation Context, Information Paper n°P165, EPBD buildings platform, December 2009, 8p., http://www.buildup.eu/publications/7041, http://www.asiepi.eu/wp-5-airtightness/information-papers.html

Part B: Bird's eye view of the project results

6. INTRODUCTION

Major contributions of ASIEPI on the "building and ductwork airtightness" issue are turned on four directions :

1. A review of regulations requirements, practices and barriers in Europe, partly based on a questionnaire submitted to experts with the 13 countries represented in the consortium, and summarized in one conference paper (**Paper n°3**);
2. A focus on 5 countries - Norway, Belgium, Germany, Finland, France - where a market transformation is underway, with short reports that analyse the market transformation mechanisms, through success stories and also some pitfalls to avoid;
3. A focus on technical issues, with a series of information and conference papers on very-low energy buildings, calculation and measurement methods;
4. Awareness raising, namely through several national and international workshops, internet sessions, and presentations in conferences.

This collected and produced information was made available in the following publications.

7. PUBLISHED RESULTS

7.1 TECHNICAL REPORTS

Six working reports have been published (> link):

- The **report 1** *"Stimulation of good building and ductwork airtightness through EPBD"*, published in March 2009, with an updated version published in April 2010, presents the work done within ASIEPI project on the "airtightness issue", the acknowledgments dressed through the different deliverables and productions, from October 2008 until April 2010, with conclusions in the form of recommendations for policy makers.
- The **report 2** "*Report on the building airtightness measurement method in European countries*", was published in March 2009, with an updated version published in February 2010. The European standard EN 13829:2000 describes different variants of measurement of building airtightness (for example method A, B, etc.). In the framework of the ASIEPI project, a survey has been made of the existance of additional specifications to this standard for the envelope airtightness measurement in EU countries. The results are reported in this paper, which reflects the state at the time of the enquiry, i.e. fall 2009, and which present also the additional specifications to the standard developed in Belgium in the context of the EPB-regulation.
- The **report 3** "*Brainstorming document on the envisaged ISO 9972 revision*", was published in September 2009. In its meeting of 4 May 2009 in Zürich, the working group ISO/TC163/SC1/WG10 has decided to launch the revision process of the ISO 9972:2006. It was also decided that

the revision work should be conducted in the harmony with related standards, i.e. the EN 13829, which is currently based on the ISO 9972:1996 with modifications. In the framework of the IEE-ASIEPI project a brainstorming has been initiated on possible improvements to these standards. The present state of discussion is described in this paper.

- The **report 4** "A*n overview of the market transformation on envelope and ductwork airtightness in 5 european countries*", published in March 2010, gives an overview of the mechanisms that have led to a market transformation on envelope and ductwork airtightness in five countries - France, Germany, Finland, Belgium, Norway - and emphasize the key elements that could inspire other member states. It consists in a collection of papers written by participants to the ASIEPI project at the end of 2008. It gives an interesting insight into success stories and difficulties to overcome.

- The **report 5** "*Synthèse du questionnaire ASIEPI : État des pratiques européennes concernant l'étanchéité à l'air de l'enveloppe et des réseaux" (in French), Synthesis of ASIEPI's questionnaire : Practices about envelope and ductwork airtightness in Europe*, published in March 2010, summarizes the results of a questionnaire submitted to 13 experts in the 13 countries (BE, CZ, DE, DK, ES, FI, FR, GR, IT, NL, NO, PL, PT) represented within the ASIEPI consortium in November 2007. The survey included 22 questions dealing with the way envelope and ductwork airtightness is taken into account in the regulation; the market uptake of better envelope and ductwork airtightness and reasons behind; and the major barriers towards better airtightness.

- The **report 6** "*Methods in the national EPB-calculation procedures to determine the ventilation heat transfer coefficient"*, published in April 2010, gives the following information: an english translation of excerpts of the national EPB-regulations to determine the ventilation heat transfer coefficient, sometimes also some background information.

7.2 INFORMATION PAPERS

Six Information Papers have been published (> link):

- **P072** "*Implementation of energy performance regulations: opportunities and challenges related to building airtightness*", published in May 2008, discusses some critical aspects that have to be dealt with to stimulate the market towards better envelope airtightness in the Member States. This includes how airtightness may be taken into account in an energy performance regulation as well as the role of standards, low-energy labels, professional networks, financial incentives, industry, training, and regulatory control in helping the market uptake.

- **P147** "*International comparison of envelope airtightness requirements & success stories that could inspire the EC and other MS*", published in September 2008, discusses international comparison of envelope airtightness requirements and brings out success stories that could inspire the EC.

- **P157** "*Airtightness requirements for high performance building envelopes*", published in March 2009, presents an overview on the existing building surface airtightness requirements in different European countries and compares them to the requirements for high performance buildings. Airtightness measurement results of realised high performance buildings show what can be achieved in practice. Indeed, especially for high performance buildings, which go beyond national energy performance requirements, infiltration losses

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become a significant factor for the energy performance.

- **P165** "*Airtightness testing of large and multi-family buildings in an Energy Performance regulation context*", published in December 2009, discusses subsequent practical issues for large and multi-family buildings, especially regarding the test procedures that must be harmonized to allow a homogenous evaluation of the air tightness value that will be used as input in the energy performance calculation. The paper illustrates that the measurement of airtightness is possible in practice for large buildings.

- **P187** "*Duct System Air Leakage - How Scandinavia tackled the problem*", published in March 2010, describes the Scandinavian situation, giving recommendations on how it can be adopted in other countries. Apart from Scandinavia, many countries in Europe have generally very leaky ventilation systems. Most people are unaware of this 'out-of-sight' problem. Inferior rectangular ductwork is widely used and poorly installed, yielding leakage rates up to 30 times higher than is observed in Scandinavia. Duct leakage is detrimental to indoor air quality (IAQ), comfort, and energy efficiency. It is often accompanied by other problems, such as inferior commissioning and cleaning. Airtight circular (round) ductwork is known to have many other benefits over rectangular ductwork, including cost. But why do designers, installers, and building owners forego airtight duct systems? It is due to: (i) lack of awareness of the benefits, (ii) lack of performance requirements and penalties for noncompliance, and (iii) no one is found accountable, as there is no commissioning. Conversely, in Scandinavia, high-quality airtight systems are the norm. 90~95% of ductwork in Scandinavia is now circular steel ductwork with factory-fitted airtight gasket joints (Class C or better). Sweden has spearheaded this development. This impressive result has come about after the problem of leakage was first identified in the 1950s, leading to the first contractual requirements on ductwork airtightness in the 1960s (e.g. Swedish VVS AMA). Since then, the requirements have been tightened concurrently with advances in duct technology. There is strict control in Sweden, Finland and Denmark, so most installations comply with these stringent requirements after commissioning.

- **AIVC VIP29** "*An overview of national trends in envelope and ductwork airtightness*", published in August 2008, summarises presentations and discussions that took place during the workshop entitled "Trends in national building ventilation markets and drivers for change" held in Ghent, Belgium, in march 2008 with a specific focus on envelope and ductwork airtightness. Before this workshop, experts were asked to provide information regarding the trends in ventilation in their country and the difficulties they felt to improve the situation in terms of market penetration of innovative systems, indoor air quality and energy use requirements, and compliance check schemes. This has resulted in a body of literature published as Information Papers which can be downloaded from the EPBD buildings platform. Based mostly on these papers and on the workshop discussions, this paper starts summarising energy savings estimates and energy regulation measures ; it continues with a number of issues that have been stressed by the experts such as indoor air quality impacts, airflows through insulation layers, airtightness databases and metrics, and finally, ways to explore to achieve good airtightness.

7.3 WEB EVENTS

Two web events were held (> link):

- During the **ASIEPI web event 1** "*Ways to stimulate a market transformation of envelope airtightness - Analysis of on-going developments and success* *stories in 4 European countries*", held in December 2008, the objective was to give an overview of increasing interest for this issue in some other European countries, with interesting developments to further stimulate the market in Belgium, France, and Norway and a feed-back on the German experience, where there has been a continuous effort on this issue during the past two decades.

- This web event was attended by 49 people from 13 countries. Following the 32 answers given to the survey, the overall satisfaction (asked on a free format) can be estimated around 4.5/5.0, with a lot of very positive comments. 31 (out of 32) people wanted to be informed about next meetings.

Introduction
Brief presentation of the ASIEPI project *by Rémi Carrié, CETE de Lyon, WP5 leader*
Introduction in the building airtightness issue bridges as covered in ASIEPI *by Rémi Carrié, CETE de Lyon*
Analysis of on-going developments and success stories in 4 European countries
Airtightness revival in Norway *by Aurlien Tormod, SINTEF*
Recent steps towards the generalization of airtight buildings in France *by Rémi Carrié, CETE de Lyon*
Recent market trends in Belgium *by Nicolas Heijmans, BBRI*
Over two decades of experience with airtight buildings in Germnay *by Bernd Rosenthal, E-U-[Z]*
Discussions
Questions
Conclusion and closure *by Rémi Carrié, CETE de Lyon, WP5 leader*

Program of ASIEPI web event n°1

- During the **ASIEPI web event 7** "*How to improve ductwork airtightness - Ongoing developments and success stories in Europe*", held in December 2009, the objective was to give: an overview of energy impacts and calculation procedures; an overview of duct leakage measurement methods; a feed-back on the Scandinavian experience and how it can be applied in others countries.

  This web event was attended by 55 people from 20 countries. The overall satisfaction was 4.3/5.0.

Introduction
Introduction to the event by Dr. Peter Schild, SINTEF Buildings & Infrastructure, Norway
Presentations
Duct leakage problems & consequences in EU by Samuel Caillou, BBRI, Belgium
Including leakage in energy calculations by Dr. Jean-Robert Millet, CSTB, France
Leakage testing methods/requirements by Dr. Peter Schild, SINTEF Buildings & Infrastructure, Norway
Practical solutions for airtight ductwork by Lars Åke Mattsson, Lindab, Sweden
The Scandinavian success story by Jorma Railio, FAMBSI, Finland
Discussions
Questions
Conclusion and closure by Dr. Peter Schild, SINTEF Buildings & Infrastructure, Norway

Program of ASIEPI web event n°7

7.4 PRESENTATIONS-ON-DEMAND

The following presentation-on-demand are available:

- **ASIEPI presentation-on-demand 2** "*Envelope airtightness: How to stimulate a market transformation?*", published in April 2009, gives an overview of ongoing developments in Europe (> link).

- **ASIEPI presentation-on-demand 6** "*Main lessons learned and recommendations from the IEE SAVE ASIEPI project*", published in 2010 in several different languages, focuses on guidelines for Member States.

7.5 ABSTRACTS AND CONFERENCE PAPERS

Seven conference abstracts have been accepted and 1 abstract has been submitted at the end of the project for the AIVC conference 2010 (> link):

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- **Paper n°1** "*International comparison of envelope airtightness measurements*", was presented at the 3rd European BlowerDoor Symposium. Held in Kassel, Germany, in May 2008. This paper aims to collect recent measurement results of whole building airtightness from different European Member States, to present a comparable analysis among them and to identify specific trends. For this purpose, a total of 1,094 n50 values from field airtightness measurements from 7 European countries were brought together.

- **Paper n°2** "*Testing the airtightness of large or mutliple-storey-buildings in an EU-regulation context*", was presented at 3rd European BlowerDoor Symposium. Held in Kassel, Germany, in May 2008. This paper presents operational difficulties associated with the measure of large buildings (installing the fans, tasks in preparing for the test), describes sample methods used in Germany and U.K for the measure of multi-family dwellings, concludes on the necessity of a standardisation of the measurement method in Europe.

- **Paper n°3** "*Stimulating better envelope and ductwork airtightness with the Energy Performance of Buildings Directive*", was presented at 2008 AIVC Conference, held in Kyoto, Japan, in October 2008. The paper is based on the analysis of the **questionnaire** submitted within ASIEPI project to experts in 13 countries as well as interviews and a literature review. The paper also describes the mechanisms that have been used in some countries, with a special focus on success stories which could inspire other member states. The measures include actions directly related to the EP regulation as well as accompanying private or public initiatives (e.g., pilot projects, training). Full results of the questionnaire are also detailed in **Report 5** (only in French).

- **Paper n°4** "*Airtightness requirements for high performance buildings*", was presented at 2008 AIVC Conference, held in Kyoto, Japan, in October 2008. The paper presents an overview on the existing airtightness requirements in different European countries and especially for high performance buildings as well as insights in how strong the impact of improved airtightness can be regarding the net, final and primary energy demand of a building. See also the "*Brainstorming document on the envisaged ISO 9972 revision*" (**Report 3**) .

- **Paper n°5** "*Measurement of building airtightness in the EPB Context : specific procedure and sources of uncertainties*", was presented at the BPS symposium, held in Leuven, Belgium, in October 2008. Because it is necessary to enssure that the same procedure is used by everyone and that the uncertainties on the result are limited, the aims of this paper is: to present additional specifications to the measurement European standard NBN EN 13829 developed in Belgium in the scope of the EPB regulation; to compare them to the usual practices in other European countries; to describe the main sources of uncertainties for airtightness, including the random errors (variability of experimental conditions), the systematic errors (instrument calibrations and corrections used in calculations), and other uncertainties related to the calculation and interpretation of the final result (divergence between overpressure and underpressure, error from volume or area calculation, etc). See also "*Report on the building airtightness measurement method in European countries*" (**report 2**).

- **Paper n°6** "*Treatment of envelope airtightness in the EPB-regulations: some results of surveys of the IEE-ASIEPI project*", was presented at Buildair conference, held in Berlin, Germany, in October 2009. Based on an instrument developed within ASIEPI to compare the EP requirement levels among the Member States, this paper illustrates that the different way envelope airtightness is dealt with in the EPB-regulations and in the EPB-calculation of the Member States can reveal sometimes diverging underlying philosophies. Notably the concept and numeric figures of a default value are different, as well as the treatment of very good airtightness: in some methods the stimulus to do better than a certain threshold value becomes very small or is nil. In other countries, the incentive remains proportional all the way to the limit value of perfect air tightness.

- **Abstract n°7** "*Envelope and ductwork airtightness in the revision of the French energy regulation: calculation principles and potential impacts*", was submitted at 2010 AIVC Conference, in Seoul, South Korea. This paper analyses the energy impact of envelope and ductwork leakage estimated with the regulatory calculation method for different building and ventilation system types, in the context of the revision of the energy performance regulation scheduled to be gradually in force between 2011 and 2013 depending on building types. The objective is to generalise low-energy buildings whose market share is increasing rapidly with the current regulatory label named BBC-Effinergie. Given that envelope and ductwork airtightness are the key in these types of buildings, significant efforts are made to better take into account these issues in the calculation methods as well as to define schemes to encourage better airtightness. These include the tuning of the default values and minimum requirements as well as quality management approaches or craftsmen and measurement technicians certification.

- **Paper n°8** "*Airtightness requirements for high-performance buildings*", was presented at the AIVC conference, held in Berlin, Germany, in October 2009. Based on the work in the project ASIEPI, it presents an overview on the existing airtightness requirements in different European countries and the US. These requirements are opposed to airtightness requirements for high performance buildings in Germany (passive house), France (effinergie label) and the US (energysmart home, RESNET). Measurements of the envelope airtightness right after construction and some years later show the practicability of the requirements.

7.6 WORKSHOP

The "envelope and ductwork airtightness" issue was discussed during the international AIVC workshop "***Trends in national building ventilation markets and drivers for change***", which was held in Ghent, Belgium, in March 2008 (> link). The objectives of this workshop were:

- to inform interested parties (industry, regulators,…) of the latest changes in national building ventilation markets, with attention not only for IAQ and energy issues, but also on airtightness and assessment of innovative systems issues,
- to identify the drivers for changes,
- to discuss the status in a round table with industry representatives.

The discussions on envelope and ductwork airtightness were summarised in **AIVC VIP29**.

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Opening of workshop
Opening of the workshop and welcome
Presentation of IEE SAVE ASIEPI
Presentation of IEE SAVE BUILDING ADVENT
Presentations of national situations and discussions
Denmark, *P. Heiselberg (Aalborg University)* Finland, *J. Kurnitski (Helsinki Un. of Technology)* Norway, *M. Eriksson (Norwegian Ventilation Contractors*)
USA, *M. Sherman (LBNL)* Brazil, *P. Lamberts (Un. Of Santa Caterina)* Portugal, *E. Maldonado (FEUP)*
Korea, *Y. Lee (KICT)* Japan , *T. Sawachi (NILIM)* UK, *M. Kolokotroni (Brunel University)*
Netherlands, *W. De Gids (TNO)* France, *F. Durier (CETIAT)* Germany, *H. Erhorn (Fraunhofer-IBP)* Poland, *J. Sowa (Warsaw Univ. of technology)*
Belgium, *N. Heijmans (BBRI*) Czech Republic, *P. Charvat (Brno University of Technology)* Greece, *M. Santamouris (NKUA)*
History of airtightness measurement and development in construction: documented by 10 years of BlowerDoor conferences on building airtightness, *B. Rosenthal (E-U-Z)*
Round table with industry representatives
Synthesis and discussion on national trends
Innovative systems issues, *P. Heiselberg, N. Heijmans* IAQ issues, *M. Sherman, M. Liddament* Airtightness issues, *R. Carrié, B. Rosenthal* Energy issues, *E. Maldonado, P. Wouters*
Conclusions and next steps, *P. Wouters, AIVC*

Program of AIVC workshop held in Ghent, in March 2008

IEE SAVE ASIEPI

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Part C. Information Papers

on

Stimulation of good building and ductwork airtightness through EPBD

P072 Implementation of Energy Performance Regulations: Opportunities and Challenges related to Building Airtightness

P137 International comparison of envelope airtightness requirements & success stories that could inspire the EC and other MS

P157 Airtightness requirements for high performance building envelopes

P165 Airtightness Testing of Large and Multi-family Buildings in an Energy Performance Regulation Context

P187 Duct System Air Leakage — How Scandinavia tackled the problem

P72

05-05-2008

Implementation of Energy Performance Regulations: Opportunities and Challenges related to Building Airtightness

Peter Wouters
Nicolas Heijmans
Belgian Building Research Institute
Belgium

François Rémi Carrié
Centre d'Etudes Techniques de l'Equipement
France

More information can be found at the ASIEPI project website: *www.asiepi.eu*

Similar Information Papers on ASIEPI and/or other European projects can be found at the Buildings Platform website: *www.buildingsplatform.eu*

This information paper discusses some critical aspects that have to be dealt with to stimulate the market towards better envelope airtightness in the Member States. This includes how airtightness may be taken into account in an energy performance regulation as well as the role of standards, low-energy labels, professional networks, financial incentives, industry, training, and regulatory control in helping the market uptake.

1 > Introduction

Building airtightness is not a new topic of interest. In the nineteen seventies, deep research has been performed on building airtightness in the Nordic countries. In the Air Infiltration Review (AIR) of August 1980 (ref. 22) (Figure 1), an article entitled 'Build tight – ventilate right' already described the challenges very well.

Figure 1 : Illustration used in the Air Infiltration Review of August 1980.

The Air Infiltration Review was the newsletter published by the Air Infiltration Centre (AIC). In 1980, the AIC published a guide entitled 'Air Infiltration Control in Housing – A Guide to International Practice'. This guide, primarily based on Swedish experience, described very well, and in more detail than the AIR article, the various aspects of building

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airtightness, including the energy and air quality issues, the airflow modelling, and the measurement methods. Airtightness has also been the central topic of the annual AIC conferences between 1980 and 1983 as highlighted by the titles of these conferences, e.g. 'Instrumentation and measurement techniques' (1980), 'Building design for minimum air infiltration' (1981), 'Air infiltration reduction in existing buildings' (1983). The full papers of these conferences can be found in the literature database AIRBASE developed and managed by the Air Infiltration and Ventilation Center (AIVC, *www.aivc.org*). The AIC became AIVC in 1987 to better reflect its activities. In fact, because of the close interactions between building leaks and ventilation systems, including fans, air terminal devices, heat recovery units and so on, ventilation issues were naturally addressed within the AIC.

Many AIVC publications on building airtightness have followed, including more recently three so-called 'Technical Notes' (TN) and one 'Ventilation Information Paper':

- TN 34 – Airflow patterns within buildings: measurement techniques (1991)
- TN 55 - A review of international ventilation, airtightness, thermal insulation and indoor air quality criteria (2001)
- TN 51 – Applicable models for air infiltration and ventilation calculations (1999)
- VIP 8 – Airtightness of Buildings (2004)

In addition, research or operational work has lead to many envelope leakage measurements, some of which can be found in the AIVC numerical database.

With the recent trend toward very low energy buildings, there is a regain of interest for envelope leakage. In fact, in such buildings, the envelope needs to be extremely airtight compared to standard practice. This trend has also been one key reason behind the success of the BlowerDoor conferences held in Germany since 1993, whereby building airtightness and related issues are the central theme. The first European edition of this conference took place in 2006 with a broader audience (over 150 attendants), which shows the growing interest for this topic in the last few years. The abstracts and papers of these conferences can be found in AIRBASE.

Therefore, this quick review of the work performed on airtightness confirms the abundance of contributions from research and practice; however, this work remains fragmented. Therefore, it is difficult, especially for policy makers, to have clear picture of the challenges and opportunities based on experience and lessons learnt by the Member States. The objective of this paper is to contribute to this clarification by giving an overview of the ongoing work motivated mostly by the Energy Performance of Buildings Directive and the initiatives taken within the Member States towards very low energy buildings.

2 > Requirements in the EPBD

The Energy Performance of Buildings Directive (EPBD) (ref. 1) imposes to the Member States requirements as regards:

- the general framework for a methodology of calculation of the integrated energy performance of buildings;
- the application of minimum requirements on the energy performance of new buildings;

- the application of minimum requirements on the energy performance of large existing buildings that are subject to major renovation;
- energy certification of buildings; and
- regular inspection of boilers and of air-conditioning systems in buildings and in addition an assessment of the heating installation in which the boilers are more than 15 years old.

According to article 3, the methodology of calculation of energy performances of buildings shall include at least the following aspects:

- thermal characteristics of the building (shell and internal partitions, etc.). These characteristics may also include **airtightness**;
- heating installation and hot water supply, including their insulation characteristics;
- air-conditioning installation;
- ventilation;
- built-in lighting installation (mainly the non-residential sector);
- position and orientation of buildings, including outdoor climate;
- passive solar systems and solar protection;
- natural ventilation;
- indoor climatic conditions, including the designed indoor climate.

As such, the EPBD does not explicitly impose to take building airtightness into account but clearly gives a signal to pay attention to building airtightness. The deadline for implementation of the above listed requirements was January 4, 2006. The Member States had the possibility to postpone the deadline until January 4, 2009 only if they were able to prove the lack of qualified and/or accredited experts. Information about the practical status of implementation of the EPBD by the Member states can be found in the Information Papers on Country Status reports as published by the EPBD Buildings Platform (*www.buildingsplatform.eu*).

3 > The role of standards

An overview of ventilation related standards can be found on the AIVC website (*www.aivc.org).* At the European level CEN, the European Committee for Standardization (*www.cen.eu*), has published different documents that promote a harmonised consideration of building airtightness in the framework of the EPBD.

A first important standard (EN 13829:2000) describes the measurement method of air permeability of buildings through fan pressurization. Due to different surface and volume calculation methods in the EU member states, measured airtightness data (usually expressed in terms of the infiltration air flow rate at 50 Pa divided by the cold surface area or the building volume) are not fully comparable. A general agreement on these calculation methods would give a more international status to the measurement data and would ease the comparison between the Member States. Other (draft) standards describe the method to calculate the ventilation air flow rates in buildings (including infiltration) to be used for applications such as energy calculations, heating and cooling load calculations, summer comfort and indoor air quality evaluation. The documents cover dwellings (EN 13465:2004), buildings in general (prEN

15242) and commercial buildings (prEN 15241). Some countries have already partially implemented these methods in their regulatory energy performance calculation tools. This allows energy consultants in particular to evaluate in detail the energy impact of envelope leakage for a given building and ventilation system in a given climate. The disadvantage is that the underlying airflow modelling is sophisticated compared to the simpler approaches used in the past in some countries.

Finally, other documents like EN 13779:2004 or TR 14788:2006 give guidance on the maximum n_{50}[(1)] value for buildings.

4 > Approaches for integrating building airtightness in energy performance regulations

Although building airtightness is presently included in many energy performance related regulations (e.g., in Belgium, Denmark, France, Germany, Slovenia, the Netherlands, Norway, United Kingdom), in practice there are major differences in the way it is taken into account:

- In some countries, a better airtightness than the default value can only be taken into account if proven by measurements at commissioning, whereas other countries also allow the use of quality management approaches (e.g., in France, Finland);
- There are countries with a minimum requirement (e.g., in Denmark, Norway, Slovenia, the United Kingdom). Some countries have guidelines for the maximum envelope leakage (e.g., Germany);
- The default value for building airtightness differs from country to country, which is not surprising given the differences in building traditions and construction types;
- The precise calculation procedure regarding building airtightness differs from country to country.

5 > Market uptake of attention for building airtightness

Several countries have had requirements for many years or at least strong recommendations regarding airtightness. Interesting developments from the last few years are the mandatory requirements for large buildings in the UK and the airtightness requirements for passive houses.

5.1 UK requirements on large buildings

Since 1 April 2002, when Part L2 of the Building Regulations (ref. 88) came into force in the UK, new buildings with excessive air leakage are no longer acceptable. All new commercial and public buildings over 1000 m^2 must be tested by an accepted testing body for airtightness. The regulation requires that air permeability should not exceed 10 $m^3/h.m^2$ at an induced pressure difference of 50 Pa across the exposed envelope.

This regulation has been strengthened in 2006. Testing is now mandatory for new dwellings, as well as commercial and public buildings over 500 m^2. The airtightness required remains the same.

5.2 Passive houses

Passive houses are characterised by extremely low transmission and infiltration losses in combination with high efficiency heat recovery ventilation systems. The airtightness requirement (i.e., $n_{50} \leq 0.6\ h^{-1}$) are very severe. It is clear that such a severe airtightness requirement is a major driver for a rational approach to airtight building concepts, whereby

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[1]The metric n_{50} is defined in EN 13829. It represents the airflow rate that passes through the building leaks at 50 Pa divided by the building volume.

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good building design in combination with appropriate products and execution techniques is essential. Therefore, today there exists a range of products specially designed to achieve excellent airtightness at given penetrations. Besides, the architects are particularly attentive at the design and construction phase to the way the penetrations will be addressed to minimise leakage and thermal bridges. In summary, the severe airtightness requirement ($n_{50} \leq 0.6\ h^{-1}$) is commonly achieved in these passive houses using similar robust methods and products.

5.3 BlowerDoor conference

As mentioned above, the existence of an international conference specifically focused on the issue of building airtightness is a good indication of the growing interest for this issue. We expect a further increase in the interest for gathering and exchanging experience on airtightness as many issues remain problematic, such as the testing of large buildings or the methods and products to be developed for the renovation of buildings.

The interest for energy efficiency issues in buildings has grown spectacularly in the last few years and this for all kinds of decision makers. Within this context, it is logical to expect that building airtightness will gain in importance. How this will happen in practice will be influenced by a number of decisions and trends. Some of these aspects are briefly described here.

6 > Challenges and opportunities

6.1 Effective ways for dealing with airtightness in regulations

Energy performance regulations

One key idea of energy performance regulations is the fact that the performance assessment (and related requirements) is focusing on the total energy performance of a building and not on the performance of individual components. As such, the designers and contractors have a large freedom in the approach to achieve a given target. Especially in very price-competitive markets, those measures with a high energy saving per invested € will be the most attractive. (This is often the case for airtightness and thermal bridge measures.) Therefore, it is essential that the calculation methods used by the Member States foresee the possibility to include the building airtightness results. It is also critical that the reference and default values used in the regulatory calculation tools be set correctly. (In particular, the setting of the default value is delicate as extremely leaky buildings can always be found.) If not, it may diminish considerably the energy-based and cost-based motivation to invest in an improved building airtightness.

Explicit air tightness requirements

Whereas a requirement based on an overall energy performance calculation procedure does not give any guarantee that attention will be paid to building airtightness, an explicit attention to building airtightness can be obtained by requiring minimum airtightness levels. Such an approach can be interesting if there is sufficient evidence that investing in building airtightness is among the most relevant measures and/or that a better building airtightness is needed (e.g., for thermal comfort or indoor air quality reasons, in particular as tightening after commissioning remains quite challenging). The risk for such a requirement is that the cost-benefit ratio may be too high in some cases. In Norway, a combination of the two above-mentioned approaches (inclusion of envelope leakage in the calculation of the energy performance and explicit airtightness requirement) has been recently adopted. This way, the motivation for achieving good or excellent airtightness is mostly driven by the calculation;

however, a minimum requirement prevents leaky houses, far beyond the default value, to comply with the regulation. This may be a good way to address the default value issue raised above.

6.2 Financial incentives - Subsidies and fiscal deduction

At present, many countries have a range of financial stimuli to accelerate the implementation of energy efficient investments in buildings, e.g., subsidies, fiscal deduction, attractive loans, etc.

Typically, a number of conditions have to be met in order to receive the benefits. Quite often, the requirements are expressed in a descriptive way—e.g., installation of high efficiency glazing, of condensing boiler, of a ventilation system with heat recovery. In case of such an approach, one has to convince the policy makers to include building airtightness in the list of acceptable measures.

An alternative and more attractive approach would be to relate the benefit to the achieved energy performance improvement whereby the energy performance calculation method can be used as the quantitative basis. As far as we know, such an approach has not been implemented in any Member State yet.

6.3 Availability of appropriate materials and systems

Achieving a good building airtightness is much more feasible when appropriate materials and systems (e.g., airtightness layers, specially-designed tapes, pre-compressed expandable foams, connecting elements for ducts and cables, etc.) are available. During the last decade, a whole range of such products have become available in several countries. It is important that these products be available to all EU countries.

6.4 Training – making building airtightness predictable

The achievement of a certain airtightness level through 'trial and error' is not the appropriate approach for a wide scale market uptake of building airtightness since it will be too expensive and too difficult to integrate in the building process.

Therefore, appropriate training tools and courses are critical. The availability of guidance on building details and appropriate execution technique is very important. With this respect, international collaboration would be very useful as many countries could be inspired by the experience of others and success stories in specific market segments and states.

6.5 Efficient framework for quality control and certification - Control of regulations

Various studies have shown that in practice, many buildings do not comply with the requirements despite the statements of various actors involved in the construction process. The risk for deviations between actual and stated values is probably quite high for airtightness results without an efficient compliance control scheme in force. Such a framework can be based on systematic control measures, on random control measures and/or on quality control of those who are in charge of the works or a third party.

No matter the approach used, it is important that building airtightness control measures be possible at economically attractive conditions. Several ways can be explored to improve the cost-benefit ratio of these approaches:

- The development of a framework whereby the building contractor can carry out control tests. This may be restricted to certified contractors within a quality management procedure, in which case, the certification framework must be defined;
- The development of sampling rules for selecting units in multi-family

buildings to ease the control of these buildings (one can probably learn from Swedish experiences regarding ductwork airtightness – see Figure 2);

- The development of cheap and small systems for testing the airtightness of apartments.

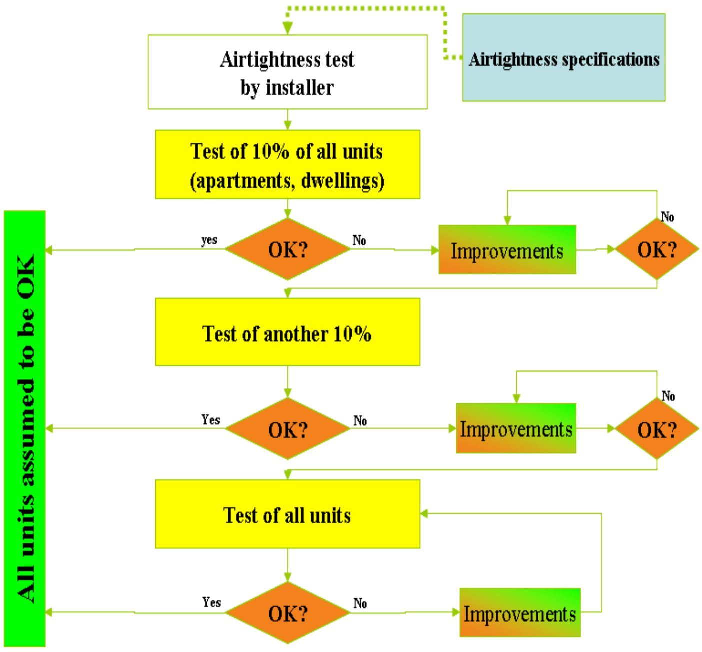

Figure 2: Possible framework for envelope airtightness test on a sample of units in multi-family buildings.

6.6 Optimal building airtightness

It is well known that the cost for reducing the U-value of a building component from 0.4 to 0.2 W/m²K is much higher than from 1.0 to 0.8 W/m²K. Similar conclusions can probably be drawn for improvements in building airtightness but the quantification of the cost induced by better airtightness remains unclear. This aspect certainly needs to be analysed in depth as it is key to identify airtightness levels with a good cost-benefit ratio to set regulatory requirements as well as to specify a specific target for a building project. The appropriate level has to be seen in the specific context of a given project, whereby the construction type (wooden structure, masonry, etc.), the available experience, or the overall energy requirement level may be important boundary conditions.
Imposing airtightness levels which in a given context require too high investment costs may be counter productive and may reduce the interest in building airtightness. A gradual increase of the regulatory requirements or a gradual enlargement of the building targets as implemented in the UK should give the market the opportunity to learn how to achieve a given airtightness level in a cost effective way.
Note also that the 'optimal building airtightness' will change with increasing demands on the overall building energy performance. This is due to the fact that the energy use due to infiltration remains about the same in absolute terms, and therefore has an increasing share in the total building energy use.

6.7 Airtightness and existing buildings

Obviously, a very substantial improvement of the energy efficiency of the existing building stock is a major objective in the medium (approximately, 2020) and long term (approximately, 2050) strategies of many member states and the EC. The Action Plan on Energy Efficiency envisions 20% savings in 2020. The potential contribution of a reduction of infiltration losses to the achievement of this target is quite large. However, appropriate techniques and execution methods for existing buildings are sorely needed, although some pilot projects have demonstrated that good airtightness could be achieved in renovation. Moreover, many existing buildings have no or inappropriate ventilation systems and therefore the installation of appropriate ventilation systems in combination with envelope sealing would be relevant.

7 > International collaboration on the handling of building airtightness in the context of energy performance regulations

One objective of the EU IEE supported project ASIEPI (Assessment and Improvement of the EPBD Impact, October 2008 until March 2010) is to study the issue of building and ductwork airtightness. The specific work package entitled 'Stimulation of good building and ductwork airtightness through EPBD', aims to give a clear picture to policy makers regarding the way better envelope and ductwork airtightness is stimulated in the Member States, including indications —where available— on the impact of the measures taken to transform the market. The project will collect information to answer the following specific questions for envelope and ductwork airtightness:

- What are the different strategies implemented in the Member States?
- What is the impact of envelope and ductwork leakage on the energy performance?
- Which control measures are taken depending on building size or usage (if any)?
- What is done in case of renovation?
- How effective are those strategies?
- How is training organized? What kinds of training schemes are available in Europe?
- What kind of actions have been successful, including evolution of the regulation, support of pilot projects, training, research and development?
- Which tools can be used to help owners, designers, builders, and craftsmen to build tighter?
- What kind of test equipment is available, including for large buildings or very airtight dwellings?
- How to carry out cost-effective control measures in multi-unit complexes (e.g., apartments)?

Once collected, this information will be structured and synthesised to allow dissemination among policy makers as well as other key market actors.

8 > Conclusions

The growing concerns about climate change and depletion of fossil energy resources have become a very strong driver for increasing the energy efficiency of the new and existing buildings. Moreover, the EPBD obliges all EU Member States to impose minimum energy efficiency targets for new buildings and for major renovations of large buildings. There is no doubt that, given the increasing share of infiltration losses with increasing building energy performance, more and more attention will be paid to improved building airtightness. This is already the case in some member states (Belgium, France, Germany, The Netherlands, United Kingdom, Norway among others) who have defined requirements in regulatory

frameworks that stimulate improved airtightness. However, the practical impact appears to depend strongly on the way various challenges are handled, including the approaches to defining the requirements, estimating the energy impact of envelope leakage, training designers and contractors, and ways to comply and check the requirements.
We expect that the ASIEPI project will provide an interesting framework for international collaboration on this issue and therefore, will accelerate the identification and implementation of appropriate cost-effective measures in the Member States.

9 > References

1. Action Plan for Energy Efficiency: Realising the Potential – Commission of the European Communities - COM(2006)545 final
2. Air Information Review – Built tight – ventilate right, AIVC, AIR Vol. 1 N°4, August 1980
3. CEN/TR 14788:2006 Ventilation for buildings - Design and dimensioning of residential ventilation systems
4. DIRECTIVE 2002/91/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2002 on the energy performance of buildings, Official Journal of the European Communities, January 4, 2003
5. EN 13465:2004 Ventilation for buildings - Calculation methods for the determination of air flow rates in dwellings
6. EN 13779:2004 Ventilation for non-residential buildings - Performance requirements for ventilation and room-conditioning systems
7. EN 13829:2000 Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method (ISO 9972:1996, modified)
8. L2B Conservation of fuel and power in existing buildings other than dwellings. Building Regulations. UK, 2006
9. prEN 15241 Ventilation for buildings - Calculation methods for energy losses due to ventilation and infiltration in commercial buildings
10. prEN 15242 Ventilation for buildings - Calculation methods for the determination of air flow rates in buildings including infiltration
11. Dorer, V., Tanner, C., Weber, A. 2004. Airtightness of buildings. AIVC VIP 08.

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International comparison of envelope airtightness requirements & success stories that could inspire the EC and other MS

1 > Introduction

This information paper discusses international comparison of envelope air-tightness requirements and brings out success stories that could inspire the EC.

2 > Envelope air-tightness requirements in Europe

Requirements on envelope air-tightness are usually expressed as maximum levels of total measured leakages through the envelope, related to either the building volume (n_{50}), the floor area (w_{50}) or the envelope area (q_{50}). Several countries have had air-tightness requirements related to building elements for some time (windows etc, related to area). Fore these countries the inclusion of joints between elements in requirements may be a relatively new situation. Difference in expression of requirements introduces some challenges if one should compare nominal requirement levels between countries. Crude conversion between the two first is often relatively easy, as volume results from the product between floor area and standard height to the ceiling. Looking into this in more detail though reveals some challenges as ways of measuring and inclusion of different volumes vary between countries.

Ways of expressing the requirement reflect different ways of building (requirements based on volume, n_{50}, are easier to achieve in larger buildings than in smaller ones, etc). Comparing neighbouring countries often reveals similarities, but regulations are revised at different intervals in different countries and this may give some differences. Many countries often have more or less publicized plans of revisions and long time goals, and a general trend is towards more ambitious energy saving requirements.

Expert questionnaire: The ASIEPI project has submitted a questionnaire to experts in the 13 countries (BE, CZ, DE, DK, ES, FI, FR, GR, IT, NL, NO, PL, PT) represented within the ASIEPI consortium in November 2007. The survey also included some questions dealing with the way envelope and ductwork air-tightness is taken into account in the regulation.

Most countries investigated (10 out of13 : BE, CZ, DE, DK, ES, FI, FR, NL, NO, PL) take into account envelope air-tightness in their energy

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EUROPEAN COMMISSION

performance calculation procedures (Figure 1). At least 7 out of these 10 countries give the possibility to reward good envelope air-tightness as it results in lower “regulatory” energy consumption. Six countries also have minimum requirements on envelope air-tightness (CZ, DE, DK, ES, NL, NO); in Spain specific requirements apply only to windows. In general, there is no requirement for existing buildings except in case of major renovation (CZ, DE).

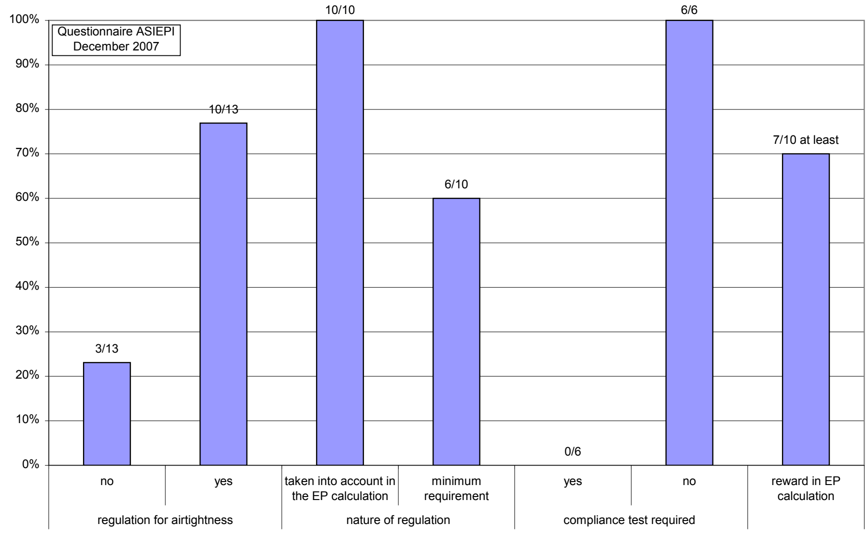

Figure 1: Overview of envelope air-tightness in national regulations

The compliance schemes to the regulation obviously depend on the nature of the requirements. Most of the time, a pressurization test has to be performed to be able to claim for a reward for good envelope or ductwork air-tightness. In theory, the compliance to a minimum requirement should be systematically tested. However, to our knowledge, this is done only in the UK, where envelope pressurization tests are compulsory since 2006 in all new buildings. This requirement extends the previous one in force since 2002 for large buildings (over 1000 m2). Note that although compulsory testing does not apply in Denmark and Germany, these countries test respectively 5% and 15-20% of their new buildings. Also, ductwork testing is very widespread in Denmark.

3 > Success stories

During the last few years the Energy Performance of Buildings Directive (EPBD) and the change of national regulations have renewed focus on air leakages and its consequences on energy use in the building industry in many countries all over Europe. This renewed attention has led to a series of success stories from some countries and these are leading in the right direction. These processes could be encouraged in all the other countries:

Low energy labelling: In recent years and in several European countries there has come up different ways of labelling buildings as having low-energy properties. The German PassivHaus concept has led the way. Some governments have sponsored low-energy building economically. A precondition for government funding of these houses has then been the documentation of air-tightness by pressurization measurement. This has led to an increase in measurements and to an increase in awareness about this important property.

The recent regulation-based BBC-Effinergie label in France, has very significantly impacted the market there in just one year. The perspective of the generalization to all new buildings of this label that includes air-tightness requirements for residences is a strong driver for change.

An example of resulting success development can be the one in a firm in northern Norway. This firm developed a building site with a series of low energy buildings. The site could be characterized as specially exposed to cold winds for large parts of the year.

Higher ambitions require changes: the firm had little experience of actually measuring air tightness when confronted with these preconditions from government funding. They were used to building houses that met their customer's expectations in a windy cold climate, and having just recommendations from the guide to national regulations quantifying this to n50 not exceeding 4 /h. In these low energy houses n50 were aimed at more challenging n50 < 1,5 /h. Compliance scheme: our institute was spreading our message to the building industry at the time, suggesting a scheme that included pressurization measurement both in early wind-tight stage and in finished stage, giving the firm a possibility of better feedback from different phases of the building process.
The two houses being tested in early wind-tight stage, B1 and B3, had results surrounding the target value; a great relief to the builder. There were some weak points observed, mainly connected with chimney and other perforations of the wind break layer.
When we returned some months later, the builder experienced that the completion of the houses, insulating and adding a new inner layer with vapour barrier, etc. did not improve the results; on the contrary, one of the houses had become much leakier! Investigating this, the conclusion was that the carpenters had done their job fairly well, but the ventilation firm had probably not been sufficiently included in the information process: they had sawed out the holes for the ventilation ducts with little concern for the carpenter's skillful prior achievements.

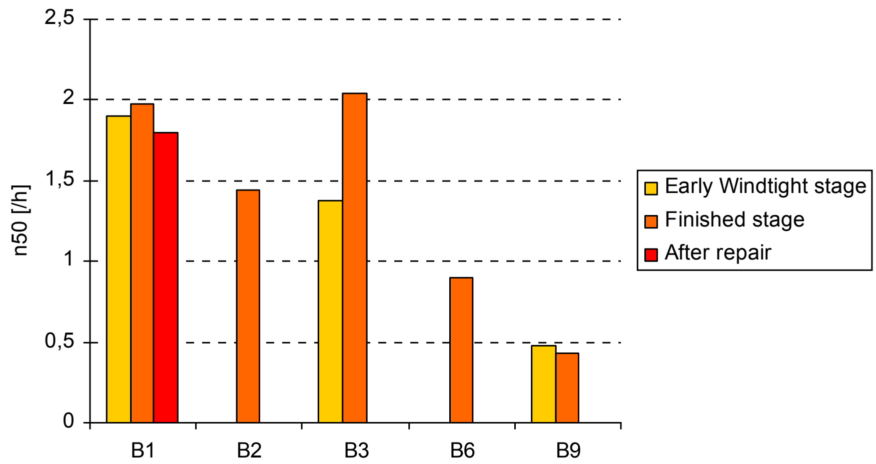

Figure 3: Air tightness results from five low energy buildings erected by the same team and measured over a period of two years.

Locating leakages is challenging: the first house was measured a third time after repair. The results were not improved as much as one had hoped. There can be several reason for this, one being that repair work was not sufficiently planned and performed. One common experience is that pinpointing remaining air leakages is increasingly difficult as the leakage air flow gets to a more and more ambitious level. Repairing minor defects and overlooking the larger ones is a possibility and a real challenge.

Compliance through Quality Assurance schemes: It has become more and more clear that compliance to air-tightness requirement must be documented by some level of mandatory blower door testing, preferably in combination with thermography. There exists one challenge to this form of compliance documentation. Pressurization tests of a given building are typically performed long after documentation of energy properties is handed inn and building permit is granted. Quality assurance schemes that

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document "common practice" in a given firm is a way of solving this.

Quality management approaches are rewarded in Finland and in France: if a builder proves that he has implemented a quality management approach to obtain good envelope air-tightness, he can use a value different from the default value in his energy performance calculation. In Finland, this route is targeted primarily at pre-fabricated houses. In France, the alternative route is applicable by all builders of individual houses. The approach has to be approved by the ministry based on a dossier filled by the builder that includes air-tightness measurements on a sample of buildings. A few dossiers are being processed in 2008.

A firm showing a development as seen in the above example is very likely to perform well if air-tightness is measured after buildings are erected.

Spread of tools and knowledge: Spread of knowledge about air-tightness is an important tool to lead the building industry into improvements. In France campaigns and events addressing the issue reach out to a growing number of participants.

Since the middle of the 1990s seminars and conferences about building air tightness have been held in Germany. Since that time about 3000 people have been qualified in air-tightness through the EUZ. This means that practically all people who have a blower door also have passed training. Since 2003 there is a certification for blower door measuring and about 230 people have achieved a certificate.

The German "Foundation of the Association for Air Tightness in the Building" was founded in the year 2000 through the initiative of the EUZ. It now has more than 260 members from Germany, Austria and Switzerland and some also from other European countries. Most of them are engineering companies which are measuring air tightness. Similar forming of interest groups can be observed also in some other countries, but at a much lower number of participants.

An important key word in this context is the link to a scientific group that can ensure good quality among the performers.

Robust design: The traditional main route to good air-tightness has always been good design. A special path of this route has been explored in the UK some years ago, based on the adoption by builders of especially "robust" construction details for residences, defined in a reference document. However, we heard that the evaluation of the scheme, based on leakage measurements of buildings that went through this process, did not give satisfactory results: apparently, about half of the tested buildings failed.

The UK experience puts into question the relevance of the more recent French and Finnish approaches through quality management schemes, although it is clear that the success of such schemes depends heavily of fine tuning. In fact, these approaches appear similar in principle, but they include important differences in their implementations. Therefore, especially if found successful, these approaches should be carefully evaluated, in particular to identify the keys to success and barriers, so that other countries could benefit from their experience.

The example that follows illustrates how the understanding and participation in a total process is of importance.

Some years back, a house builder firm in windy western Norway had a complaint case: a house that the buyer felt was too drafty. Unfortunately for the firm, a pressurization tests, very rarely performed, showed large total air leakages; and other measurements located the fault mainly to the junction between foundation and outer walls. The firm turned these resulting large repair expenses into a positive challenge. It started a systematic process of becoming better on air tightness.

Design process: a while later the firm built a series of low energy houses. These houses were carefully designed in the firm's main office. In addition to this they made an emphasis on their strategy to perform a "Design-on-site" process, together with their skilled and experienced workers. In this process the designers got feedback on the workability on the details that were planned. In addition they went through also the details that were not thought about in the planning phase. There were some challenges with the use of relatively new materials and details; how to manage large sheets of wind-break materials very much resembling sails in wind very fit for sailing, being one example. This dialogue resulted in general principles being understood by all participants all through the process.

Funding sponsoring pressurization tests: again documentation of air-tightness by measurement was a precondition for government funding of these "low energy" houses. The goal was to achieve a leakage number, n50 of not higher than 1.5 /h.

Record breaking: envelope pressurization tests were performed in early wind tight stage, with n50-values around 0.3 /h for three measured similar houses. In finished stage these houses ended up with n50-values less than 0.2 /h, with fairly little difference between the houses.

After this achievement, the firm set out to try to build a house with much more ambitious details, and at the same time try to break their own leakage number record: they succeeded, with a n50-value less than 0,1 /h in early wind-tight stage!

Figure 4 : Building with ambitious details, with a n50-value less than 0.1 /h in early wind-tight stage.

Quality, at what cost: there was a considerable interest among house builders on what it had cost extra to achieve these very good results. Obviously, it was made quite a lot of extra effort in these buildings, and this was announced by the firm, but they also told us that "we did not really build very differently from how we now build in ordinary projects".

4 > References

1. François Rémi Carrié, Bernd Rosenthal: "Trends in national building ventilation markets and drivers for change" EPBD Buildings Platform meeting. Ghent, Belgium, March 2008
2. F.R. Carrié, M. Fleury, G. Voisin, T. Aurlien: "Stimulating better envelope and ductwork airtightness with the Energy Performance of Buildings Directive" 29th AIVC conference: Advanced building ventilation and environmental technology for addressing climate change issues. Kyoto, Japan, 14-16 October 2008
3. Air Information Review – Built tight – ventilate right, AIVC, AIR Vol. 1 N°4, August 1980
4. DIRECTIVE 2002/91/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 16 December 2002 on the energy performance of buildings, Official Journal of the European Communities, January 4 2003
5. EN 13465:2004 Ventilation for buildings - Calculation methods for the determination of air flow rates in dwellings
6. EN 13829:2000 Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method (ISO 9972:1996, modified)
7. L2B Conservation of fuel and power in existing buildings other than dwellings. Building Regulations. UK, 2006
8. prEN 15241 Ventilation for buildings - Calculation methods for energy losses due to ventilation and infiltration in commercial buildings
9. prEN 15242 Ventilation for buildings - Calculation methods for the determination of air flow rates in buildings including infiltration

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Airtightness requirements for high performance building envelopes

Especially for high performance buildings, which go beyond national energy performance requirements, infiltration losses become a significant factor for the energy performance. This information paper presents an overview on the existing building surface airtightness requirements in different European countries and compares them to the requirements for high performance buildings. Airtightness measurement results of realised high performance buildings show what can be achieved in practice.

1 > What is a high performance building?

Buildings that do not only fulfil the national requirements, but are designed to use considerable less energy, are often called high performance buildings. There are different terms used in this area, from low energy building over passive houses and 3-litre houses to zero energy or zero emission buildings and many more. An information paper [1] soon available on the Buildings Platform summarises the used terms and definitions as well as the currently realised number of high performance buildings in the EU Member States. Though the definitions of the various types of high performance buildings differ from each other, the very most of them imply a building airtightness that is better than for regular buildings.

2 > Existing building envelope airtightness requirements in the EU Member States

The implementation of the Energy Performance of Buildings Directive (EPBD) [2] has caused in most of the EU Member States more severe requirements for the energy demand of buildings. In order to meet these requirements, not only buildings components with better U-values and more efficient building systems have to be used, also the ventilation losses have to be reduced. A contribution to this necessary reduction is the improvement of the building envelope airtightness, mainly the airtightness of building components and joints. With the EPBD implementation or even before some of the countries have included minimum airtightness requirements in their building codes.

According to an investigation at the end of 2007 in the ASIEPI project [3] 7 of 14 EU Member States have minimum requirements regarding the building envelope integrated in their building codes. These are: the Czech Republic, Germany, Denmark, the Netherlands, and Great Britain. Spain has partial requirements focussing on windows. The existing minimum requirements that refer to new buildings (residential and non-residential) differ from country to country and are presented in the following table.

EU Member State	Air tightness requirements at 50 Pa pressure	
	Natural ventilation	Mechanical ventilation
Czech Republic	4.5 1/h	w/o heat recovery: 1.5 1/h with heat recovery: 1.0 1/h
Germany	3.0 1l/h or 7.8 m^3/h per m^2 floor area	1.5 1/h or 3.9 m^3/h per m^2 floor area
	Leakage rate per façade area: 3.0 m^3/m^2h	
Denmark	1.5 l/s per m^2 floor area	
Norway	3.0 1/h	
The Netherlands	Dwellings: 200 dm^3/s (at 10 Pa) Non-residential buildings: 200 dm^3/s per 500 m^3 (at 10 Pa)	
United Kingdom of Great Britain	New dwellings and new commercial and public buildings over 500 m^2: 10 m^3/m^2h (stated as reasonable limit for the design air permeability in building regulations 2000 L1A and L2A)	

Existing airtightness requirements in European Union Member States.

It has to be stated though that in all countries with air tightness requirements, except in the UK, there is no generally required compliance test. However, in Germany and Denmark pressure tests are required in some cases. In Denmark the pressure test is generally optional but can be required by building authorities. In Germany the pressure test has to be made if a mechanical ventilation system is considered in the calculation of the energy performance certificate of a new building. The reduction of the ventilation losses can only be taken into account if the airtightness was proven.

In Finland the basic air leakage rate for calculation of the energy performance can be reduced if a pressure test or some other accepted method presents better performance.

North view (above) and South view (below) of the passive house buildings monitored incl. airtightness tests.

3 > Air tightness requirements for high performance buildings

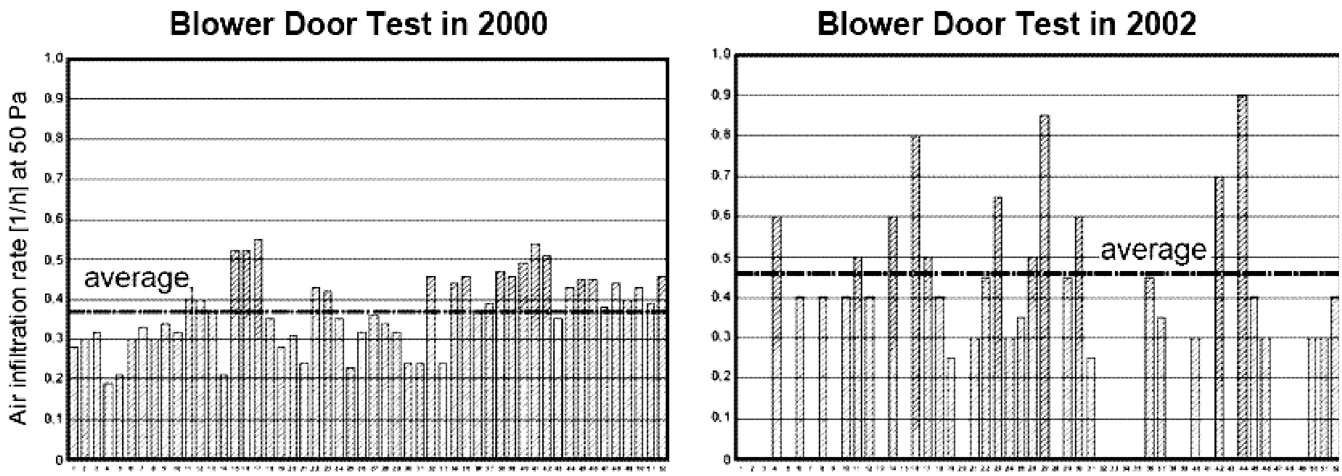
As written in the introduction high performance buildings require in general an improved airtightness of the building envelope. Otherwise the desired low energy demands can't be achieved. Most of the various high performance buildings however have not specified values that have to be fulfilled.

Example 1: Passive house (Germany)

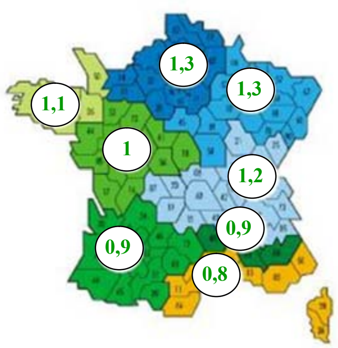
An exception is the so-called passive house. The passive houses originally created in Germany are calculated with a procedure that differs from the national German energy performance calculation standard, mostly in the area of the ventilation losses. The net heating energy demand of these houses has to be 15 kWh/m^2a or lower and the primary energy demand for heating, ventilation, domestic hot water and household electricity shall not exceed 120 kWh/m^2a. In the definitions set by a private organisation in Germany, which are applied in some other central European countries as well, the infiltration rate at 50 Pa overpressure is set to 0.6 1/h.

As the passive houses generally include a mechanical ventilation system which is also used for heating purposes, this value has to be compared to German air tightness requirements for buildings with mechanical ventilation systems: 1.5 1/h. The airtightness of a passive house is supposed to be more than twice as good as for a regular house.

Experiences from many pressure tests at the Fraunhofer Institute for Building Physics show that values below 1.0 1/h are difficult to achieve. However the Institute has tested some buildings, also some passive houses, which do meet this requirement in practice. The figure on the left shows two exemplary photos of a series of row houses built according to the passive house definition in Stuttgart, and which were monitored by the Fraunhofer Institute for Building Physics [4]. The results of the Blower Door tests made right after the construction phase (2000) and two years later are presented in the following figure.



Results of airtightness measurements at 31 passive houses in Stuttgart, Germany measured right after the construction phase and 2 years later.



Climate factors [6]

Single-family house with BBC-Effinergie label [5]

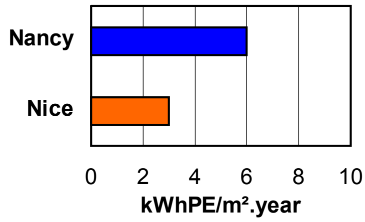
The results of the air leakage test show that the average infiltration rate of all 52 row houses measured right after the construction phase was 0.37 1/h and the average value of 31 of the houses measured two years later was 0.46 1/h. That proves not only that the very low leakage rates are possible, but also that they were only slightly worse after two years of building use. Yet in 5 of 31 buildings measured in 2002, the original goal of 0.6 1/h which was met at the end of the construction period could no longer be achieved.

Example 2: BBC-Effinergie (France)

The BBC-Effinergie label was created jointly by the Ministry of Housing and Effinergie association in 2007. Requirements to obtain the BBC-Effinergie label in new buildings are as follows [5]:

- The global energy consumption in dwellings shall be less than 50 kWh/year/m² multiplied by a factor depending on the altitude and the climate zone, resulting between 40 and 65 kWh/year/m².
- The airtightness must be measured and less or equal to 0.6 $m^3/h.m^2$ under 4 Pa for single-family houses and less or equal to 1 $m^3/h.m^2$ under 4 Pa for multi-family houses.
- The global energy consumption in tertiary buildings shall be 50% less than the level of RT 2005.

For existing buildings, the Ministry of Housing has not yet issued a label.



Primary energy consumption increase due to the deterioration of airtightness in a single-family house (from 0,6 to 1.3 m³/h.m²) [6]

Effinergie association released a first label on the following bases [5]:

- In dwellings, the global energy consumption shall be less than 80 kWh/year/m² multiplied by a factor depending on the altitude and the climate zone, resulting between 64 and 104 kWh/year/m².
- The airtightness must be measured and less or equal to 0.8 $m^3/h.m^2$ under 4 Pa for single-family houses and less or equal to 1.3 $m^3/h.m^2$ under 4 Pa for multi-family houses.
- In tertiary buildings, the global energy consumption shall be 40% less than the level of RT 2005.

The calculation of consumption in both cases is performed with tools based on Th-CE rules for new buildings and on Th-CEex for existing buildings. The reference area for the airtightness measurements is the envelope area minus the floor area. Measurements must be performed by authorised technicians.

In low energy buildings, infiltration losses represent an important part in the heat balance. To have the possibility to correct infiltration defects, Effinergie association suggests to make an intermediate measure before closing the casing. The airtightness required for the BBC-Effinergie label is more than double as good as for the notional building (1.3 m^3/hm^2). The saved consumption due to the improvement of the airtightness in a typical family house in cold and hot climate (Nancy and Nice) is presented in the figure on the left.

4 > Conclusions and recommendations

Infiltration losses have a significant influence on the energy use of buildings. The relative influence becomes bigger when the total energy use is lower, e.g. in high performance buildings. Especially in mechanically ventilated buildings the building shell should be airtight. Yet only few EU Member States have requirements for the airtightness for new or existing buildings included in their building codes and only two high performance building definitions could be found that contain specific requirements to the airtightness of the building shell. It was also shown that very low air infiltration rates (< 0.5 1/h at 50 Pa) can be achieved in practice and nearly retained for two years of building use.

Based on the analysis of requirements, but also on earlier information papers on airtightness available on the Building Platform (IP 72 [7] and IP 137 [8]) it is recommended that:

- Member States include airtightness requirements in their national building codes
- Member States add a requirement or at least a recommendation to measure the airtightness of the building during the construction phase in order to find and fix leakages. This would prevent the building from having air leakages that can't be fixed during commissioning.
- Member States add a requirement to measure the airtightness of the building shell after the construction phase before reduced ventilation rates for mechanical ventilated buildings can be used in the calculation of the energy performance (proof of airtightness).
- European standardisation committee proposes airtightness requirements or airtightness classification of buildings. These could include climatic grading.
- Definitions for high performance buildings should include even stronger requirements for the airtightness of the building shell (at least < 1.0 1l/h at 50 Pa)

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5 > References

1. Erhorn-Kluttig, H. and Erhorn, H.: Terms and definitions used in the EU Member States for High Performance Buildings (2009). Information Paper soon available on the Buildings Platform *www.buildingsplatform.org*.
2. European Union. Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings. Official Journal L 001, 04/01/2003 P. 0065 – 0071.
3. Carrié, R. et al.: Internal questionnaire in the EU project ASIEPI (Assessment and Improvement of the EPBD Impact, (for new buildings and building renovation)), 2008. Intelligent Energy Europe programme contract EIE/07/169/SI2.466278).
4. Reiss, J. and Erhorn, H.: Messtechnische Validierung des Energiekonzeptes einer großtechnischen umgesetzten Passivhausentwicklung in Stuttgart-Feuerbach. Report WB 117/2003 of the Fraunhofer Institute for Building Physics.
5. Effinergie web site: *www.effinergie.org*
6. Effinergie association : Réussir un projet de bâtiment basse consommation, *http://www.effinergie.org/xwiki/bin/view/Main/TelechargementsGuides*
7. Wouters, P. et al: Implementation of Energy Performance Regulations: Opportunities and Challenges related to Building Airtightness (2008). Information Paper #72 available on the Buildings Platform *www.buildingsplatform.org*.
8. Aurlien, T.; Rosenthal, B.: International comparison of envelope airtightness requirements & success stories that could inspire the EC and other MS (2008). Information Paper #137 available on the Buildings Platform *www.buildingsplatform.org*.

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Airtightness Testing of Large and Multi-family Buildings in an Energy Performance Regulation Context

In many European countries, the Energy Performance (EP) regulations defined or revised with the implementation of the Energy Performance of Buildings Directive (EPBD) take into account envelope air tightness in their calculation method. This paper discusses subsequent practical issues for large and multi-family buildings, especially regarding the test procedures that must be harmonized to allow a homogenous evaluation of the air tightness value that will be used as input in the EP calculation.

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1 > Introduction

The growing interest for airtight building envelope, which is driving a market transformation in some European countries, is very likely to continue and increase. This is due to the potentially large energy savings associated with good envelope airtightness (see for instance information paper P 157) combined with the proven feasibility to achieve much better envelope air tightness than what is observed today in common buildings.

The objective of this paper is to discuss some details concerning the measurement practice, the preparation of the buildings according to what is needed for the energy calculation showing the problems of and finding solutions for unclear definitions for testing separate zones concerning large and multi-family buildings.

General information and in some cases practical information about the handling of large buildings are available by ATTMA (Air tightness testing and measurement association), in a "Technical Standard" *[1]*, by BSRIA *[2] [3]*, ISO 9972 *[4]*, EN 13829 *[5]* and several information papers from AIVC *[6]* and other organisation *[7] [8] [10] [11] [12] [15]* and companies *[9] [13] [14]*.

2 > Background on airtightness measurement of large buildings

To carry out the measurement of large buildings, the natural reference in Europe is EN 13829 [5] that mentions that for buildings whose volume is "approximately greater than 4000 m^3", a very large fan or several fan-units can be fitted into the opening(s) of external door(s). It is clear that large buildings involve more work on installing the fan(s) and more organisational tasks in preparing the test *[8,9,10]*. Hundreds of measurements with more than two and up to ten standard fans (fig. 1) or with one single "king size fan" *[10]* (fig. 2) have shown that such tests can be carried out *[11,12]*, in order to test the complete building as one zone. It must be possible to achieve an even pressure distribution in the entire building, e.g. by opening internal doors *[8]*. The pressure differences inside should deviate less than 10% from the pressure difference measured between the interior and the exterior. It is important to ensure this throughout the building during the test. Note that the opening size of a normal door (2 m x 1 m) = 20 000 cm^2 creates a pressure difference of only 1 Pascal when 6 000 m^3/h passes through it. Therefore, it usually is not an issue provided that the stack effect (i.e., the pressure difference variation with height) remains negligible.

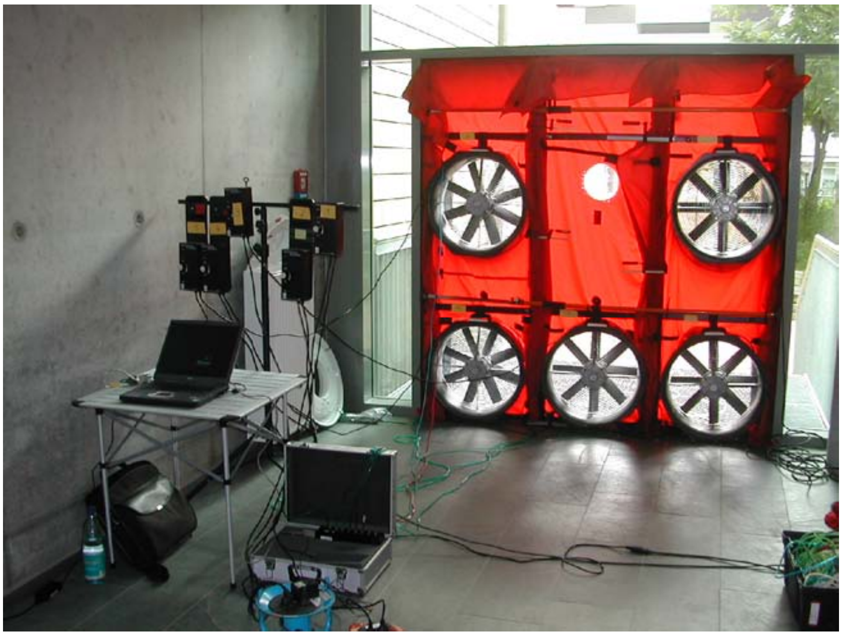

Fig. 1: Installation of 5 single Minneapolis Blower Door. Source: Blower Door GmbH, D, www.blowerdoor.eu

Fig. 2: Mobile fan, King size Fan, Source: www.bsria.co.uk

In practice, buildings as large as 100 000 m^3 can be tested with test equipment available today; if the buildings have an excellent air tightness,

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such as Passive Houses, it is possible to test volumes as large as 200 000 m^3. To illustrate this, assuming one fan supplies 6 000 m^3/h, 10 fans supply 60 000 m^3/h. Therefore, the largest building that can be tested with 10 fans assuming an airtightness of n_{50} = 1 1/h is 60 000 m^3; assuming n_{50}=0.5 1/h, the maximum volume that can be tested is 120 000 m^3.

Expressed in terms of air permeability per unit area of exterior walls (q_{50}), a building with an external wall area of 12000 m^2 and q_{50} = 5 $m^3/(h\ m^2)$ can be tested; if q_{50} = 1 $m^3/(h*m^2)$, the limit goes up to 60 000 m^2 of external walls.

Organisation of measurement

To limit time and personnel expenditure for the measurement, it is necessary to prepare and organize the test carefully. In particular with large buildings, it is useful to do a site inspection before the measurement *[13]*. This allows the technician to assess the condition of the air barrier, to inspect possible locations for the installation of the measuring devices and to determine where to temporarily seal any openings (e.g., ventilation system). The date for the test is scheduled based on the knowledge acquired during the inspection. If the technician is short of time, it may often have to be scheduled during nights or weekends.

Cost of a measurement

It is always difficult to give a cost range as it can vary considerably between specific contexts, regions and even more between different countries, but it is possible to describe the expense for a measurement of a 10 000 m^3 building as follows:

- Organisation, site inspection 3 hours
- Deduction of the apparatus
- Preparation 4 hours of 2 persons,
- Searching for leakage and report 3 hours of 2 persons,
- Measurement half an hour (2 persons),
- Reporting 4 hours.

In summary, the cost is in the region of 22 person-hours plus the deduction of the apparatus.

Overall, there are no major practical problems with the air tightness testing of a large building *[12] [13]*.

3 > Preparation of the building

General

The Standard of EN 13829 describes two types of methods:

- Method A: (test of building in use) means, that the condition of the building envelope should represent its condition during the season in which heating or cooling systems are used. There are no further measures to improve the air tightness. All air terminal devices of mechanical ventilation or air conditioning systems shall be sealed. Other ventilations openings, (e.g. openings for natural ventilation) shall be closed.
- Method B (test of the building envelope): “Any intentional opening in the building envelope shall be closed. All adjustable openings shall be closed and remaining intentional openings shall be sealed. All air terminal devices of mechanical ventilation or air conditioning systems shall and other ventilations openings, (e.g. openings for natural ventilation) shall be sealed.”

In most countries, there are no precise guidelines indicating whether method A or B should be used, although EN 13829 can be ambiguous or even misleading. In many cases, method A and B lead to the same building preparation (i.e., the same openings are either closed or sealed) and therefore to the same result. However, there are also many cases where method A and B will lead to radically different results: this can happen in the presence of construction openings (e.g. burning gas outlets, lift shafts).This issue is being discussed in a few countries. The Belgian Building Research Institute has written a paper as a working document explaining the way it is addressed in Belgium; this paper is available at the ASIEPI website.

Preparation of large buildings

With large buildings or multifamily houses, there are in general only a few unclear situations: the large openings to the outside in lift shafts, openings in technical shafts, temporarily turned on ventilation systems (e.g., kitchen exhaust hood), individual combustion appliances that take combustion air from the room. To use the result of the measurement to calculate the heat losses and energy use of the building, these openings must not be sealed (method A) unless their influence is taken into account in the calculation method used. To use the result to prove the airtightness of the envelope, it is possible to seal these openings (method B). Because it may be ambiguous, it is very important to record the temporarily closed and sealed openings in the measurement report.

4 > Evaluation of “air tightness of a whole building” based on tests of separate zones

There are many cases where a building cannot be tested as a whole, for instance, when:

- two floors cannot be connected with an internal airflow path, or
- e.g. 25 apartments (flats) are not connected with an airtight stairwell, or
- the building is too large.

Besides, it is often more practical and less expensive to test a sample of flats in a block rather than to test the whole block as one zone.

In all cases mentioned above, the building must be divided in different areas that are tested separately. There is no widely accepted method to perform and to analyse such tests. In practice, the major issues that are raised include:

- Does the test need to be performed on all building zones?
- If not, how should the tested zones be chosen?
- How should the test be performed on those zones?
- Which airtightness requirements in those zones?

It is clearly not the role of the EPBD to resolve those issues. These should be addressed in standards (e.g., in EN 13 829 / ISO 9972) or guidelines, but this is not the case today.

Besides the described technical reasons there is of course a financial reason why only a fraction of the building zones should be measured. The measurement can be less expensive, e.g. when all identical flats do not have to be checked.

Sampling method under discussion in Germany for multi-family buildings

The current proposal of the Fachverband Luftdichtheit im Bauwesen e.V. (FliB e.V., *www.flib.de*) in Germany (Association for Air Tightness in the Building Industry) in buildings is that at least 20% of the total number of apartments, in a building should be tested. At least one tested apartment should be at the top floor, one at an in-between floor and one at the ground floor.

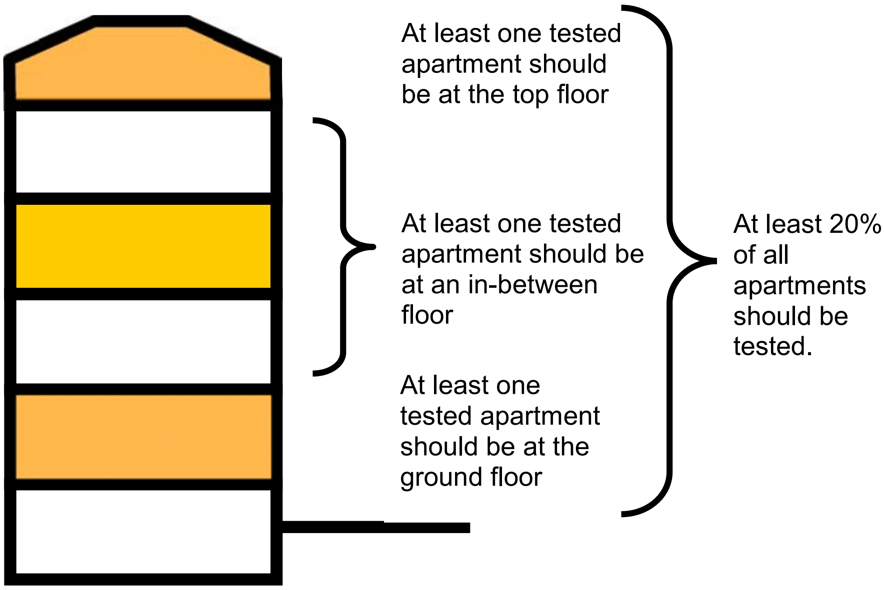

Fig. 3: German proposal of sampling method

Limit values of air tightness for discrete building parts

Regulations standards, or guidelines for the evaluation of the air tightness of the building envelope, have been defined for entire building. On the other hand, when evaluating the measuring results of a building measured in sections, the air permeability measured can include flows through leaks to adjacent, heated or cooled building parts (internal leakage).

Extrapolating measurements after sampling method in Germany

In Germany, (FLiB e.V.) a weighted average from the results in the separate zones can be calculated, based on the volume (or other basis provided that it is consistent with the airtightness metric used) and compared with the limit value required. The zones can be up to 30% leakier than the limit value for the whole building. This is due to the fact that a) the zone measurement takes into account leaks between zones; and b) untested zones can be tighter. On the other hand, it implicitly neglects the fact that untested zones including other apartments, halls, stairwells, etc. can be leakier. In practice, if one zone (flat) exceeds the limit value plus 30%, leaks to neighbouring apartments and leaks to outside must be corrected until readings fall below that value.

This means that conventionally, the weighted average is equivalent to the value that would be measured on the building as a whole.

Sampling methods in other countries

In the UK, zone testing should cover 20% of the building's exterior walls area. The ATTMA rule says that the limit value for every measured flat is 10% smaller than that of the whole building. Thus, unlike in Germany, some provision is taken to account for untested zones including other apartments, halls, stairwells, etc. which can be leakier than the zones measured. Therefore, it is assumed that this 10% margin gives confidence in the achievement of the limit value for the whole building.

An alternative to testing is in UK for a third party expert to carry out a full design review/audit and also carry out site inspections of air barriers. This can be reinforced with some sample testing, whether this is mock-up testing or small zones.

France or Norway also allow zone measurements in some cases, although the methods used do not always have an official status. In France, in multi-family buildings, 3 apartments have to be measured if the building has 30 units or less, 6 apartments otherwise. The sample is chosen based on the length of floors and windows. This sampling rule is being discussed because a) the sample is found to be too small in many cases; and b) floor and window lengths are sometimes ambiguous and complicated to extract.

In France or Germany, by convention, the permeability of the building is extrapolated with the weighted average of the measurements on the sample. Note that in Belgium, such extrapolations not allowed. The measurement must be carried out on the whole building or on each and every part separately.

Guarded zone pressurisation technique

Another approach to perform measurements by separate zones is to create a pressure in the neighbouring rooms/zones equal to pressure in the test room. This method is commonly called the "guarded zone pressurisation technique". This way, air flows between neighbouring zones are prevented, which allows one to measure accurately the air leakage flow rate to outside through the envelope area. In Germany the FLiB proposes that, for the sake of simplicity, such zone measurements can also be up to 30% leakier that the limit value.

Limitations of sample-based methods

The evaluation of the airtightness of the entire building, based on tests on separate zones, has one major fundamental limitation: a very leaky zone which is not selected in the sample tested could lead to radically different conclusions. For instance, the lift shafts and technical shafts are usually ventilated to the outside and can cause significant leaks; in case of multi-family buildings, sampling is generally focussed on apartments, and there can be significant leakage in halls or stairwells for instance. Therefore, a side effect of such sampling methods could be that great attention is paid to building parts that are systematically excluded.

Another limitation lies in the lack of feed-back from the use of the above mentioned methods. It seems that these methods have been derived according to expert intuition but without solid argumentation. In fact, such argumentation would imply costly studies with large measurement campaigns, which in addition may be difficult to conciliate with the agenda of regulation revisions.

5 > Results of the measurements and limit values: q50 instead of n50 for large buildings?

In Germany, the results of the measurements of large buildings almost always meet the requirements stipulated in the German Energy Savings Regulation in terms of air change rates (n_{50}). Experience shows that the n50-values are always significantly lower than for smaller buildings. There are normally two reasons for these seemingly better results. Large buildings usually have less connection points per m^2 of envelope area, i.e. less possibly critical points, than small buildings. In addition, low A/V ratios (area-to-volume ratio) lead to relatively lower leakage air flow rates for large buildings. In comparison to the large internal volume, the building envelope area through which air can enter or leave the building is relatively small.

Based on this experience, a limit based on the leakage flow rate per m^2 of envelope area (e.g., q_{50}) seems more appropriate than based on the leakage flow rate per m^3 of the building's volume (e.g., n_{50}). The relationship between the n_{50} and q_{50} is:

$$n_{50} = q_{50} * (A/V)$$

where :

q_{50} is the air permeability divided by the envelope area [$m^3/(h\ m^2)$],
V is the internal volume [m^3],
A is the envelope area [m^2], and
n_{50} is the air change rate at 50 Pa [1/h].

Figure 4 shows the correlation between n_{50} and q_{50} for various values of the A/V ratio. The different A/V ratios are based on examples of different types of buildings:
1.2 for a bungalow (366 m^3);
0.8 for a single family house (600 m^3);
0.5 for a small multi-family building (2600 m^3);
0.3 for a multi-family building (10000 m^3);
0.2 for a storage building (42000 m^3).

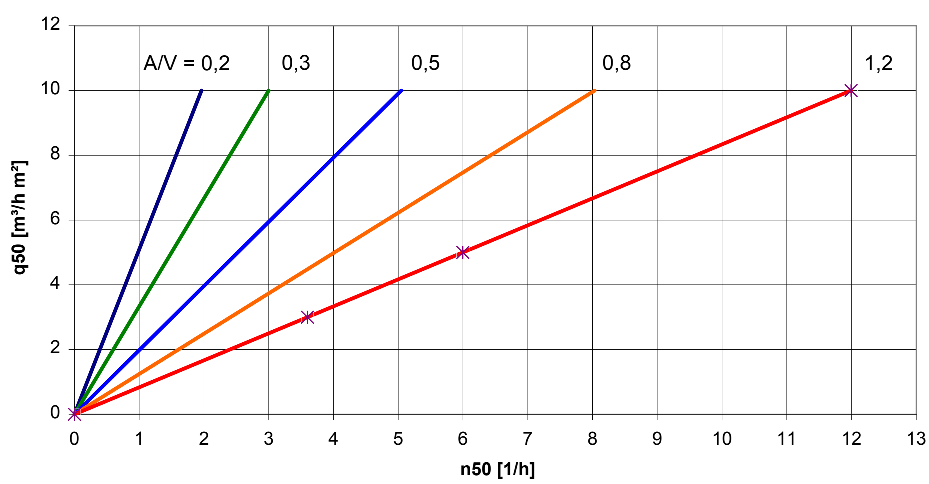

Fig. 4: Comparison between n_{50} and q_{50}. Example: a large building with A/V = 0.2 and with q50 = 5 corresponds to n_{50} = 1 h^{-1}.

If we establish a direct correspondence between q_{50} and n_{50} values based on q_{50} the limit value of 3.0 $m^3/(h·m^2)$ for residences recommended in the German Standard DIN 4108-7 and the above A/V ratios, we obtain for instance :
$n_{50} \leq 1.5$ [1/h] for an A/V ratio of 0.5 (small multi-family building);
$n_{50} \leq 0.9$ [1/h] for an A/V ratio of 0.3 (multi-family building);
$n_{50} \leq 0.6$ [1/h] for an A/V ratio of 0.2 (storage building);

The same exercise for a q_{50} limit value of 1.25 $m^3/(h·m^2)$ (which is achievable in single family houses since it corresponds to n_{50} = 1 1/h would have lead to n_{50} values of 0.63, 0.38 and 0.25 respectively.

The problem remains to define the appropriate limit values, but this cannot be done at an EU-scale, since should take into account climate and usage, which are key parameters influencing the impact of envelope leakage.

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6 > Conclusions and recommendations

The major issue here is to be able to evaluate the airtightness of large or multi-family buildings so it can be used as an input in the calculation method or as proof of compliance; and to have a set of clearly defined rules that are robust in case of legal disputes.

Significantly different methods are used in some countries to overcome this problem. They should be evaluated to make sure that they do not generate problems in practice. Then they should be harmonised and find there way into regulations.

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7 > References

1. ATTMA: TECHNICAL STANDARD 1 - MEASURING AIR PERMEABILITY OF BUILDING; The air tightness testing and measurement association, www.attma.org
2. BSRIA Guide: Airtightness Testing for New Dwellings- The essential guide to Part L1 of the BG 11/2004.2 by Chris Knights and Nigel Potter; www.bsria.co.uk
3. BSRIA Guide: Airtightness Testing - The essential guide to Part L2 of the 2006 Building Regulations by David Pickavance and Tom Jones BG 4/2006; www.bsria.co.uk
4. ISO 9972: second edition 2006-05-01 - Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method
5. EN 13829: February 2001 – Thermal performance of buildings - Determination of air permeability of buildings - Fan pressurization method (ISO 9972:1996, modified)
6. Airtightness of buildings, Ventilation Information Paper n°8, December 2004, AIVC, by V. Dorer, C. Tanner, A. Weber
7. Justifications on the Additional specifications on building airtightness measurement within the context of EPB regulations [in Belgium] ww.epbd.be/media/docs/Airtightness_measurement_EPB _justifications_v1_081020.pdf
8. Bolender, T.: Messung der Luftdurchlässigkeit an großen Gebäuden - Bauphysik 26(2004); Ernst & Sohn Verlag, Berlin
9. Dorschky, S. : BlowerDoor-Messung großer Gebäude - Bauphysik 27(2006): Ernst & Sohn Verlag, Berlin - Auswertesoftware: www.blowerdoor.de
10. Sharples, S.: Airtightness: the largest building ever tested - Air information review Vol 25, No.3, June 2004; AIVC
11. FLiB-Beiblatt zur DIN EN 13829 - Fachverband Luftdichtheit im Bauwesen e.V., 34131 Kassel
12. Erhorn-Kluttig, H., Erhorn, H., Lahmidi, H. 2009. Airtightness requirements for high performance buildings. Information paper # 157. Available on www.buildup.eu
13. Experience with Air Tightness Tests of Large Building.Information paper, BlowerDoor GmbH, Energie- und Umweltzentrum 1 31832 Springe, Germany www.blowerdoor.eu
14. Rolfsmeier, Simons: Erfahrungen aus der Luftdichtheitsmessung großer Gebäude, Messtechnik im Bauwesen, Spezial 1 2009, ErnstSohn, Germany
15. Sharples S, Closs S and Chilengwe N (2005) Air tightness testing of very large buildings: a case study Building Services Engineering Research & Technology, 26(2), 167-172.

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Duct System Air Leakage — How Scandinavia tackled the problem

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Fig. 1 System with failed tape, and omitted fasteners, in USA [© Weldin Engineering]

Fig. 2 Circular ducts in a compact Norwegian plant room [foto: SINTEF]

Apart from Scandinavia, many countries in Europe have generally very leaky ventilation systems [16]. Most people are unaware of this ‘out-of-sight’ problem. Inferior rectangular ductwork is widely used and poorly installed, yielding leakage rates up to 30 times higher than is observed in Scandinavia. Duct leakage is detrimental to indoor air quality (IAQ), comfort, and energy efficiency. It is often accompanied by other problems, such as inferior commissioning and cleaning. Airtight circular (round) ductwork is known to have many other benefits over rectangular ductwork, including cost. But why do designers, installers, and building owners forego airtight duct systems? It is due to: (i) lack of awareness of the benefits, (ii) lack of performance requirements and penalties for noncompliance, and (iii) no one is found accountable, as there is no commissioning.

Conversely, in Scandinavia, high-quality airtight systems are the norm. 90~95% of ductwork in Scandinavia is now circular steel ductwork with factory-fitted airtight gasket joints (Class C or better). Sweden has spearheaded this development. This impressive result has come about after the problem of leakage was first identified in the 1950s, leading to the first contractual requirements on ductwork airtightness in the 1960s (e.g. Swedish VVS AMA). Since then, the requirements have been tightened concurrently with advances in duct technology. There is strict control in Sweden, Finland and Denmark, so most installations comply with these stringent requirements after commissioning.

This paper describes the Scandinavian approach, giving recommendations on how it can be adopted in other countries. More details are given in the full ASIEPI WP5 Technical Report [1]. This paper focuses on metal ductwork, but mentions other materials.

1 > Today’s situation

Duct airtightness classes A to D (see Fig.3) are defined in European Standard EN 12237 [10] for circular ducts and EN 1507 [6] for rectangular ducts. A new standard for airtightness of ductwork components is in preparation: prEN 15727 [14]. The leakage test method for system commissioning is described in EN 12599 [11]. Airtightness classes for air handling units (L1 to L3) are defined in EN 1886 [7]. ASHRAE’s classes are different. System standards, in particular EN 13779 [12], give further recommendations for airtightness class selection for different purposes.

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Table 1 Duct airtightness classes, measured at a test pressure of 400 Pa. Area is calculated according to EN 14239

Airtightness class	Limiting leakage $(\ell/s)/m^2$
A - worst	< 1.32
B	< 0.44
C	< 0.15
D - best	< 0.05

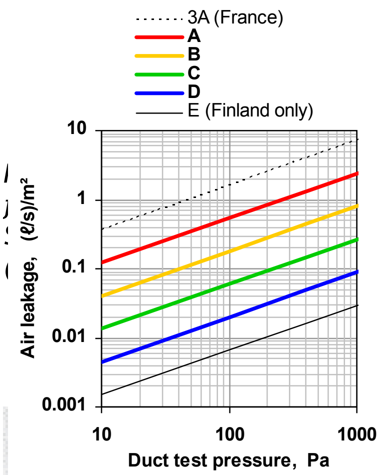

Fig.3 Illustration of duct leakage classes listed in Table 1 (with exponent 0.65) Special classes in France (3A) and Finland (E) are also shown

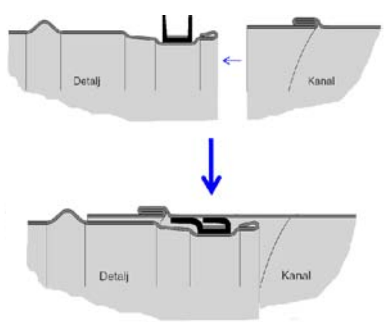

Fig.4 Cross section of circular duct joint with double gasket, giving airtightness Class D. Single gaskets generally achieve Class C, but there are other factors that affect airtightness, such as roundness and flatness of seams at the joints. [Lindab]

Duct systems used in Scandinavia

The Scandinavian countries have similar climates and architecture. Requirements on IAQ and building services are therefore largely harmonized. The Nordic Committee on Building Regulations (NKB, now disbanded) published Nordic guidelines on '*Indoor climate – Air quality*' [3] which give recommendations for duct systems and its commissioning. This consolidated a common stance on ductwork airtightness in Scandinavia.

90-95% of ductwork installed in Scandinavia is spiral-seam steel circular ducts (Fig.2) with factory-fitted sealing gaskets (Fig.4), with airtightness Class C or better. This product is gaining popularity in other countries, including The Netherlands and Germany. The gasket system enables easy joining and dismantling. To prevent the joints from sliding apart, they are fixed in position using special screws or rivets[9]. One manufacturer has recently introduced a clickable system that makes screws/rivets obsolete, and thus can speed up installation (not dismantling!). Duct products are generally certified by 3rd-party laboratories.

Sweden

Nearly all Swedish buildings and their installations fulfil the voluntary AMA specification guidelines ('*General Requirements for Material and Workmanship*'). AMA is referenced in building contracts between the owner and contractors. One section of the guidelines concerns HVAC ('VVS AMA'). The current version of VVS AMA is from 1998[2]. AMA refers to national and European standards. AMA's ductwork airtightness classes are the same as those defined in European standards. VVS AMA specifies which airtightness class shall be used in different situations, and commissioning rules/protocols. Installations that do not fulfil the requirements when installed are eventually corrected, due to the strict commissioning regime.

VVS AMA requirements for duct system airtightness

- **Class A** (the lowest level allowed) applies to visibly installed ducts in the space being served. A leakage here will not have any real significance, as the leakage airflow is beneficial to the space.
- **Class B** (3 times tighter than A) applies to all rectangular duct systems, and any duct systems with surface area ≤ 20 m². Surface area is according to EN 14239 [13]. This generally applies to small houses.
- **Class C** (3 times tighter than B) applies to round duct systems with surface areas > 20 m². This applies to the vast majority of buildings.
- **Class D** (3 times tighter than C) is not a standard requirement, but can optionally be specified for systems in which airtightness is essential. This normally calls for round duct systems with double gaskets (Fig.4).

VVS AMA requirements on commissioning of duct systems

- This is done by HVAC contractors as part of the contract. AMA requires contractors to include the cost of testing in their contract price.
- The contractor can conduct the measurements themselves if they have the necessary competence and equipment. More often, they engage specialised subcontractors to do the testing.
- The owner's consultant, is normally also present during the test
- The parts to be measured are chosen by the owner's consultant
- For round duct systems, 10 % of the duct surface area is tested; For rectangular duct systems, 20 % of the duct surface area
- A one-pressure leakage measurement is taken, normally at 400 Pa (a flow exponent of 0.65 is assumed).

It is expensive for contractors to install inferior duct systems, because they have to pay for both remedial work and additional tests. This motivates contractors to ensure that the work is done properly in the first place.

Fig.5 Collar saddle for in-situ tees [source: L.A.Matsson]

Fig.6 Factory made tee with low flow resistance and airtightness Class D (©Lindab)

Fig.7 Rectangular duct with standard length [Lindab]

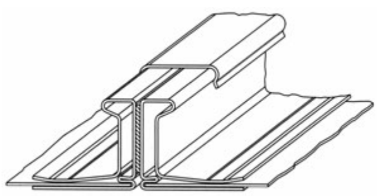

Fig.8 Close up cross-section of a flange for connecting two rectangular ducts. Cleat slides on the top to hold the two flanges together.

Other Commissioning and Maintenance Issues

VVS AMA is much broader than just covering duct airtightness. Commissioning includes criteria related to safety (e.g. fire protection installations), energy performance and indoor environment (e.g. cleanliness, airflow). All extracted and supplied airflows in the building shall be measurement and adjusted if needed; the result should be within ±15 % of design (including uncertainty). For this, measurement points shall be provided in the main ducts for measuring total airflow, both for commissioning and for future monitoring. VVS AMA also requires that all commissioning details shall be included in the building's Operation and Maintenance manuals, to ease maintenance and retrofit. This shall include detailed drawings of ductwork installations, specifications for the materials and devices, and a maintenance schedule.

Norway

The building regulations state merely that "*Ducts and air-handling units shall be satisfactorily airtight*". Neither the building regulations, nor the national standard for building specs (NS 3420), give quantitative minimum requirements for airtightness; so it is up to the building owner to specify in each case. In practice, the specified minimum requirement is normally Class B [20]. Despite this, over 90% of installed ductwork is round with Class C. This is because most ductwork suppliers deliver Class C (with gaskets) to the Scandinavian market; it is cost effective and simple to fit.

Leakage tests were common until the mid 1990s. Norway has exactly the same commissioning approach as AMA. Since the 1990s, testing has become uncommon as it is now rarely a contractual obligation. Nevertheless, major ventilation contractors still recommend their own employees to perform pressure tests on their own systems to uncover installation faults at an early stage of construction, not just before handing over. This is especially true for critical ductwork (i.e. with high operating pressures, and main duct risers before they are built-in), not small ducts near air terminals (operating pressure < 100 Pa). If such a leakage test is done, then the results are handed over as part of the handover documentation.
Few systems are tested this way, maybe < 10% of large buildings.

Why is testing no longer required? It may simply be because duct leakage is no longer regarded as an issue, now that Class C has become the *de-facto* standard product in the Scandinavian market. However, this is a false premise. Measurements have shown that there can be a significant difference between leakage in a real building and that documented in laboratory conditions[25]. Air leakage can amount to 5~7 % of the total ventilation flow rate in a commercial Norwegian building[21]. The reason for this is that, in a real installation, many components are connected without gaskets, which creates numerous opportunities for leakage, particularly on branch ducts as opposed to main ducts [24]. Examples are flexible ducts, plenum collars, VAV-box collars, and pressed saddle taps (Fig.5)[22][25]. The latter are a popular alternative to tee pieces (Fig.6, which are both more airtight and aerodynamic) because they simplify fitting, but poor workmanship can leave gaps between the collar and the duct.

Finland

The Finnish situation is similar to that in Sweden. The building regulations (Part D2 '*Indoor climate and ventilation*') require minimum Class B for the whole system, and gives experience-based recommendations to generally use ducts and components of Class C (minimum default) or better, and air handling units of Class L3 or better. Compliance with the regulations is tested during the building process in all buildings except in single family dwellings, for which also use of Class C products is strongly recommended.

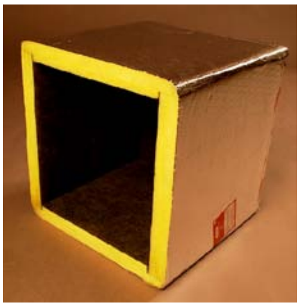

Fig.9 Example of duct-board

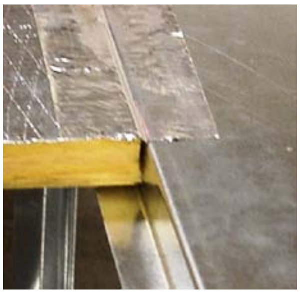

Fig.10 Duct-board tape seal

Fig.11 Conventional duct tape (i.e., fabric-backed tape with natural rubber adhesive) fails more rapidly than all other duct sealants [22]. It has also been shown that the trade standard for advanced tapes (UL 181) does not guarantee durability [22].

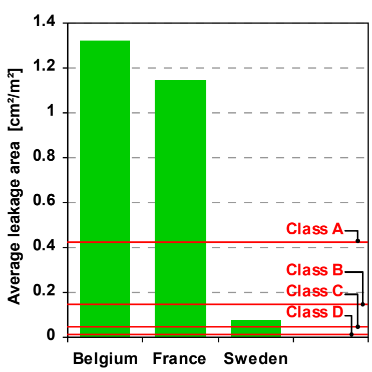

Fig.12 Comparison of average measured duct leakage in Belgium, France & Sweden [16]

For commissioning, Finland has adopted the Swedish principle of random tests but permits random tests if the duct system components are Class C or better. The random tests shall cover 20% of the ductwork surface area in the case of Class C, and 10% in the case of Class D or better. In case of failure in the random test, or if inferior or non-tested components have been used, then the whole system shall be measured.

The Finnish D2 regulations also have requirements for air handling units (Class L3 or better), and requires Class E (i.e. ⅓ of the leakage of Class D) for ducts & components for certain very special applications.

Denmark

The Danish code of practice for mechanical ventilation installations is DS 447 [5]. It has the same status as AMA in Sweden, in that it is not statutory, but ensures compliance with the building regulations. DS 447 states that airtightness of ductwork and air handling units shall be *documented* and satisfy the requirements in the building contract. The majority of systems are tested, even though other means of documenting airtightness are allowed besides leakage tests, such as referring to product documentation. Typically, the contractor bears the responsibility for documentation, which is presented at commissioning. Systems normally fulfill at least Class B and often Class C, just as in Norway and Finland.

Other countries

In other European countries, rectangular ducts are more common than in Scandinavia. Flange systems (Fig.7 & Fig.8) are often used with metallic rectangular ducts and with other components that need to be dismantled regularly for maintenance. Round ducts are still generally sealed in-situ using duct tape (Fig.11) in combination with screws or mastic (screws/mastic are sometimes omitted). Next to metal ducts, an important part of the market is site-assembled duct-boards, which are made of rigid insulation (mineral wool or foams) covered with aluminium foil (Fig.9). These are mainly used in warmer climates (South Europe and USA) where air-conditioned buildings need thermally insulated ducts. Mastic and fastening clamps are rarely used in practice even though they are recommended, and the clamps (if installed at all) and taped seals (Fig.10 & Fig.1) can fail or loosen with age [22]. In conclusion, ductwork airtightness in these countries depends a lot on workmanship and materials.

Tests are very seldom performed in standard buildings, as there are no incentives to do so. This has led to poor ductwork installations in much of the building stock. Knowledge about the ductwork airtightness mainly relies on a few studies[16][18]. Field studies suggest that duct systems in Belgium and in France are typically 3 times leakier than Class A (Fig.12). Studies in USA show a similar or worse pattern [24]. Analysis of specific cases indicates that leakage drastically affects overall system performance. Duct leakage therefore probably has a large energy impact outside of Scandinavia.

2 > Other duct materials

Besides metal ducts, other available duct types include:

- *Rigid insulation ducts*: These can be rectangular (made of 'duct-board', Fig.9) or round (Fig.13). Besides having providing thermal insulation, they are light to transport and have good acoustic properties (partly due to higher break-out noise than round metal ducts). Typical sealing methods include tapes or mastics applied around the joints in the system. Field examinations have shown that taped seals tend to fail over extended periods of time [22][24].

Fig.13 Round foam duct

Fig.14 Flexible duct

Fig.15 Round plastic duct [23]

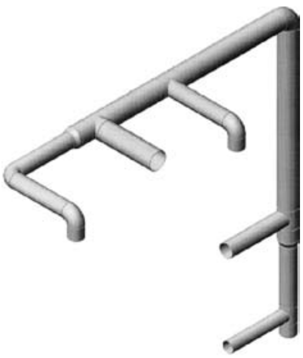

Fig.16 Round plastic duct system with Class C [23]

Fig.17 Example of a machine for manufacturing spiral ducts [Spiro Tubeformer]

In addition, the clamps required by the trade standard (UL 181[4]) can fail and their durability has been questioned [22]. Good airtightness can potentially be achieved with durable mastics applied with by good workmanship. In this case, round insulated foam ducts (Fig.13, which can achieve airtightness Class C when new) may share many of the benefits of round metal ductwork.

- *Flexible round ducts* (Fig.14): These are generally composite ducts made of plastic, metal, and possibly insulation fibre. They come in wide range of qualities, from flimsy ducts with thin plastic foil walls to semi-rigid ducts with walls of aluminium sheet with a concertina form. These ducts a convenient means of connecting components such as ducts to air terminals, and also act as duct silencers. However, they are known to be difficult to clean and the less rigid varieties can easily become compressed. Their use should therefore generally be kept to a bare minimum. Just as ductboard, they flexible ducts pose a challenge with respect to achieving airtight connections (see [22]).
- *Plastic ducts* (Fig.15): Round plastic ducts exhibit the same benefits as round metal ducts. Because of their flamibility, they should not be used in systems spanning multiple fire cells. They are therefore mainly limited to residential ventilation, except connections to kitchen hoods. One particular Finnish product is made of low-emitting antistatic polypropylene, with many components (bends, tees etc., Fig.16) available with the same self-sealing joint that achieves Class C airtightness [23]. Other types of plastic ducts are used for underground ductwork, with watertight joints, because of their corrosion resistance.

3 > HOW DID WE GET TO WHERE WE ARE? The evolution of duct airtightness in the last 50 years

Here we summarize the chain of events that led to the solution of the ductwork airtightness problem in Scandinavia [15][16]. More details are given in the full ASIEPI WP5 report [1]. The problem of leakage was first identified in the 1950s, when mainly rectangular, prepared on site, and little attention was given to airtightness, balancing, or energy performance. This decade also saw the world's first Spiro Tubeformer (Fig.17), a machine for making revolutionary spiral ductwork. In 1966 the seminal AMA defined two airtightness 'norms' A and B, to be spot-checked by the contractor. The 1970s and 80s saw growing use of round ductwork, and further breakthroughs in product quality, such as rubber gaskets which replaced putty and tape that had been used before. Airtightness Class C was introduced in the 1983 revision of AMA; later Class D was added in 1998. In the early 2000s CEN standards on airtightness were published, based largely on Nordic experiences.

4 > RECOMMENDATIONS : The 3 ingredients for success:

The Scandinavian experience has shown that there are 3 basic steps in a market transformation to more airtight duct systems: (i) awareness, (ii) requirements, and (iii) compliance testing. Obviously, if quality is not demanded, there are no penalties or incentives, and no checks made, quality will not be provided [15].

(i) Increased awareness of the benefits quality round ductwork

The first step along the path of a market transformation is to increase awareness of the consequences[16] of air leakage, and that commercially-available airtight round duct systems have many additional benefits over both rectangular duct systems and round ducts without gaskets.

An important decision that must be taken early in the design of an HVAC system, is whether to use round, rectangular, or flat-oval ductwork, or maybe even ductless solutions. Often, a combination of these is used.

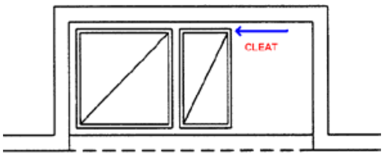

Fig.18 The need for access space to install cleats makes it difficult to use the whole shaft area with rectangular ducts [16]

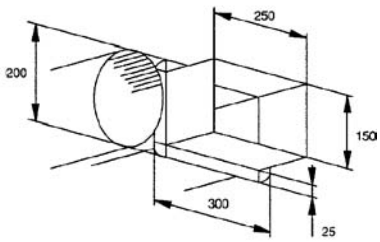

Fig.19 Rectangular duct (with flanges) and circular duct with same height requirement and same free duct area [16]

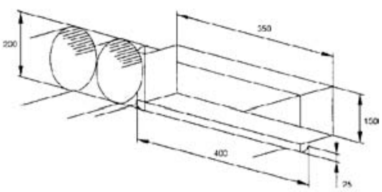

Fig.20 A flat rectangular duct can often be replaced by several parallel round ducts. The example here shows equal height and free duct area [16]

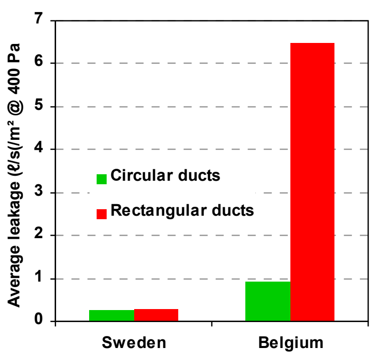

Fig.21 Rectangular versus circular ductwork in Sweden and Belgium [16]

In Scandinavia, HVAC designers take it for granted that round ducts are used throughout the whole system, using rectangular ductwork only where it is unavoidable, such as connection plenums at the air handling unit. This maxim is echoed in ASHRAE Fundamentals, which simply says '*Use round ducts wherever feasible*'.

Below are some moments that illuminate the benefits of round ducts:

Space efficiency

It is commonly believed that rectangular ducts have the advantage that they make maximal use of limited rectilinear spaces. However, this belief needs moderation. Here are three examples:

- A common practice is to use rectangular ducts near the fans, where the airflow is large, and large ducts are needed in a cramped space. Further away, the smaller branch ducts can be round. However, one problem with this is that ductwork near fans experiences a higher operating pressure than smaller ductwork near air terminals, so its airtightness is more critical. Rectangular ducts are known to be leakier.
- To the inexperienced designer, rectangular ducts seem a logical choice in rectangular service spaces (risers, shafts). However, in practice, one must provide access space to slide cleats onto all the flanges (Fig.18). This access space must be as wide as the widest rectangular duct. Round ducts often need less installation space than rectangular ducts with the same pressure drop (Fig.19 & Fig.20) [17].
- One advantage of rectangular ductwork is that it can have virtually any aspect ratio. For example, flat-&-wide ducts can be used in ceiling voids above rooms with crossing beams or in corridors with little head-room. However, the flanges around rectangular ducts protrude 20–40 mm, so round ducts do not necessarily occupy more space. The alternative is to use multiple parallel round ducts. Incidentally, this can simplify balancing and enable zoning (See Chapter 8 in [17]). If considered early in the design phase, it is possible to influence the architectural planning to ensure sufficient space for round ductwork.

Leakage

- Fig.21 compares average leakage from on-site measurements of round and rectangular duct systems in Sweden and Belgium. The Swedish data shows little difference between round and rectangular systems, simply because the round and rectangular systems in this particular data set had approximately the same airtightness requirement (Class B).
  In Belgium, which has neither strict tightness requirements nor any testing, rectangular ducts are very leaky, while round duct systems perform only slightly worse than in Sweden (Class A). This shows us that huge reductions in duct leakage can be achieved simply by adopting round ducts as an industry standard, even if testing is not practiced as part of commissioning.
- Round ducts are tighter. Larger duct systems (≥ 50 m² duct surface area) are, according to VVS AMA 83 (1984), required to be three times tighter than a rectangular duct system;
- Connecting two round spiral wound ducts only requires one fitting, whereas rectangular ducts are connected by use of a completely separate flanging system (Fig.22 & Fig.23). Round ducts can have any length between the connections, a duct length of 3 m is standard but 6 m is also frequently used. The length of a rectangular duct is limited by the size of the steel sheet, which is usually less than 2 m, which requires more connections.

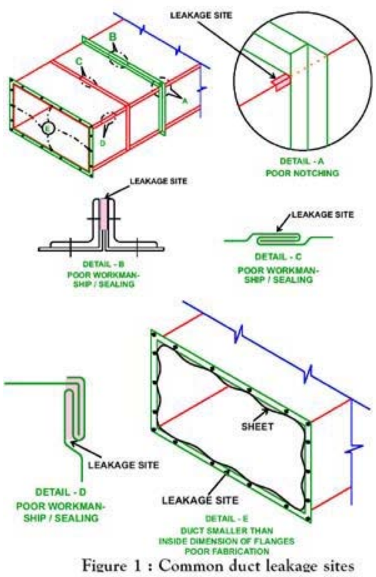

Fig.22 Illustration of typical leakage points for rectangular ductwork [source: AC&R J.]

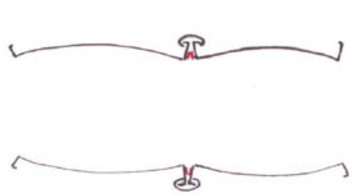

Fig.23 Cross section of a rectangular duct under pressure – causing the flange gasket seal to open [source: L.A.Matsson]

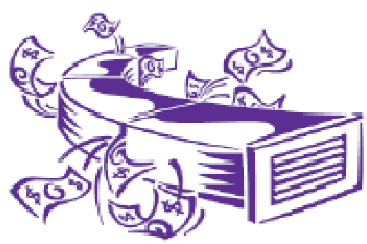

Fig.24

Indoor environment, health & safely

- Reduced leakage means that the air needed to maintain the indoor environment flows exactly where it is intended to go. Hence the whole system can be dimensioned and balanced exactly as it should, providing good indoor environment.
- Round ducts are easy to clean, as there are no sharp corners.
- The noise generated in straight ducts is normally insignificant compared to the noise generated in e.g. elbows. Standardized round duct components have well known acoustic properties, whilst the properties of 'tailor-made' parts in rectangular ducts is often unknown.
- It is easier to measure the airflow in round ducts, which can make for simpler and more accurate balancing.
- The round duct wall is stiffer than the rectangular one and thus will allow less sound transmission through the duct wall. Whether this is an advantage or not depends on the application.
- Fire insulation of a duct to a specified fire safety class might be achieved with thinner insulation on round ductwork. Rectangular ductwork may need thicker insulation as it is compressed at corners.

Energy efficiency & environmental impact

- The pressure drop in round duct systems is often lower than in a rectangular duct at the same air velocity due to industrially manufactured and aerodynamically designed duct components such as elbows and branches. This leads to lower fan power.
- The total airflow rate can be lower due to less leakage, which further reduces fan power. Class C round ductwork has typically 30% less fan power than traditional Class A ductwork. Similarly, airtight systems facilitate exploitation of the full benefit of other energy efficiency measures, including demand-control, and heat recovery, and energy for heating & cooling is reduced by approx. 15%.
- Less material (steel & insulation) is used. On a large scale, this has environmental benefits.

Costs

- The installation time for a round duct system is normally shorter, approximately half that for a similar rectangular system [19]. Delivery times can also be shorter due to the standardized sizes & components.
- Using round ductwork with standard sizes (the diameters of the ducts increase by 25 % upwards: 80, 100, 125, 250, mm, etc.) decreases the waste during installation. Short pieces of round duct, or surplus components, need not be scrapped, but can be used elsewhere. The investment cost for suspensions and insulation are also reduced. Thus total material costs can be 12~25% less than rectangular systems [19].
- The overall cost (sum of material and assembly costs) is normally lower, approximately by 25% [19], at least in countries where round ducts have been in use for a longer period of time.
- Any additional investment cost (if any) for round ductwork is probably not significant since labour cost is considerably reduced. Furthermore, any higher investment cost for a higher quality duct system should be considered based on Life Cycle Costs (LCC) due to the energy savings.

(ii) Establish guidelines & requirements, ideally with incentives

Trade guidelines

Each country should establish trade norm or requirements on duct systems in verifiable terms. This should be referred to/specified in tender and contract documents.

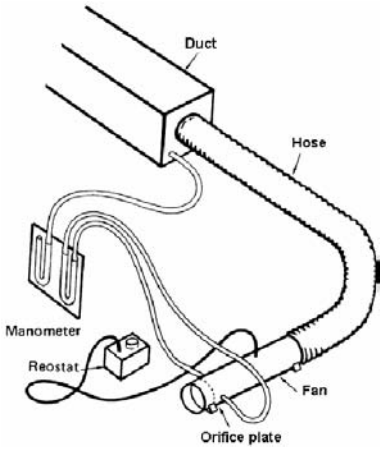

Fig.25 Illustration of test setup for leakage testing [20]


Fig.26 Example of Scandinavian duct leakage testing equipment [Swema]


Fig.27 Another example of Scandinavian duct leakage testing equipment [Lindab]

Energy performance requirements

Duct leakage can be included as a parameter in the national Energy Performance Calculation method. For example, in France, the default leakage rate corresponding to 15% of the nominal air flow rate (about 3 times worse than airtightness Class A in the EN standards. If no documentable information is available on the ductwork airtightness then one has to assume the default value.

Include them in building contracts

These are made valid when they are referred to in the contract between the owner and the contractor - which is practically always the case in Sweden, for example.

(iii) Verify them in each project, with predefined penalties

All ventilation and air conditioning systems should be carefully commissioned. Building contracts should include the cost of leakage testing, and describe what method is to be used, and what happens if the requirements are not met. VVS AMA is a very good model to use.

ASIEPI

5 > References

[1] Guyot, G.; Carrié, F.R.; Schild, P.G.; Aurlien, T. *ASIEPI WP5 Technical Report 'Stimulation of good building and ductwork airtightness through EPBD'*, 2010. *www.asiepi.eu, www.buildup.eu*

[2] VVS AMA 98. in: *Allmän material- och arbetsbeskrivning för VVS-tekniska arbeten*. AB Svensk Byggtjänst. Stockholm, 1998. Copyright 1998.

[3] NKB 61E. *Indoor climate - Air Quality*. Nordic Committee on Building Regulations. NKB Publication No. 61E, 1991.

[4] Underwriters Laboratories, Standard UL 181. *'Factory-Made Air Ducts and Air Connectors'*, *ulstandardsinfonet.ul.com*

[5] Danish Standard DS 447. *Norm for mekaniske ventilationsanlæg*

[6] European Standard EN 1507:2006. *Ventilation for buildings - Sheet metal air ducts with rectangular section - Requirements for strength and leakage*

[7] European Standard EN 1886:2007. *Ventilation for buildings - Air handling units - Mechanical performance*

[8] Norwegian Standard NS 3420-V:2008. *Specification texts for building, construction and installations, Part V: Ventilation and air conditioning systems*

[9] European Standard EN 12097:2006. *Ventilation for Buildings - Ductwork - Requirements for ductwork components to facilitate maintenance of ductwork systems*

[10] European Standard EN 12237:2003. *Ventilation for buildings - Ductwork - Strength and leakage of circular sheet metal ducts [Leakage classification and measurement method]*

[11] European Standard EN 12599:2000. *Ventilation for buildings - Test procedures and measuring methods for handing over installed ventilation and air conditioning systems (Corrigendum AC:2002 incorporated) [Leakage measurement method, etc.]*

[12] European Standard EN 13779:2007. *Ventilation for non-residential buildings - Performance requirements for ventilation and room-conditioning systems [General requirements, including leakage]*

[13] European Standard EN 14239:2004. *Ventilation for buildings - Ductwork - Measurement of ductwork surface area*

[14] European Standard FprEN 15727:2009. *Ventilation for buildings. Ducts and ductwork components, leakage classification and testing*

[15] Andersson, J. Chapter 19: 'Ducting Systems — Location, Design, Inspection and Cleaning', in: *'AIR'*. Ekberg L.E., Bitton J., Wilcox M. (eds) Kvänum, Sweden : Swegon Air Academy, 2008. ISBN 9197744301

[16] Andersson, J.; Carrié, F.R. and Wouters, P. *Improving Ductwork — A Time for Tighter Air* Distribution *Systems*. EU Project SAVE-DUCT, Brussels 1999. ISBN 1902177104

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[17] Andersson, J.; Carrié, F.R.; Delmotte, C.; Malmstöm, T. and Wouters, P. *Source book for efficient air duct systems in Europe*. EU Project AIRWAYS, Brussels 2002

[18] Carrié, F.R.; Bossaer, A.; Andersson, J.V.; Wouters, P. Liddament, M.W. 'Duct leakage in European buildings: status and perspectives'. *Energy and Buildings*, No.32 (2000). pp.235–243

[19] Hofmeister, Peter. *Advisory Opinion regarding the comparative test and evaluation of the overall installation costs of various installed air systems under consideration of the functional requirements and seal in accordance with EN 12237 and EN 1507*. TUV Rheinland Industrie Service GmbH, TUV order no. 9986501. 2008

[20] Rehn. C. Ventøk 5.1, *Kanaler - praktisk utforming*. 2003

[21] Rehn. C. Ventøk 5.8, *Kanaler - et effektivt distribusjonssystem for luft*. 2001

[22] Sherman, M.H. and Walker, I.S. *Duct Tape Durability Testing*. Report LBNL 54767. Lawrence Berkeley National Laboratory, 2004

[23] SINTEF Technical Approval No.2380, '*Uponor Inomhusventilationssystem*', (*www.byggforsk.no*), 2009

[24] Wray, C.P.; Diamond, R.C. and Sherman, M. Rationale for measuring duct leakage flows in large commercial buildings. LBNL 58252. Lawrence Berkeley National Laboratory, 2004

[25] Vaille, P.-J. Air Tightness of Ventilation Ductwork Equipped with Joints. Proceedings 27th AIVC Conference: Technologies & Sustainable Policies for a Radical Decrease of the Energy Consumption in Buildings, Lyon. 2006

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Part D. Web events

on

Stimulation of good building and ductwork airtightness through EPBD

ASIEPI web event 1: Ways to stimulate a market transformation of envelope airtightness - Analysis of on-going developments and success stories in 5 European countries

ASIEPI web event 7: How to improve ductwork airtightness – Ongoing developments and success stories in Europe

ASIEPI web event 1

Ways to stimulate a market transformation of envelope airtightness - Analysis of on-going developments and success stories in 5 European countries

Date: 12 December 2008, 10:00-12:00 GMT+1 (Paris time)

Envelope airtightness is an important feature for low-energy, well-ventilated buildings. Germany has produced a continuous effort on this issue during the past two decades. More recently, there has been an increasing interest for this issue in some other European countries, with interesting developments to further stimulate the market.

The objective of this WebEvent is to give you :

- an overview of those interesting developments in Belgium, France, Finland, and Norway;
- feed-back on the German experience;
- an opportunity to give your point of view.

Event page: http://www.asiepi.eu/wp-5-airtightness/web-events/web-event-1.html

Ways to stimulate a market transformation of envelope airtightness - Analysis of on-going developments and success stories in 5 European countries
Brief presentation of the ASIEPI project *by Rémi Carrié, CETE de Lyon, WP5 leader*
Introduction in the building airtightness issue bridges as covered in ASIEPI *by Rémi Carrié, CETE de Lyon*
Airtightness revival in Norway *by Aurlien Tormod, SINTEF*
Recent steps towards the generalization of airtight buildings in France *by Rémi Carrié, CETE de Lyon*
Recent market trends in Belgium *by Nicolas Heijmans, BBRI*
Over two decades of experience with airtight buildings in Germnay *by Bernd Rosenthal, E-U-Z*
Questions
Conclusion and closure *by Rémi Carrié, CETE de Lyon, WP5 leader*

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ASIEPI web event 7

How to improve ductwork airtightness – Ongoing developments and success stories in Europe

Date: 16 December 2009, 10:00-12:00 GMT+1 (Brussels time)

Several studies have shown that ductwork air leakage can significantly affect the energy performance and indoor air quality in buildings. Scandinavian countries identified this issue over 50 years ago. For example, the first requirements on ductwork airtightness were introduced in Sweden in 1950, and the use of components with certified pre-fitted seals is now in standard use. Other countries are now tackling the same problems, due to increased use of ducted ventilation systems, some with heat recovery, heating or cooling. Despite this, the interest for airtight ducts in most European countries has remained low until now.

The objective of this WebEvent is to give you :

- an overview of energy impacts and calculation procedures;
- an overview of duct leakage measurement methods;
- a feed-back on the Scandinavian experience and how it can be applied in your country;
- an opportunity to give your point of view and ask questions.

Event page: http://www.asiepi.eu/wp-5-airtightness/web-events.html

How to improve ductwork airtightness – Ongoing developments and success stories in Europe
Introduction to the event *by Dr. Peter Schild, SINTEF Buildings & Infrastructure, Norway*
Duct leakage problems & consequences in EU *by Samuel Caillou, BBRI, Belgium*
Including leakage in energy calculations *by Dr. Jean-Robert Millet, CSTB, France*
Leakage testing methods/requirements *by Dr. Peter Schild, SINTEF Buildings & Infrastructure, Norway*
Practical solutions for airtight ductwork *by Lars Åke Mattsson, Lindab, Sweden*
The Scandinavian success story *by Jorma Railio, FAMBSI, Finland*
Questions, open exchanges on success stories
Conclusion and closure *by Dr. Peter Schild, SINTEF Buildings & Infrastructure, Norway*

I E E   S A V E   A S I E P I

The EPBD as support for market uptake for innovative systems

Summary report

Main authors:

Nicolas Heijmans, BBRI

Marleen Spiekman, TNO

SUMMARY

In the context of EPB regulations, *innovative systems (or technologies)* are defined as systems (or technologies) that, in most cases, improve the building's energy performance AND whose performance cannot be assessed by the standard EPB calculation procedure in a particular country.

If a Member States does not want its EPB regulation to be a barrier to innovation, it should have a kind of framework to allow the assessment of innovative systems (as defined here above). This is vital for the industries (as demonstrated for instance by the European project RESHYVENT) and this why this issue was addressed by ASIEPI.

The main recommendations, which are described in more detail in part A of this summary report, can be summarised as follows (but the reader is kindly invited to read part A to understand the nuances behind those recommendations):

1. It is important that Member States explicitly foresee the possibility of assessing technologies not covered by the standard calculation procedure, so that their EPB regulation does not become a real barrier for innovation.
2. As this alternative assessment procedure should be the exception rather than the rule, different approaches should be combined (if legally possible) to limit its use.
3. Given the need for quality and the complexity of a coherent assessment of innovative systems, it is important to have a framework that can ensure the quality of the studies.

Part B gives an overview of all project material that is available on this topic.

Part C is a collection of all the Information Papers produced on this topic.

Finally, Part D presents the related organised web events.

Part A: Final recommendations

1. INTRODUCTION

1.1 SHORT PROBLEM DESCRIPTION

The EPBD is one of the European Union's tools to reduce its energy consumption. New and innovative products, systems and technologies may help to achieve this final goal. **It is therefore of vital importance that EPBD related regulations don't become barriers to innovation**.

The EPBD requires that each Member State defines EPB calculation procedures. Member States are free to develop calculations as they want; the EPBD itself only gives a list of parameters that should be included. In some Member States, calculations are based on a simplified monthly steady state approach; in other Member States, calculations are based on dynamic simulations. But, independently of the complexity of the calculation procedures, they cannot cover all types of building systems or technologies that will be invented in the future – and they probably do not cover all those that are already on the market.

This is a real problem for such technologies, as reported by a manufacturer: *"The fact that our products are not included in the national EPB calculation procedure is a barrier to their market uptake because the architects firstly try to fulfil the EPB requirements. After having paid for this, they don't have money left for products that saves energy, even if these products have good return on investment."*

Consequently, if a Member State does not want its EPB regulations to be a barrier to innovation in the building sector, it should design its EPB regulations in such a way that the assessment of innovative systems (or buildings) is legally and technically possible.

In order to increase or even to create enough awareness on this important issue, it was decided to analyse this in the IEE SAVE ASIEPI project.

1.2 DEFINITIONS

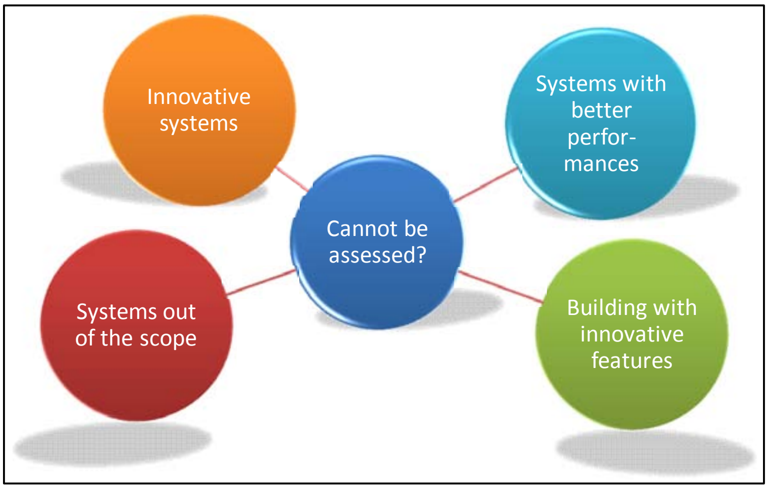
In the context of EPB regulations, *innovative systems (or technologies)* are defined as systems (or technologies) that, in most cases, improve the building's energy performance AND whose performance cannot be assessed by the standard EPB calculation procedure in a particular country.

The alternative assessment framework for the assessment of innovative systems or buildings is often called the *Principle of Equivalence*. This comes from The Netherlands, where the *Gelijkwaardigheid Principe* is well established. However, it must be noticed that the concept of principle of equivalence may vary from country to country; in some Member States, it does not apply to EPB regulations only, but to the whole building code.

However, the definition mentioned above does not cover all situations. Indeed, three other situations may occur.

- There are systems that have better performances than the one mentioned in the standard calculation procedure, but that cannot prove these better performances because the standard calculation procedure does not mention how to prove them. In some countries, the principle of equivalence may be used to prove better performances, whereas in others, it may not be used.

- A third category might be *(innovative) buildings* that use special features, designed specifically for them, and that cannot be assessed by the standard calculation procedure due to their novel/unconventional design.



- The last category concerns systems that perform better than the usual systems, but for a purpose that is not integrated in the calculation procedures. An example would be an intelligent lighting system for residential buildings, as most of the Member States does not consider this type energy use in residential buildings. The "principle of equivalence" is not expected to take such kind of systems into account.

2. KEY POINTS OF ATTENTION THAT COULD INSPIRE MEMBER STATES

On basis of the analyses carried out by ASIEPI, some key points of attention have been identified and will be discussed below.

2.1 REMARKS

- The way the "principle of equivalence" is implemented in a country depends on several national factors. Consequently, not all points of attention are applicable in all Member States.
- The information provided is mostly based on personal experiences of the partners involved in the ASIEPI project and therefore does not necessarily reflect the official position of a country.

2.2 EPB REGULATIONS SHOULD NOT BE A BARRIER TO INNOVATION

Independently of the approach they have implemented, several Member States included in this analysis have reported as the main advantage that *"a principle of equivalence allows any product to get a chance to be taken into account, which is necessary for innovation to have an impact"*.

Therefore, **it is important that Member States explicitly foresee the possibility of assessing technologies not covered by the standard calculation procedure, so that their EPB regulations do not become a real barrier for innovation.**

Several options are available to achieve this goal. However, in any case, the following points of attention should be considered.

2.3 EXTENSION OF THE STANDARD CALCULATION METHOD

The "principle of equivalence" approach should be considered as an extention of the standard calculation method.

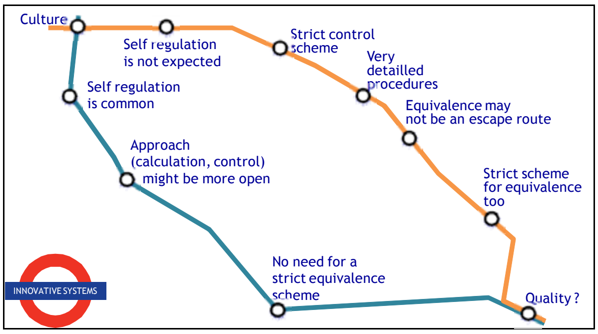
Therefore, **it is important that the "principle of equivalence" approach is implemented in accordance with the EPBD implementation.**

For instance:

- the way the equivalence studies are

carried out should be compatible with the way the standard calculation procedures was set up; this might require defining a so-called "technical framework", as discussed below

- if a Member States has implemented a strict control scheme, the "principle of equivalence" must not be an escape route to it, and it must also be kept under control,



- ideally, it should be possible to introduce the results of the equivalence studies directly into the EP calculation tool(s), especially if the EP calculation tool has to be used to electronically report the EP calculations to the authorities. In this case, the EP calculation tool(s) must be designed in such a way that the result of the equivalence studies *can* be introduced.

- ...

2.4 AN EXCEPTION, NOT THE USUAL APPROACH

The use of the "principle of equivalence" approach should be the exception, not the rule.

As the use of the "principle of equivalence" approach has it own disadvantages (see the country situations in annexes), it should be the exception, not the rule.

By definition, the need to use the "principle of equivalence" approach is reduced if the standard calculation procedure includes as many technologies as possible. This is shown by the German calculation procedure, which includes several systems or technologies which are not included in many other Member States (see D6.1). Consequently, the number of equivalence studies is rather limited.

To achieve this, **Member States should improve the EPB standard calculation procedures on a regular basis.**

On the one hand, when the standard calculation procedures specify a fixed or a default value, it should also specify how to prove the better performances than this default value (e.g. "the efficiency has to be measured according to EN 12345").

On the other hand, the existing equivalence studies could be used to identify the technologies that should be integrated in priority into the standard calculation procedures, and could be used as basis for procedure updates. (Technologies that appeared to save energy on paper only could possibly be integrated in such a way that their use is discouraged.)

2.5 NEED FOR QUALITY AND MANAGEMENT OF COMPLEXITY

One of the main disadvantages reported by every Member States where the studies can be performed by anyone (DE, DK, FI, FR, ES, NL) is that *"allowing anyone to make the equivalence study might lead to significant differences in the quality of the studies and also to studies of poor quality"*. This disadvantage can be further increased if the evaluation of the equivalence study is the responsibility of the municipalities.

Therefore, **given the need for quality, and the complexity of a coherent assessment of innovative systems, it is important to have a framework that can ensure the quality of the studies.**

One option would be to have a single body authorised to perform the studies, but this would not match the practice and/or the legal framework of many Member States and also has its own disadvantages (see D6.2).

Fortunately, there are other options. Some are related to the way the studies must be carried out, others to the way the studies must be evaluated.

2.6 HOW SHOULD AN EQUIVALENCE STUDY BE CARRIED OUT?

Some Member States (FR, NL) reported that "the assumptions of the equivalence study have to be similar to the assumptions of the standard calculation procedures". In France, where this also applies, it has been reported that, "as no technical example was presented [as annex of the Title V legislation], the first equivalence study was incomplete and unclear". However, once a template was provided, several studies were performed.

Moreover, this is only possible if the assumptions of the standard calculation procedures are published, which is probably not always the case, especially as by definition, innovative systems are systems not included in the standard calculation procedures.

Even if this may be a difficult task, **it might be useful that Member States that do not have a technical framework for the assessment of innovative systems analyse the necessity to define one, at least a minimal one**....

This technical framework could include the following elements: the type of calculations to be done, the characteristics of the buildings to be simulated, the occupancy pattern, the outdoor climatic conditions, the pollutant emissions, the internal gains...

This technical framework should be in line with the standard calculation procedure; if both have not been written by the same people, at least a close collaboration between them is required.

2.7 HOW TO EVALUATE THE STUDIES?

In some Member States (DE, DK, FI, NL, NO), the alternative assessment is evaluated at municipal level. All those Member States have reported that having an assessment at municipal level is one of the main disadvantages of the system. To overcome this disadvantage, **a first option could be to approve the alternative assessment studies at a sufficiently high administrative level.** However, the implementation of this option can be difficult, as it might need a (more or less drastic) change in the general legal framework.

A second option (if the first one is not possible) could be to have an appropriate support infrastructure for local authorities. For instance, it might be possible:

- to set up a consultative central body that would establishes a technical framework to perform the studies and criteria to accept them,
- to set up a consultative central body that would provide advice on the studies, on request of the municipalities,
- to publish the list of accepted studies, as it this the case in France and Belgium (Flemish Region), where the evaluation is centralised.

A list of criteria for accepting studies would be helpful for both the municipalities and for the experts that make the studies, as obviously they would respect them if they knew that their studies would be evaluated at least on the points mentioned in the list.

It must be noted that the municipalities might be reluctant to publish to studies they have accepted, as they might have accepted poor quality studies. However, a centralised publication of accepted studies would not only help municipalities to take a decision, but it would also increase the transparency of the system and it would help the experts in charge of the EP calculations. This is compulsory in Spain.

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2.8 COMMUNITY SUPPORT

In order to have the required community support, it might be useful to have a structured approach for interaction with the market.

For instance, some kind of public consultation might be organised if a technical framework is defined (just as public consultation has been organised for the standard calculation procedure...). This happens in Spain and Belgium.

2.9 MARKET INFORMATION

It is important to **pay attention to inform the market about the possibilities offered by the "principle of equivalence" and to provide information on approved systems.**

As said previously, a centralised publication of accepted studies would increase the transparency of the system.

2.10 DELAY AND COSTS ISSUE

It is important to **pay attention to the costs for carrying out studies of equivalence and the time for assessment of innovative systems.**

Some Member States reported that there could be a long delay (BE, DK, FR, ES), up to 6 months or 1 year. Only one Member State (NO) reported that the delay could be short. The fact that the system is open or closed seems not to be a determining factor for the delay (it is interesting to note that two Member States with a more open approach reported different delays for obtaining approval for a study).

2.11 NEXT EPBD REVISION

The issue of the assessment of innovative systems is not addressed in the EPBD. However, **as the EPBD should act as a driver for innovation and surely not create barriers to innovation, this issue could be integrated in the next EPBD revision.**

Article 3 could require Member States to have a legal framework for the assessment of building technologies that cannot be assessed by the national or regional calculation methodology. It must be noticed that such a legal framework, exists already in several Member States...

As a first suggestion, the following paragraph could be added to Article 3: "*In order to stimulate the market uptake of innovative technologies, Member States shall adopt a legal framework for an alternative assessment of building technologies that are not covered by the (national) calculation methodology set in accordance with the first subparagraph of this paragraph.*"

2.12 CONCLUSIONS

From the various ways innovative systems are handled by the national EPB approaches, some key points of attention have been identified, as shown in the figure.

These could inspire both the Member States that do not have a framework for the assessment of innovative systems and those that have one but would like to improve it.

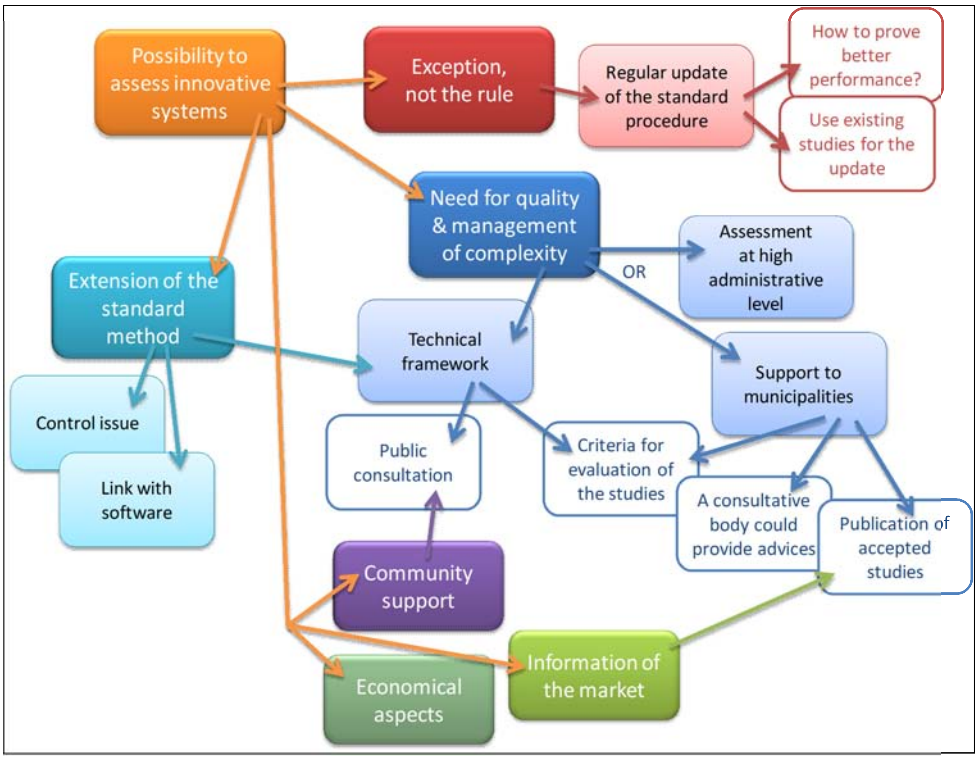
The three main points of attention could be summarised as:

4. It is important that Member States explicitly foresee the possibility of assessing technologies not covered by the standard calculation procedure, so that their EPB regulation does not become a real barrier for innovation.

   If a legal framework is defined, the extent of its application should be clearly defined. Is it applicable to systems not covered by the standard calculation procedure only? Is it also applicable to prove a better performance than the one included in the standard calculation procedure? Is there also an approach for "innovative buildings" (which are only valid for a single building)?

5. As this alternative assessment procedure should be the exception rather than the rule, different approaches should be combined (if legally possible) to limit its use. The standard calculation procedure should be updated on a regular basis (on basis of the equivalence studies) and should include the specifications to prove a better performance than the default value.

6. Given the need for quality and the complexity of a coherent assessment of innovative systems, it is important to have a framework that can ensure the quality of the studies. Several options have been identified to go in that direction: e.g. the assessment of the study should not be performed by the municipalities but by at sufficiently high administrative level, a technical framework could be defined,...



Part B: Bird's eye view of the project results

3. INTRODUCTION

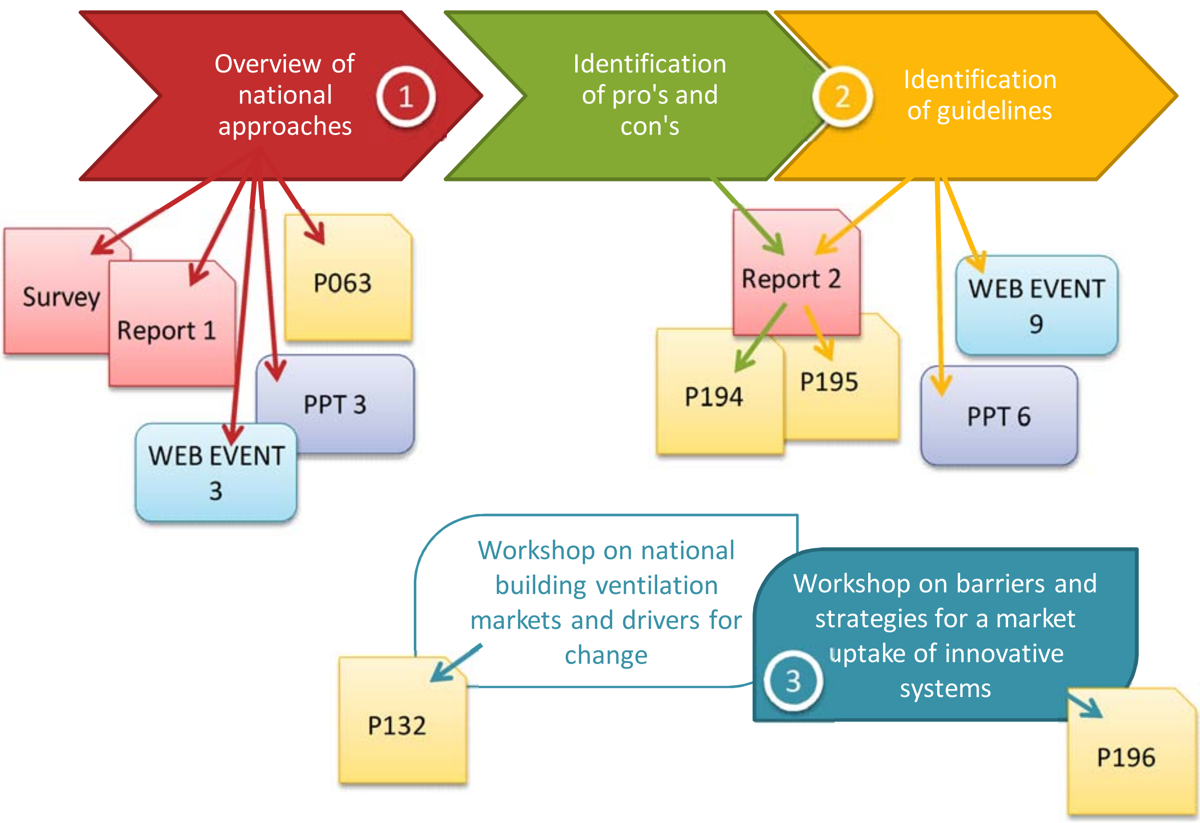
The "innovative systems" issue was articulated in three main steps.

1. The first step was to make an overview of the current situation regarding the assessment of innovative systems across EU. To achieve this goal, a survey was launched amongst the ASIEPI participants, as well amongst some industrial partners.

2. Based on the collected information, pro’s and con’s for the various approaches were identified, and guidelines made available, allowing Member States to accelerate the realisation of a qualitative environment for the assessment of innovative systems in the EPBD context. (These guidelines cover legal and technical issues. However, as SAVE is not a framework for technical projects, ASIEPI did not intend to develop new methodologies to assess the performance of innovative systems.)

3. A workshop related to barriers and strategies for an accelerated market uptake of innovative systems was organised.

This information was made available in the following publications.



4. PUBLISHED RESULTS

4.1 TECHNICAL REPORTS

Two technical reports were published:

- The report D6.1 (> link) "*Overview of national approaches for the assessment of innovative systems in the framework of the EPBD*", published in March 2009, summarises some key facts of the national approaches for the assessment of innovative systems in the framework of the EPBD or, more precisely, in the framework of the national Energy Performance of Building (EPB) regulations. It is based on the results of a survey (> link) launched amongst ASIEPI participants.

- The report D6.2 (> link) "*Stimulating innovation with EPBD - What countries can learn from each other*", published in 2010, summarises the pro's and con's of the various approaches and the proposed guidelines for Member States.

4.2 INFORMATION PAPERS

Five Information Papers were published (> link):

- **P063** "*Assessment of innovative systems in the context of EPBD regulations*", published in March 2008, discusses the overall context of the "innovative systems" issue, as well as the approaches used in Netherlands, France, Belgium and Germany.

- **P132** "*An overview of national trends related to innovative ventilation systems*", published in November 2008, summarises the discussion related to innovative (ventilation) systems that took place at the AIVC workshop organised in Ghent, Belgium, in March 2008.

- **P194** "*Stimulating innovation with EPBD - What countries can learn from each other*", published in 2010, discusses the pro's and con's of the national approaches of several countries.

- **P195** "*Stimulating innovation with EPBD - Key points of attention for Member States*", published in 2010, identifies some key points of attention or guidelines for the Member States on the "innovative systems" issue.

- **P196** "*National trends of innovative products and systems for energy-efficient buildings - Barriers and strategies for an accelerated market uptake*", published in 2010, summarises the discussion of the ASIEPI workshop "*National trends of innovative products and systems for energy-efficient buildings - Barriers and strategies for an accelerated market uptake*" that took place in Amsterdam, Netherlands, in March 2010.

4.3 WEB EVENTS

Two web events were held (> link):

- During the **ASIEPI web event 3** "*Overview of national approaches for the assessment of innovative systems in the framework of the EPBD*", held in February 2009, the overall context of the "innovative systems" issue was discussed and the approaches used in Netherlands, France, Germany, Denmark and Belgium were presented; moreover, two industrial associations (ES-SO, EuroAce) have shared their point of view.

  This web event was attended by 51 people from 18 countries. The overall satisfaction was 4.0/5.0.

The program of the web event is given in the next table.

Introduction
Welcome *by Peter Wouters, INIVE, project coordinator*
Presentation of the ASIEPI project *by Peter Wouters,INIVE*
What is the potential problem with EPBD and innovative systems? *by Peter Wouters*
Overview of alternative assessment procedures across EU *by Nicolas Heijmans, BBRI*
Examples of national approaches
Netherlands *by Marleen Spiekman, TNO*
France *by Hicham Lahmidi, CSTB*
Germany *by Heike Erhorn-Kluttig, IBP*
Denmark *by Kirsten Engelund Thomsen, SBi*
Belgium *by Nicolas Heijmans, BBRI*
The industry point of view, expressed by two ASIEPI sponsors
ES-SO *by Dick Dolmans, ES-SO*
EuroAce *by Jean-Luc Savin, AERECO (as member of EuroAce)*
Discussions
Questions
Conclusions and closure *by Peter Wouters, INIVE, project coordinator*

Program of ASIEPI web event n°3

- During the **ASIEPI web event 9** "*Stimulating innovation with EPBD*", held in February 2010, the problems and potential solutions of the national approaches were discussed; moreover, one industry and one consultant shared their practical experiences with the Dutch approach.

  This web event was attended by 39 people from 20 countries. The overall satisfaction was 4.1/5.0.

  The program of the web event is given in the next table.

Introduction
Welcome and introduction to ASIEPI *by Nicolas Heijmans, BBRI*
Importance of dealing with innovative systems in EPBD *by Nicolas Heijmans, BBRI*
National presentations
Advantages and disadvantages of the Danish approach *by Jorgen Rose, SBi*
Advantages and disadvantages of the Dutch approach *by Marleen Spiekman, TNO*
Advantages and disadvantages of the Belgian approach *by Nicolas Heijmans, BBRI*
Advantages and disadvantages of the French approach *by Charles Pele, CSTB*
Synthesis, problems and potential solutions *by Marleen Spiekman, TNO*
Practical experiences
What does industry see what goes right and wrong in their/other countries related to their market. What would they like to see? *by Rick Bruins, Zehnder*
Study on the use and control of the principle of equivalence in practice in the Netherlands: results and possible solutions *by Tom Haartsen, Climatic Design Consult*
Discussions
Questions
General guidelines, conclusion and closure *by Nicolas Heijmans, BBRI*

Program of ASIEPI web event n°9

4.4 PRESENTATIONS-ON-DEMAND

The following presentation-on-demand are available:

- **ASIEPI presentation-on-demand 4** "*The EPBD as support for market uptake of innovative systems*", published in April 2009, discusses the importance of the issue and identifies some first guidelines for Member States (> link).

- **ASIEPI presentation-on-demand 6** "*Main lessons learned and recommendations from the IEE SAVE ASIEPI project*", published in 2010 in several languages, focuses on guidelines for Member States.

4.5 WORKSHOPS

The "innovative system" issue was discussed during two international workshops.

- The AIVC workshop "***Trends in national building ventilation markets and drivers for change***" was held in Ghent, Belgium, in March 2008 (> link). The objectives of this workshop were:
  - to inform interested parties (industry, regulators,…) of the latest changes in national building ventilation markets, with an attention not only for IAQ and energy issues, but also on airtightness and assessment of innovative (ventilation) systems issues,
  - to identify the drivers for changes,
  - to discuss the status in a round table with industry representatives.

  The discussions were summarised in **P132**.

  The program of the workshop is given in the next table.

Opening of workshop
Opening of the workshop and welcome
Presentation of IEE SAVE ASIEPI
Presentation of IEE SAVE BUILDING ADVENT
Presentations of national situations and discussions
Denmark, *P. Heiselberg (Aalborg University)* Finland, *J. Kurnitski (Helsinki Un. of Technology)* Norway, *M. Eriksson (Norwegian Ventilation Contractors)*
USA, *M. Sherman (LBNL)* Brazil, *P. Lamberts (Un. Of Santa Caterina)* Portugal, *E. Maldonado (FEUP)*
Korea, *Y. Lee (KICT)* Japan , *T. Sawachi (NILIM)* UK, *M. Kolokotroni (Brunel University)*
Netherlands, *W. De Gids (TNO)* France, *F. Durier (CETIAT)* Germany, *H. Erhorn (Fraunhofer-IBP)* Poland, *J. Sowa (Warsaw Univ. of technology)*
Belgium, *N. Heijmans (BBRI)* Czech Republic, *P. Charvat (Brno University of Technology)* Greece, *M. Santamouris (NKUA)*
History of airtightness measurement and development in construction: documented by 10 years of BlowerDoor conferences on building airtightness, *B. Rosenthal (E-U-Z)*
Round table with industry representatives
Synthesis and discussion on national trends
Innovative systems issues, *P. Heiselberg, N. Heijmans* IAQ issues, *M. Sherman, M. Liddament* Airtightness issues, *R. Carrié, B. Rosenthal* Energy issues, *E. Maldonado, P. Wouters*
Conclusions and next steps, *P. Wouters, AIVC*

Program of the workshop n°1

- The ASIEPI workshop "***National trends of innovative products and systems*** *for energy-efficient buildings - Barriers and strategies for an accelerated market uptake*" was held in Amsterdam, Netherlands, in March 2010 (> link). The objectives of this workshop were:
  - to identify national trends and barriers for adoption of current and emerging energy-efficient technologies and products for buildings,
  - to outline strategies and drivers for change to incentives to increase adoption rate of these technologies, and accelerate the transition process towards a comfortable, healthy, and energy-efficient built environment,
  - to discuss what are emerging technologies with high potential to realize energy-efficient buildings and good indoor environments,
  - to document success stories and best practices that facilitated effective uptake and implementation of energy-efficient and innovative technologies in buildings, while taking high quality and healthy environments into account.

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The discussions were summarised in P196.

The program of the workshop is given in the next table.

Session 1: Opening of workshop
General welcome *by TNO, Aart de Geus, Netherlands*
Welcome on behalf of AIVC and ASIEPI project, *by Peter Wouters, BBRI, Belgium*
Energy performance regulations and innovative systems: lessons learned from the EU SAVE ASIEPI project *by Nicolas Heijmans, BBRI, Belgium*
Session 2: Market uptake of emerging technologies
Cool roofs: what are the possibilities and opportunities? What about challenges and difficulties for market uptake? - European Cool Roof Council, *by Mat Santamouris, NKUA and European Cool Roof Council, Greece*
Assessment of innovative technologies – role of modern identification techniques, *by Hans Bloem, JRC Ispra and Henrik Madsen, DTU, Denmark*
Medium and long-term trends in innovative ventilations and the role of national energy efficient targets for new buildings in their market uptake, *by Wouter Borsboom, TNO*
Market uptake of innovative facades - experiences and view of a facade manufacturer&contractor, *by Henk De Bleecker, Group R&D Manager of Permasteelisa Group*
Panel Discussion
Session: 3 Long term performance of energy-efficient buildings and systems
Commissioning for Comfort in the Netherlands, *by Henk C. Peitsman, TVVL, Dutch society for building services*
Quality of innovative systems: the role of technical approval schemes and successful examples, *by Peter Wouters, BBRI*
Long term performances of building airtightness: Importance and possibilities, *by Stefanie Rolfsmeier & Jörg Birkelbach*
Dutch experiences on long term performances of ventilation systems, *by Willem de Gids, TNO*
Session: 4 Energy-efficient communities and standards
A new approach to energy efficient communities - examples from IEA Annex 51, *Reinhard Jank*
City of the sun - Heerhugowaard (Netherlands)
Is there need for research on energy-efficient buildings ? *by Bruno Smets, Philips*
Role of standards, *by Jaap Hoogeling, Chairman of CEN/TC 371*
Session 5: Overview of instruments for stimulating market uptake
The role of NL Agency within innovations in the built environment, *by Wim Berns, NL Agency*
Regulations and financial incentives – barriers or drivers for market uptake of innovative systems? *Peter Wouters BBRI*
Panel discussion - Representatives from industry and market
Conclusions and next steps

Program of the workshop n°4

I E E S A V E A S I E P I

ASIEPI

Part C. Information Papers

on

The EPBD as support for market uptake for innovative systems

[European projects]

P132

18-11-2008

Nicolas Heijmans
Peter Wouters
Belgian Building Research Institute
Belgium

Per Heiselberg
Aalborg University
Denmark

More information can be found at the ASIEPI project website: *www.asiepi.eu*

Similar Information Papers on ASIEPI and/or other European projects can be found at the Buildings Platform website: *www.buildingsplatform.eu*

An overview of national trends related to innovative ventilation systems

This paper summarises the discussion related to innovative (ventilation) systems that took place at the AIVC workshop organised in Ghent, Belgium, in March 2008.

1 > Introduction

This paper summarises presentations and discussions that took place during the workshop entitled "Trends in national building ventilation markets and drivers for change" held in Ghent, Belgium, in March 2008 with a specific focus on innovative (ventilation) systems. Before this workshop, experts were asked to provide information regarding their national situation and the difficulties they experienced to improve the situation in terms of market penetration of innovative systems, indoor air quality and energy use requirements, and compliance check schemes. This has resulted in a set of Ventilation Information Papers published by the AIVC. This paper summarises the innovation issue.

2 > Definition of innovative systems

The word "innovation" is often used to promote new products. And indeed, the usual definition of innovation is "a new method, idea, product, etc" [11].

However, in the context of energy performance of buildings (EPB) regulations, and in particular in the context of IEE SAVE ASIEPI WP6 [22], ***innovative systems*** are defined as:

- systems which most probably give a better performance in terms of the energy performance of buildings than the usual systems and,
- whose performance cannot be assessed by the standard EPB calculation methods.

The discussions during the workshop have reflected these two aspects.

3 > Drivers and barriers for innovation in the ventilation industry

Based on the national contributions, the current drivers for innovation in the ventilation industry were identified. It appeared that some drivers were common to the residential and the non-residential ventilation markets, but some drivers were clearly different, and that three main driver types could be identified: the *Indoor Air Quality* aspects, the *thermal comfort* aspects and the *energy* aspects.

Directorate-General for Energy and Transport
EUROPEAN COMMISSION

Market / Driver type	Both residential and non residential	Residential ventilation market	Non-residential ventilation market
Indoor Air Quality	- Commissionning and compliance - Maintenance	- Higher client expectations - Increase in prevalence of asthma and allergies - Health and healthy materials	- Improved productivity
Thermal comfort		- Higher client expectations - Increased need for cooling	- Improved productivity - Increased need for cooling
Energy	- Increasing energy price - Holistic approach (EPBD)		

Historically, the energy aspects were maybe the first drivers for change. Due to the energy crisis, we moved from a situation where ventilation was provided by building leakages and/or window openings only to a situation were simple ventilation systems, like controlled natural ventilation or mechanical exhaust ventilation, were installed.

Definitions
In the context of EPB regulations, and in particular in the context of ASIEPI WP6, ***innovative systems*** are defined as:
- systems which most probably give a better performance in terms of the energy performance of buildings than the usual systems and,
- whose performance cannot be assessed by the standard EPB calculation methods.

Note: according to this definition, some systems may innovative in some countries and not in other ones.

In the context of EPB regulations, and in particular in the context of ASIEPI WP6, the ***principle of equivalence*** is defined as the procedure to assess the energy performance (in terms of the energy performance of buildings) of innovative systems.
Note: in some Member States, the principle of equivalence is not limited to EPB regulations.

Different technical solutions were identified to solve the energy issues:
- Reduction of the ventilation need by reducing the emission of pollutants. Finland is certainly a pioneer in this way with the development of a material labelling scheme; Japan also mentioned such a scheme.
- Reduction of the air flow rate, for instance by demand controlled ventilation, or by increasing the ventilation effectiveness.
- Reduction of the heating demand, by using heat recovery, solar walls and ground heat exchangers.
- Reduction of the cooling demand, by using mechanical free cooling and intensive natural night ventilation.
- Reduction of electricity consumption for air transport, by using high efficiency fans, low pressure systems, decentralised systems.

According to the presentations given at the workshop, hybrid ventilation is considered as a potential innovative solution in several countries, including Brazil, Japan, Korea, Poland, even if there is currently a lack of adequate technical solutions (as mentioned in the Brazilian presentation) or if further researches are still necessary.

The role of standards and regulations as barriers or as drivers for change has been highlighted in several contributions. Examples:
- In the UK presentation, it was mentioned that regulations are the main driver for changes.
- Demand controlled ventilation could be a way to save energy without deteriorating the IAQ, but is not allowed in residential buildings in Denmark at the present time.
- In the UK and Finland presentations, it was considered that the ventilation regulations are good drivers for innovative ventilation systems, as they are performance based, as most requirements are related to indoor climate targets and fewer requirements for system specific issues.

- At the same time, the Finnish speaker considers that the Finnish EPB regulation was not a driver until 2007, because it was only based on U-values and not on a holistic approach, as requested in the EU by the EPBD [33].
- In contradiction, Norway considers that the Norwegian EPB regulation is a major driver, as it makes modern energy efficient ventilation compulsory in all type of buildings.
- In any case, the EPB regulation must have a framework to assess the energy performance of innovative ventilation systems, otherwise it becomes at least a lack of driver, or even a barrier. For instance, increased ventilation effectiveness could be a way to save energy without reducing IAQ, but the Belgian EPB regulation does not take this into consideration. The system is not forbidden by the regulation, but is clearly not supported. (See also § 4.)

4 > Assessment of innovative ventilation systems in the framework of the national EPB regulations

4.1 > Situation in some Member States of the European Union

This issue was addressed in the contributions of Belgium, Denmark, France, Germany, Netherlands and UK [44]. To highlight some characteristics of the framework for the assessment of innovative systems, we will compare the situation in Netherlands, Belgium, France, Denmark and Portugal.

- In The Netherlands, the framework is known as the "Principle of Equivalence". It exists for more than 10 years and is included in the Dutch building code; it can be applied not only for the assessment of innovative (ventilation) systems in the framework of the EPB regulation, but to any requirement of the building code. The Dutch Principle of Equivalence is not assessed at national level since the equivalence is evaluated at municipal level. The study can be done by anyone.
- The Dutch experience has strongly influenced the way Belgium[1] has implemented its own Principle of Equivalence. It was decided to have a centralised approach, at least for products or systems, as the study is carried out by a group of experts nominated by the Belgian Union for the technical approval in the construction (BUtgb – UBAtc) and is evaluated by the Regions.
- In France, the situation is in between those of Belgium and the Netherlands, as the study can be done by anyone but its evaluation is done by a central body, namely the Minister for Ecology, Sustainable Development and Spatial Planning.
- In Denmark, the situation is different. There is no framework to assess the energy performance of innovative system, but the standard procedures themselves can be gradually and quite quickly improved, with the direct support of the industry.
- In Portugal, the situation is once again different. Portugal claims not having a need for a Principle of Equivalence framework, because the energy performance of a building has not to be calculated according to a published comprehensive calculation procedure but, at the design stage, it has to be proved with dynamic simulations and, after a few years, it has to be compared to the actual energy consumption.

Those very different situations show that the need for a Principle of Equivalence scheme and the way to implement it are strongly influenced by the way the EPB regulation itself is implemented. The fact to have a specific calculation procedures that the assessor has to follow in all details

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[1] Belgium is a federal state, composed of 3 Regions. The EPBD implementation is under the responsibility of the Regions.

(as it is the case in Belgium, Denmark, France, Netherlands) or not (as in Portugal), and the fact that this calculation procedures can't be adapted quickly (as in Belgium, France, Netherlands) or can be (as in Denmark) will deeply influence the need for a Principle of Equivalence.

When a Principle of Equivalence is needed, it can be implemented very differently. Each solution has its own advantages and drawbacks, some of them were identified in the framework of the European ASIEPI project.

- The fact that the procedure was quite open in Netherlands (anyone can make its own evaluation according to its own methodology) has as main advantage the rapidity of the system and the fact that the cost may be lower, but at the same time leads to a lack of confidence in the Principle of Equivalence system (as all municipalities do not have the resources to evaluate the studies and as different municipalities may come to different assessments) that sometimes reduce the confidence in the EPB regulation itself.
- In opposition, the fact that the procedure is very centralised in Belgium may potentially lead to a longer time for assessing new systems but increase the confidence of the various stakeholders.
- According to the Finnish, German and Dutch participants to ASIEPI, the equivalence studies should not be evaluated at municipal level, whereas the Belgian and French participants estimate that the evaluation of the studies at national level is an advantage.

4.2 > About the IEE SAVE ASIEPI project

As seen here above, the framework for the assessment of innovative systems differs in each Member State, from both the technical and the administrative points of view. The IEE SAVE ASIEPI project is expected to give support to the Member States regarding the setting up or improvement of such a framework; this might lead to more harmonisation.

The project is also addressing other technical aspects of the EPBD implementation, as the evaluation of the thermal bridges, the building airtightness, the duct airtightness, and the summer comfort issue. Finally, ASIEPI intends to make a cross comparison of the national energy requirements across EU.

5 > Conclusions

The workshop has shown that there is an increased interest in ventilation systems that deliver good IAQ and good thermal comfort, but that use less energy. Various trends to meet this expectation were identified, i.e. demand controlled ventilation and hybrid ventilation. However, a potential barrier to the application of such system is the EPB regulations, if they do not offer a possibility to evaluate their energy savings potential. The discussions during the workshop have shown that various frameworks for the assessment of innovative systems have been implemented in various countries. The advantages and drawbacks of some of them are summarised in this paper.

6 > References

1. Compact Oxford English Dictionary, Oxford University Press, 2008 (http://www.askoxford.com).
2. IEE SAVE ASIEPI project, http://www.asiepi.eu.
3. EPBD (2002). Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings, Official Journal of the European Communities, 04.01.2003.
4. Ventilation Information Papers 17 to 29, published on http://www.aivc.org.

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Assessment of innovative systems in the context of EPBD regulations

As the Energy Performance of Buildings (EPB) regulations cannot cover all possible kind of new technologies, Member States have to develop "principle of equivalence" procedures, in order to allow the assessment of systems not covered by the standard calculation procedures. This information paper discusses the overall context and describes the approaches used in several countries.

1 > Introduction

The implementation of the European Energy Performance of Buildings Directive (EPBD) [1] requires all EU Member States to develop calculation procedures for the determination of the energy performance of buildings. The EPBD annex specifies the aspects which have to be included, i.e. thermal characteristics of the building, heating installation and hot water supply, ventilation, air-conditioning installation, passive solar systems and solar protection and indoor climatic conditions.

In practice, it is not possible to develop in the framework of energy performance regulations calculation methods that cover all possible kind of systems. Therefore, in order to prevent the EPB regulations to constitute barriers to innovation, it seems necessary that Member States include in their legislation the possibility of alternative ways to assess those systems not covered by the standard calculation procedures. This approach is usually called the "principle of equivalence". In some countries, the principle of equivalence is often relevant/necessary for systems with time variable properties, e.g. demand controlled ventilation, double ventilated façades, etc.

Experience in e.g. France, Germany and the Netherlands has shown that a proper handling of innovative systems in the national EPB regulation often leads to a market transformation (e.g. humidity controlled ventilation is widely spread in France, with more than 1.5 million dwellings equipped, whereas the in other EU countries, the market is marginal). Experience in the Netherlands also has shown that various difficulties can arise related to the principle of equivalence, illustrating that the way to handle equivalence is not so evident.

This paper first presents a discussion of the overall context, followed by a description of the approaches used in several countries. Then, a brief summary of related international projects is given.

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Definitions
In the context of EPB regulations, and in particular in the context of ASIEPI WP6, ***innovative systems*** are defined as:

1. systems which most probably give a better performance in terms of the energy performance of buildings than the common systems and,
2. the performance of which cannot be assessed by the standard EPB calculation methods.

Note: according to this definition, some systems may be innovative in some countries and not in others.

In the context of EPB regulations, and in particular in the context of ASIEPI WP6, the ***principle of equivalence*** is defined as the procedure to assess the energy performance (in terms of the energy performance of buildings) of innovative systems.
Note: in some Member States, the principle of equivalence is not limited to EPB regulations.

The Energy Performance of Buildings Directive

The objective of this Directive is to promote the improvement of the energy performance of buildings, taking into account outdoor climatic and local conditions, as well as indoor climate requirements and cost-effectiveness.

This Directive lays down requirements as regards:

- the general framework for a methodology of calculation of the integrated energy performance of buildings;
- the application of minimum requirements on the energy performance of new buildings;
- the application of minimum requirements on the energy performance of large existing buildings that are subject to major renovation;
- energy certification of buildings; and
- regular inspection of boilers and of air-conditioning systems in buildings and in addition an assessment of the heating installations in which the boilers are more than 15 years old.

2 > Assessment of innovative systems in France, The Netherlands, Belgium and Germany

2.1 > The Netherlands

The Netherlands have a long experience of the principle of equivalence; its application is foreseen in the Dutch Building Decree. Note that in The Netherlands the principle may be applied for all aspects related to construction work, and not only those related to EPB regulation.

The equivalence study has to be evaluated by the municipality where the construction work will take place. Of course, all municipalities do not have the same competences to evaluate such reports. Consequently, the same building with the same innovative system could possibly be accepted in one municipality and rejected in another one. Moreover, different approaches can be used for similar technologies. And in addition it happens that too optimistic evaluations of innovative products get approved by the municipalities. This is a direct consequence of the complexity of many of the equivalence studies and the fact that the procedure of the control of these studies does not contain a pool of experts somewhere in the process.

Anyone can make an analysis (as far as the report is accepted by the municipality).

The regulation does not specify anything about how an analysis must be carried out, and especially about the reliability of the assumptions that have to be made. Consequently, the principle of equivalence can be considered as a very open approach. Which in practice has been a huge stimulation for innovation, but also, as mentioned above, a source of confusion, misunderstanding and misuse. See also [2].

2.2 > France

For the assessment of the system not covered by regulation calculation (Th-CE), an application called Titre V for approval of the project with this system or for the calculation method concerning all buildings must be addressed to the Ministry for Ecology, Sustainable Development and Spatial Planning. It is accompanied by a case study and composed as described in annex V (Arrêté du 24 mai 2006). The technical study has to prove the respect of requirements.

2.3 > Belgium

In Belgium, the implementation of the EPBD is the responsibility of the three Regions (Flemish Region, Walloon Region, and Region of Brussels Capital).

In the three Regions, a Decree (or Ordinance), voted by the Parliament, gives the general framework for the EPBD implementation. The specific procedures, including the calculation methods and the requirements, have to be fixed by each regional government. The Decree (or Ordinance) also gives the government the possibility to define the procedure for the assessment of innovative systems.

This specific procedure is currently defined in the Flemish Region only. Firstly, the manufacturer of an innovative system has to apply for an "ATG-E", which can be seen as a specific Technical Approval limited to energetic aspects, to the *Belgian Union for the technical approval in the construction* (BUtgb/Ubatc). Secondly, the manufacturer must provide this ATG-E and a technical dossier to the Flemish Region, which decides how to make the link between the ATG-E and the regional EPB regulation. If this system is also followed by the two other Regions, it will allow the manufacturer to make only one principle of equivalence study for the three Regions.

2.4 > Germany

The German energy decree for the implementation of the EPBD from 2006 defines the two energy performance assessment methods that have to be used for calculating the EP certificate values. For the residential buildings the two applied standards (DIN 4108-6 and DIN 4701-10) are simpler than the one for the non-residential buildings. The new German energy performance assessment standard for non-residential buildings (DIN V 18599) is a detailed calculation method, which includes already calculation procedures for many systems such as double skin façades, combined heat and power systems, etc.

In the case where a planned building includes technologies or strategies for which the assessment using state-of-the-art methods is impossible, it is defined in paragraph 23 of the energy decree [3] that the systems have to be verified by alternative methods. The used method has to be accepted by the local authority. There are no requirements for the alternative methods defined: in practice, detailed simulation tools are then most often used to calculate the characteristic performance values.

The principle of using alternative methods is utilised in Germany since many years. It is for example also included in the energy saving decree of 1995.

3 > International research projects dealing with assessment of innovative systems

3.1 > IEA ECBCS Annex 35 Hybvent project

Annex 35 of the International Energy Agency's (IEA) Implementing Agreement on Energy Conservation in Buildings and Communities (ECBCS *www.ecbcs.org*) was entitled Hybvent - Hybrid ventilation in new and retrofitted office buildings (1998-2002). One of tasks dealt with the issue of assessing hybrid ventilation systems in the context of energy performance regulations. The final report [2] can be downloaded from *http://hybvent.civil.auc.dk*, or from the Buildings Platform website (*www.buildingsplatform.eu*).

3.2 > SAVE ENPER Project

The ENPER project (2001-2003) was a SAVE project in which various aspects of energy performance regulations were studied. One of the work packages was the assessment of innovative systems. It built further on the

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work of the IEA Hybvent project. The final report [4] can be downloaded from *www.enper.org*, or from the Buildings Platform website (*www.buildingsplatform.eu*).

3.3 > EC RESHYVENT project

The RESHYVENT project (2002 – 2004) was an EC funded project part of the 5th Framework Programme and focused on the use of hybrid ventilation systems for residential buildings. In this project, the assessment of innovative systems was evaluated whereby a Monte-Carlo based analysis method has been worked out and implemented on a few theoretical cases. The final report [5] can be downloaded the buildingsplatform website (*www.buildingsplatform.eu*).

3.4 > SAVE ASIEPI project

The SAVE ASIEPI (ASsessment and Improvement of the EPBD Impact - *www.asiepi.eu*) project, submitted to the SAVE call 2006, has started in October 2007. One of the work packages is dedicated to innovative systems (WP6 - The EPBD as support for market uptake for innovative systems).

This work package is led by BBRI. Its first step is to make a "State-Of-The-Art analysis" of the current situation in the different Member States (MS) participating in the project (as partners or as subcontractors). Attention will also be given to knowledge exchange between MS which have experience with handling of innovations in the national EPB regulations, like France, Netherlands, Sweden and Norway, because the lessons learned from this subtask are interesting for all member states. In the ASIEPI project, the following points will be analysed:

- What is the legal framework in each MS (if any)?
- What kind of systems are considered as innovative (according the definition above) in each MS?
- Who is allowed to make the performance assessment? Are there assessment and specific quality control schemes? Is there a role for organisations involved in technical approval of systems? What problems concerning performance assessment are found in practice? Can solutions be found in other countries? To what extent can results obtained in one country be relevant for other countries?
- Financial aspects, e.g. who is paying the study?
- How does it work in practice (good and bad experiences from industry)? How many studies have been carried out so far? What are the conditions for a successful implementation? Why do some barriers occur in one country and not in another, what lessons can MS learn from each other?
- What is the impact of the procedure on the market for innovative systems?

Based on the information collected, a structuring of the various approaches will be made. Moreover, guidelines (with pro's and con's for the various approaches) will be made available allowing MS to accelerate the realisation of a qualitative environment for the assessment of innovative systems in EPBD context. These guidelines will cover legal and technical issues. However, it is not the intention to develop new methodologies to assess the performance of innovative systems, but limit the work on reporting interesting technical approaches.

The expected outcomes of this work package are:

- Short-term outcome: create/increase awareness of policy makers and industry about the potential barriers that their EPB regulations could be for innovative systems, and providing them guidelines.
- Mid-term outcome: clear away barriers for innovative systems, due to improved legal frameworks.
- Long-term outcome (after the project): faster progress towards improved energy efficiency in the building stock in the EU, healthier, fairer and more transparent market for the development of innovative

technologies.

4 > Conclusions

It is expected that the implementation of the EPBD by the EU Member States will substantially contribute to the improvement of the energy efficiency of buildings. As such, it can also be a strong driver for the market uptake of innovative systems.

However, it requires the availability of an appropriate framework for the assessment of such innovative systems. This approach, often called the "principle of equivalence", will vary from country to country, from both a technical and an administrative point of view.

The SAVE ASIEPI project is expected to give support to the EU Member States regarding the setting up or improving of such a framework; which in turn might lead to more harmonisation.

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5 > References

1. EPBD (2002). Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings, Official Journal of the European Communities, 04.01.2003.
2. Wouters P., Heijmans N., De Gids W., Van der Aa A., Guarracino G., Aggerholm S. (2000). Performance assessment of advanced ventilation systems in the framework of energy and IAQ regulations - Critical issues, challenges and recommendations, HYBVENT technical report n°9.
3. Bundesregierung: Verordnung über energiesparenden Wärmeschutz und energiesparende Anlagentechnik bei Gebäuden. (Energieeinsparverordnung – EnEV). BGBL 2007, Teil 1, S. 1519 – 1563, published 24.07.2006.
4. ENPER (2004). Energy Performance of Buildings Assessment of innovative technologies. ENPER report B2.
5. Wouters P., Heijmans N., Loncour X. (editors) (2004). Outline for a general framework for the assessment of innovative ventilation systems. RESHYVENT working report n°WP4 D4.4.

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More information can be found at the ASIEPI project website: *www.asiepi.eu*

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Stimulating innovation with EPBD
What countries can learn from each other

European countries deal with innovations in the context of the Energy Performance of Building Directive (EPBD) in different ways. These different frameworks cannot be seen separately from other national procedures and systems. All of these systems have their advantages and disadvantages. And although the balance between the pros and cons depends on the national context, countries can learn from each other. Therefore, this Information Paper elaborates on various national frameworks, and in a following Information Paper [1] some key points of attention will be identified.

1 > Introduction

To be able to achieve national and international goals on energy saving in the building environment, it is inevitable that we need innovation in building construction and systems. Therefore it is of the utmost importance that legislation based on the Energy performance of Buildings Directive (EPBD) stimulates, or at least not limits, innovations.

The EPBD requires that all Member States of the EU define an Energy Performance (EP) method and corresponding EP requirement levels. The EPBD prescribes the framework of the EP methods. On a national level the EP methods are developed taking into account the national Building Code, building practice, compliance and control methods and standards as well as national behavioural and cultural aspects.

Consequently, what a country requires to overcome barriers for innovation will differ. However, that doesn't alter the fact that countries can learn from each other when they are aware of the possibilities and the advantages and disadvantages of the various options.

2 > What is the problem with innovation within the framework of the EPBD?

In a first report on this subject [2] a manufacturer was cited who described the problem of innovations within the framework of the EPBD for the industry very clearly. When certain products are not included in the national EP calculation procedure, it is a barrier to their market uptake, since the focus on energy efficiency chiefly starts and finishes with fulfilling the EP requirements. Some countries, like Portugal and to a lesser extent Denmark, have a very open procedure, where no or only limited additional frameworks are needed for innovative products to be take into account in the EP calculations. In most countries however, the EP calculations are more rigid and additional frameworks are needed to be able to take into account products outside the scope of the EP calculations.

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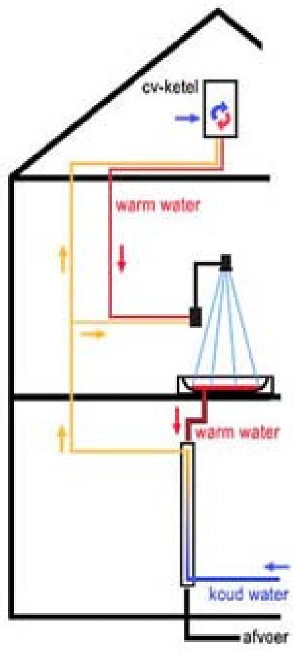
Perhaps it could be concluded that having a more open method is the solution to avoid barriers for innovation. In some countries this might be true, but in many situations an open and flexible method has several disadvantages too. These disadvantages are comparable to the disadvantages which some of the additional equivalence framework has, as will be shown below.



Example of an innovative system: heat recovery from shower water (source drawing: [5])

Complex technology

The definition often used for innovative systems or technologies in the context of the EP regulation is:

- systems or technologies that, in most cases, improve the building's energy performance, and
- whose performance cannot be assessed by the standard EP calculation procedure in a particular country.

This definition is one of the main issues related to the assessment of innovations in the context of the EPBD: How can we ensure that a particular innovation really improves, in most cases, the building's energy performance? The procedure on how to assess an innovation is rarely standard; we often deal with complex technology of which only experts can make a proper assessment, and only experts can check whether the assessment was prepared correctly. In this context, a method taking into account innovations in a national method is one thing, but making sure innovations are handled properly, case by case in practice, is a different story.

A second, even more important issue, is that it is important to realise that developing a calculation method of a physical principal is not just a scientific task. An energy calculation means making choices, for instance related to indoor and outdoor climate, user behaviour or default values to simplify more complex models. These choices are often arbitrary (between boundaries), but can influence the outcome of the calculation, sometimes hugely. Different choices can favour different interest groups. If such an interest group performs the equivalence study, it is not difficult to imagine what happens with these influential arbitrary choices. And even when interest groups hire an independent expert, you can imagine the discussion this still can raise with the competition, since arbitrary choices are always debatable.

It will be demonstrated that countries deal differently with this issue.

3 > Country experiences

The following countries that participated in this study have a legal framework to assess the energy performance of innovative systems: Netherlands, Belgium, France, Germany, Finland, Spain, Norway and Denmark. The annex of the report [3] summarises these legal frameworks and illustrates them with an example. Every participant in this study was asked to describe advantages and disadvantages of their national method. These are given in [3].

Roughly speaking there are 3 ways for taking innovations into account in the EPBD:

1. Countries which have an **open method**: most innovations can be taken into account in the method itself (e.g. Denmark and Portugal)
2. Countries which have a **light framework** for equivalence, based on equivalence studies made by the market or by experts, with local control (E.g. Netherlands and Finland)
3. Countries which have a **heavy framework** for equivalence, based on equivalence studies made by a national committee with national control (E.g. Belgium)

Remarks:
The information provided is mostly based on personal experiences of the partners involved in the ASIEPI project and therefore does not necessarily reflect the official position of a country.
The list of MS is based on the information collected within the surveys, but is not intended to be exhaustive.
To simplify, Norway is including in the list of Member States, even if it is not a Member of the European Union.

The world is not black and white, and there are shades of grey within these 3 ways, but globally all national frameworks of the countries interviewed could be placed in one of these groups.

From the point of view of the industry developing the innovation, it could be concluded that the 3 ways described above increase in the strength of the barrier to innovation. The effort, time and/or money involved and the number of procedures increases with each step. On the other hand it could be argued that the first 2 methods can become a barrier to innovation if the actual performance of the innovative product appears to be less than the claimed performance in the equivalence study, due to the poor quality of the study and/or a lack of control. How this can happen will be explained.

Real performance versus claimed performance

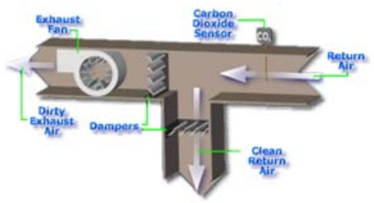
As described in paragraph 2, the main issue related to the calculation of the effect of innovative systems is the fact that the development of the calculation method often involves complex physics and partly arbitrary choices. The complexity of the physics makes it hard to develop a proper methodology and makes it difficult to check whether the expert has done a proper job. In practice this can lead to false claims. The EP-level which is claimed, is not achieved in practice due to an inferior performance of the innovation. The consequence of this is clearly seen in practice in some countries. If the actual energy conservation of an innovation is less than claimed, the energy goals will not be reached. In addition, innovations and other products which could have achieved the energy goals are not fully taken advantage of the general support for innovative products, and even the EP-method as a whole, is weakened. Clearly, uncertainty about the actual performance of the innovations is a barrier to innovation as well.

Extra effort, time and costs to make an equivalence study can be a barrier to innovation, but what can also become a barrier to innovation as well is when the actual performance of a product is less than the claimed performance in the equivalence study.

The partly arbitrary choices e.g. user behaviour aspects, which need to be taken into account when a calculation method for innovations is developed, increase this effect. These choices can have a large effect on the energy use of the building and can favour the interest of one market party over another.

> *It could be argued that, for instance, user behaviour aspects are just a matter of statistics. For instance in Norway they state that user behaviour can only be taken into account based on statistical studies. The problem is that of the many user behavioural aspects no statistical figures are known. Especially when you realise that user behaviour is influenced by the technology used: available statistical studies usually do not go beyond the average situation and user behaviour due to the innovation is definitely unknown (especially the user – technology interaction components), since the innovation has not been used in practice. If user behaviour is not fixed when no statistics are known, as in Norway, these choices will be partly arbitrary choices. On the other hand: fixing the user behaviour can be undesirable, since occasionally it is the effect of user behaviour which the innovation tries to improve (e.g. by automatic control).*

In an open method these choices are made by an expert who produces the EP calculation. This is also the case in countries with a light framework, where experts, hired by the market, perform the equivalence studies. In both situations the local authorities might check the studies, but even if they have enough expertise, the question is: is this procedure valid for making the right policy choices? Perhaps it is, especially when the forces in the market are not very strong. But perhaps it is not. A clear example of the latter is the Netherlands, where there is strong competition between



Example of an innovation where user behaviour is partly overruled by automation: in this case demand controlled ventilation with CO_2-sensor (source drawing: [6])

industries related to the EP building requirements. Many companies try to convince decision makers that with their product can more effectively meet the EP requirements. So for them it is a marketing tool to show how well their innovations perform in the EP-calculations. In this environment it is less likely to achieve objective influential arbitrary options.

Global technical framework

To face these kinds of problems, many countries have at least a global technical framework for equivalence studies in which states that assumptions made in the equivalence study should be similar to the assumptions made in the national EP-method. Some countries go a step further and state that fixed values in the national EP method cannot be changed in equivalence studies. For example: if the amount of ventilation is a fixed value, an innovation which reduces the amount of ventilation needed in a room by introducing a smart detection system cannot be properly rated. This is a protection against unclear claims, but a barrier to systems which really can make a difference. Again the question arises how do we stimulate innovations but protect against faulty claims?

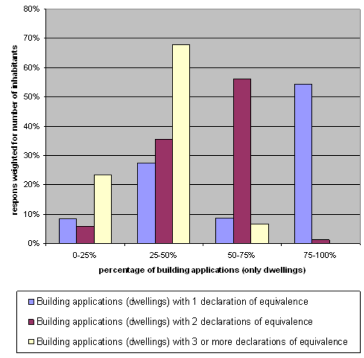
In some countries the national regulations do not allow values to be fixed. Although also in these countries the general rule is that assumptions made in the national EP-method should be used in the equivalence study, there is always the possibility to show equivalence related to one of these assumptions. In these countries effective guidance, specially related to user behavioural aspects is extra important, since even these figures can never be totally prescribed.

Product improvement

Some countries do not differentiate between product improvement and new products. This could be due to the fact that the national regulations forbid excluding any product from an equivalence study. Other countries reduce the need for equivalence studies by having distinct procedures for innovations and product improvements. For instance in France and Germany equivalence studies are only used for innovations, while improvements of existing products are measured and rated via qualified organizations often following national or EN standards. A weak part of this is the ‘product attesting’ (‘kwaliteitsverklaring’ in Dutch) used in the Netherlands. Improvements of existing products can be declared via NEN (Dutch) or EN standards if this is included in the national EP method for the specific product type. The advantage is that this method is fixed so no ambiguous decisions can be made by the expert. This also applies to the German and French systems. The extra advantage of the German and French procedure is that the organization doing the study is accredited, while in the Netherlands, anyone can do the study. Since these studies can be complex, the quality can be debated and it can be difficult to judge the quality and distinguish between real improvements and faulty claims, especially for the local authority. In France the results of the accredited studies are published on public databases, making the data accessible for anyone making an EP calculation. With this the quality control the studies become much easier and the barrier to using the improved product becomes even lower.

Upgrade of national methods

An interesting difference between countries is the way they deal with equivalence studies related to the upgrade of the national EP method. Many countries upgrade the national EP method as soon as the equivalence study is ready (or at least as soon as the national regulations allow this procedure to happen), while in other countries it is less evident that the national EP method is upgraded. Of course there is a relation with the thoroughness of the equivalence procedure. Countries like Belgium who have a heavy equivalence procedure and can be quite sure of the quality of the study use it directly to upgrade the method, while in the Netherlands this automatic upgrade is far from evident, but the quality of the study is more debatable. But this is another argument to withhold this automatic upgrade and that is that these countries want to wait and see how valid the claims of the innovations are in reality. History has shown that several innovations which perform well in theory, fail in practice due to numerous, often non-technical barriers. Some countries therefore choose only to integrate a new product in the national EP method after it has been used regularly in buildings and it proves to be an actual energy efficient product.



Graph shows the number of equivalence studies per application for a Building Permits in the Netherlands in the period 2006-2009.

The graph shows that most applications contain one or more equivalence studies: in the Netherlands using equivalence with a Building Permit request is not an exception, it is the rule. (Source: [7])

France has introduced an interesting **two-stage procedure**:

1. An equivalence study can be performed for one building. This study is not valid for other buildings. It can be made by anybody, but it is checked by a national committee of experts enforced by the government. The checking procedure is relatively easy and takes only one month.
2. An alternative is to do an equivalence study for a specific product. In that situation the checking procedure, again by a national committee of experts enforced by the government, is much more stringent and takes six months. But in this case the study is published as a statute of law and becomes part of the French regulations.

The advantage of this system is that there is a relatively easy version of the equivalence procedure in the early stage of a new product. allowing time to test the product in practice without major barriers. Once the product has been proven in practice, and maybe even improved, the more stringent procedure follows and the product becomes part of the national method.

Who pays for the equivalence studies?

Who pays for the studies differs between countries. Some explicitly claim that the manufacturer of an innovation cannot be blamed for the fact that his product is not accepted as a national method and the equivalence study therefore should be paid for by the government. Other countries have the opinion that it is the task of a manufacturer to prove the feasibility and efficiency of their new product. If the product can reduce the EP level significantly, this will be a selling point for the product, so these countries argue that it is logical that the manufacturer pays for the study.

It is important to realise here is that the number of equivalence studies carried out in a country can differ largely and that this number influences the consideration of the pros and cons of a framework for equivalence. For instance, in Belgium recently only a few equivalence studies have been performed, in the Netherlands around three hundred different equivalence studies are currently used within Building Permit requests to lower the EP level. One can imagine that the time and costs involved in the control of the studies surge when hundreds of studies are involved.

Boundaries of the national EP method

A final distinction between national EP methods under discussion is the fact that not all EP methods incorporate similar energy utilities in buildings. For instance Norway only evaluates the energy demand of a building, but no systems are taken into account. Therefore in Norway system innovations cannot be part of an equivalence study simply because it does not take everything into account. In many countries products like dishwashers and washing machines with ‘hot-fill’ (the machine is filled with hot water from the domestic hot water boiler instead of cold water) cannot be taken into account since these products are not 'building bound'. On the other hand, these products can only be used gas is supplied to the building, which in itself is a building bound measure. Until now, if a manufacturer of these products wants his products rated and even if he proves the measure to be effective, he will not succeed in these countries.

4 > Conclusions from country experiences

It is clear that there are many ways to deal with innovations in the context of the EPBD, all of which have their own pros and cons. Often there are logical explanations behind the differences we see in the European countries.

The differences are partly due to differences in national EP methods themselves. For instance: Denmark has a very open EP method, where many innovative systems can be taken into account. Therefore the need for a legal framework is less than in countries with more strict EP methods, resulting in a different and lighter legal framework.

National legislation is an important parameter which influences the possible framework for innovation. For instance: some countries limit the number of components and systems which can use the principle of equivalence by restricting the definition of innovative systems (e.g. France and Germany). In other countries national legislation does not allow such restrictions and allows that all systems can claim an improved performance by using equivalence, if the manufacturer finds the EP method too conservative for his product (e.g. the Netherlands and Finland).

Also the way compliance and control of the national EP method is handled in a county influences the legal framework for innovative systems. If compliance is high without the need for firm control, the need for a strict legal system for innovative systems might be less. Belgium is an example where it worked in reverse, where compliance in the past proved to be low, resulting in the need for a strict procedure now.

It has already been seen (see IP "Synthesis report: Approaches and possible bottlenecks for compliance and control of regulations" by B. Poel [4]) that cultural aspects related to the interaction between society and government influence the compliance and control of the national EP method in a country. Poel makes obvious in his paper that the relationship between citizens and authorities depends on values that vary from country to country. In some countries a very strict enforcement is the common approach, while in other countries the authorities can apply alternative control schemes partly based on self regulation. This will also influence the framework for innovative systems in these countries. A very open method might work in one country but not in another.

This also depends on the market interest, which apparently differs in different countries. For example, the EP requirement levels in the Netherlands are very strict and the urge to claim better performance of products is high; much higher than in various other countries. Combined with the fact that a claim for better performance is possible by Law without restriction, the amount of claims of the principle of equivalence is very high. The framework for innovation must be able to handle this large number of claims.

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We have seen that there are various barriers for innovation:

- heavy procedures which take a lot of effort, time and money can be a huge barrier,
- but also bad quality of equivalence studies can harm the support of innovations in general or even the support of the EP method as a whole. When people see that, due to national legislation, new products are used which claim energy savings, but do not do so in practice, people will not understand this. And since it is difficult for a layman to distinguish between good and bad it is not surprising that they lose confidence in more than the specific products themselves.

These barriers result in main issues that the equivalence procedure needs to deal with:
- how to assure the quality of the assessment of complex techniques
- how to deal with influential and partly arbitrary choices required by the method, such as like user aspects
- how to balance the effort, time and cost aspects of these two issues.

Where some countries trust independent experts in the field and a relative light control system on local level, others introduce a heavy control system, using a national committee of experts. It is obvious that without a national committee comprehensive rules are needed to deal with aspects such as user behaviour. Simply fixing these values might not always be satisfactory, and statistical values often might be scarce.

Explicit alternative routes for product improvements might simplify the problem, as might the two step approach used in France where a light procedure can be used in the early stages of the development of an innovation and a more strict procedure after the innovation has proved itself.

It is clear that there is no readymade solution for the issues related to equivalence, but it is clear that countries can learn from each other's experiences.

5 > References

1. Heijmans N., Wouters P., Caillou S., Stimulating innovation with EPBD - Key points of attention for Member States, Information Paper P195, 2010.
2. EPBD (2002). Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings, Official Journal of the European Communities, 04.01.2003.
3. M. Spiekman, Heijmans N., Wouters P., Caillou S., Stimulating innovation with EPBD - What countries can learn from each other, ASIEPI project, 2010. *http://www.asiepi.eu/fileadmin/files/WP6/ASIEPI-WP6-Report2.pdf*
4. B. Poel, Synthesis report: approaches and possible bottlenecks for compliance and control of regulations, ASIEPI project, Information Paper P178, 2010. *http://www.asiepi.eu/wp-3-compliance-and-control/workshop.html*
5. *http://www.dutchsolarsystems.com*
6. *http://www.bsdsolutions.com*
7. T.J. Haartsen, Climatic Design Consult, presentation on ASIEPI web event on February 3 2010, ‘Experience with application of principle of equivalence in NL’, *http://www.asiepi.eu/wp-6-innovative-systems/web-events.html*

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Stimulating innovation with EPBD

Key points of attention for Member States

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Remarks:
The information provided is mostly based on the personal experiences of the partners involved in the ASIEPI project and therefore does not necessarily reflect the official position of a country.
The list of MS is based on the information collected within the surveys, but is not intended to be exhaustive.
To simplify, Norway is included in the list of Member States, although it is not a Member of the European Union.

European countries deal with innovations in the context of the European Performance of Building Directive (EPBD) in different ways. These different frameworks cannot be seen separately from other national procedures and systems. All of these systems have their advantages and disadvantages. And although the balance between the pros and cons depends on the national context, countries can learn from each other. Therefore, in a previous Information Paper [1] we elaborated on various national frameworks, and in this Information Paper some key points of attention will be identified.

1 > Introduction

The EPBD [2] is one of European Union's tools to reduce its energy consumption. New and innovative products, systems and technologies may help to achieve this final goal. It is therefore of primary importance that EPBD related regulations do not become barriers to innovation. For this reason, the issue of innovative systems has been addressed by ASIEPI.

The first report [3] gives an overview of the current situation regarding the assessment of innovative systems across the EU.

In a previous Information Paper [1], we have discussed the pros and cons of those national approaches. From this analysis, some key points of attention that could inspire Member States have been identified and will be discussed in this Information Paper.

2 > Key points of attention that could inspire Member States

As stated previously, how the "principle of equivalence" is implemented in a country depends on several national factors. Consequently, not all points of attention are applicable in all Member States.

EPB regulations should not be a barrier to innovation

Independently of the approach they have implemented, several Member States included in this analysis have reported as the main advantage that *"a principle of equivalence allows any product to get a chance to be taken into account, which is necessary for innovation to have an impact".*

Therefore...

> It is important that Member States explicitly foresee the possibility of assessing technologies not covered by the standard calculation procedure, so that their EPB regulations do not become a real barrier for innovation.

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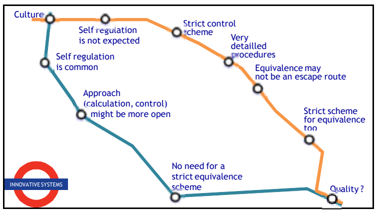
Several options are available to achieve this goal. However, in any case, the following points of attention should be considered.



The "principle of equivalence" approach should be implemented in accordance with the EPBD implementation.

The "principle of equivalence" approach should be considered as an extention of the standard calculation method

Therefore...

It is important that the "principle of equivalence" approach is implemented in accordance with the EPBD implementation.

For instance:

- the way the equivalence studies are carried out should be compatible with the way the standard calculation procedures was set up; this might require defining a so-called "technical framework", as discussed below
- if a Member States has implemented a strict control scheme, the "principle of equivalence" must not be an escape route to it, and it must also be kept under control
- ideally, it should be possible to introduce the results of the equivalence studies directly into the EP calculation tool(s), especially if the EP calculation tool has to be used to electronically report the EP calculations to the authorities. In this case, the EP calculation tool(s) must be designed in such a way that the result of the equivalence studies *can* be introduced.
- ...

In some MS, and for some innovative systems, it is possible to change the value of a specific parameter. In some MS and/or for some innovative systems, the calculations have to be done manually.

The Spanish approach is probably the most developed on this point: an equivalence study includes a piece of software that will be added to the standard calculation tool, as pre-processor or post-processor.

The use of the "principle of equivalence" approach should be the exception, not the rule

As the use of the "principle of equivalence" approach has it own disadvantages (see the country situations in [5]), it should be the exception, not the rule.

The possibility to quickly improve the standard calculation procedure depends on several factors, including the status of the document that specifies the procedure. It might be much more complex to update it quickly if it is published as a legal text that must be published in the national law gazette (such as a law, a Governmental order or Ministerial order) than if it is published as a document from a recognised institute.

By definition, the need to use the "principle of equivalence" approach is reduced if the standard calculation procedure includes as many technologies as possible. This is shown by the German calculation procedure, which includes several systems or technologies which are not included in many other Member States (see [4]). Consequently, the number of equivalence studies is reduced. To achieve this...

Member States should improve the EPB standard calculation procedures on a regular basis.

A specific approach to prove better performances exists in several Member States, as in Netherlands ("kwaliteitsverklaring" or "declaration of quality"), France ("agrément technique" or "technical agreement"), Germany, Belgium... It might require to be validated by a neutral body or not.

On the one hand, when the standard calculation procedures specify a fixed or a default value, it should also specify how to prove better performances than this default value (e.g. "the efficiency has to be measured according to EN 12345").

On the other hand, the existing equivalence studies could be used to identify the technologies that should be integrated in priority into the standard calculation procedures, and could be used as basis for procedure updates. (Technologies that appeared to save energy on paper only could possibly be integrated in such a way that their use is discouraged.)

Need for quality and management of complexity

One of the main disadvantages reported by every Member States where the studies can be performed by anyone (DE, DK, FI, FR, ES, NL) is that *"allowing anyone to make the equivalence study might lead to significant differences in the quality of the studies and also to studies of poor quality"*. This disadvantage can be further increased if the evaluation of the equivalence study is the responsibility of the municipalities.

Therefore...

Given the need for quality, and the complexity of a coherent assessment of innovative systems, it is important to have a framework that can ensure the quality of the studies.

One option would be to have a single body authorised to perform the studies, but this would not match the practice and/or the legal framework of many Member States and also has its own disadvantages (see [5]).

Fortunately, there are other options. Some are related to the way the studies must be carried out, others to the way the studies must be evaluated.

How should an equivalence study be carried out?

Some Member States (FR, NL) reported that "the assumptions of the equivalence study have to be similar to the assumptions of the standard calculation procedures". In France, where this also applies, it has been reported that, "as no technical example was presented [as annex of the Title V legislation], the first equivalence study was incomplete and unclear". However, once a template was provided, several studies were performed.

Moreover, this is only possible if the assumptions of the standard calculation procedures are published, which is probably not always the case, especially as by definition, innovative systems are systems not included in the standard calculation procedures.

Even if this may be a difficult task, **it might be useful that Member States that do not have a technical framework for the assessment of innovative systems analyse the necessity to define one, at least a minimal one...**

This technical framework could include the following elements: the type of calculations to be done, the characteristics of the buildings to be simulated, the occupancy pattern, the outdoor climatic conditions, the pollutant emissions, the internal gains...

This technical framework should be in line with the standard calculation procedure; if both have not been written by the same people, at least a close collaboration between them is required.

How to evaluate the studies?

In some Member States (DE, DK, FI, NL, NO), the alternative assessment is evaluated at municipal level. All those Member States have reported that having an assessment at municipal level is one of the main disadvantages of the system. To overcome this disadvantage, **a first option could be to approve the alternative assessment studies at a sufficiently high administrative level.** However, the implementation of this option can be difficult, as it might need a (more or less drastic) change in the general legal framework.

In The Netherlands, Vereniging Stadswerk (union for profesionals who work in the field of the physical living environment) may help the municipalities. See: www.senternovem.nl/epn/handhaving/index.asp and www.stadswerk.nl (in Dutch).

In Denmark, SBi publishes FAQ about the EP calculations. See http://www.sbi.dk/miljo-og-energi/energiberegning/anvisning-213-bygningers-energibehov/faq/typiske-sporgsmal-og-svar-faq/?searchterm=None (in Danish).

In The Netherlands, Vereniging Stadswerk has an unpublished database of accepted studies, available for its member www.stadswerk.nl.

Accepted studies are published in France and Belgium, where the evaluation is centralized.
France: www.rt-batiment.fr/batiments-neufs/reglementation-thermique-2005/titre-v-etude-des-cas-particuliers.html (7 studies so far)

Belgium, Flemish Region: www.energiesparen.be/epb/gelijkwaardigheid (5 studies so far)

In Spain, the documents under public consultation can be found on: http://www.mityc.es/energia/desarrollo/EficienciaEnergetica/CertificacionEnergetica/propuestaNuevosReconocidos/Paginas/nuevos.aspx.

A second option (if the first one is not possible) could be to have an appropriate support infrastructure for local authorities. For instance, it might be possible:

- to set up a consultative central body that would establishes a technical framework to perform the studies and criteria to accept them,
- to set up a consultative central body that would provide advice on the studies, on request of the municipalities,
- to publish the list of accepted studies.

A list of criteria for accepting studies would be helpful for both the municipalities and for the experts that make the studies, as obviously they would respect them if they knew that their studies would be evaluated at least on the points mentioned in the list.

It must be noted that the municipalities might be reluctant to publish to studies they have accepted, as they might have accepted poor quality studies. However, a centralised publication of accepted studies would not only help municipalities to take a decision, but it would also increase the transparency of the system and it would help the experts in charge of the EP calculations. This is compulsory in Spain.

Community support

In order to have the required community support, it might be useful to have a structured approach for interaction with the market.

For instance, some kind of public consultation might be organised if a technical framework is defined (just as public consultation has been organised for the standard calculation procedure...). This happens in Spain and Belgium.

Market information

It is important to pay attention to inform the market about the possibilities offered by the "principle of equivalence" and to provide information on approved systems.

As said previously, a centralised publication of accepted studies would increase the transparency of the system.

Delay and costs issue

It is important to pay attention to the costs for carrying out studies of equivalence and the time for assessment of innovative systems.

Some Member States reported that there could be a long delay (BE, DK, FR, ES), up to 6 months or 1 year. Only one Member State (NO) reported that the delay could be short. The fact that the system is open or closed seems not to be a determining factor for the delay (it is interesting to note that two Member States with a more open approach reported different delays for obtaining approval for a study).

Some Member States (BE, FI) reported that the cost might be "high" whereas some (NL, DE) reported that the cost might be "low". In one Member State (ES), the cost can be subsidised.

Article 3 of EPBD [2] states that:
Adoption of a methodology

Member States shall apply a methodology, at national or regional level, of calculation of the energy performance of buildings on the basis of the general framework set out in the Annex. Parts 1 and 2 of this framework shall be adapted to technical progress in accordance with the procedure referred to in Article 14(2), taking into account standards or norms applied in Member State legislation.

This methodology shall be set at national or regional level.

The energy performance of a building shall be expressed in a transparent manner and may include a CO_2 emission indicator.

Next EPBD revision

The issue of the assessment of innovative systems is not addressed in the EPBD. However...

> As the EPBD should act as a driver for innovation and surely not create barriers to innovation, this issue could be integrated in the next EPBD revision.

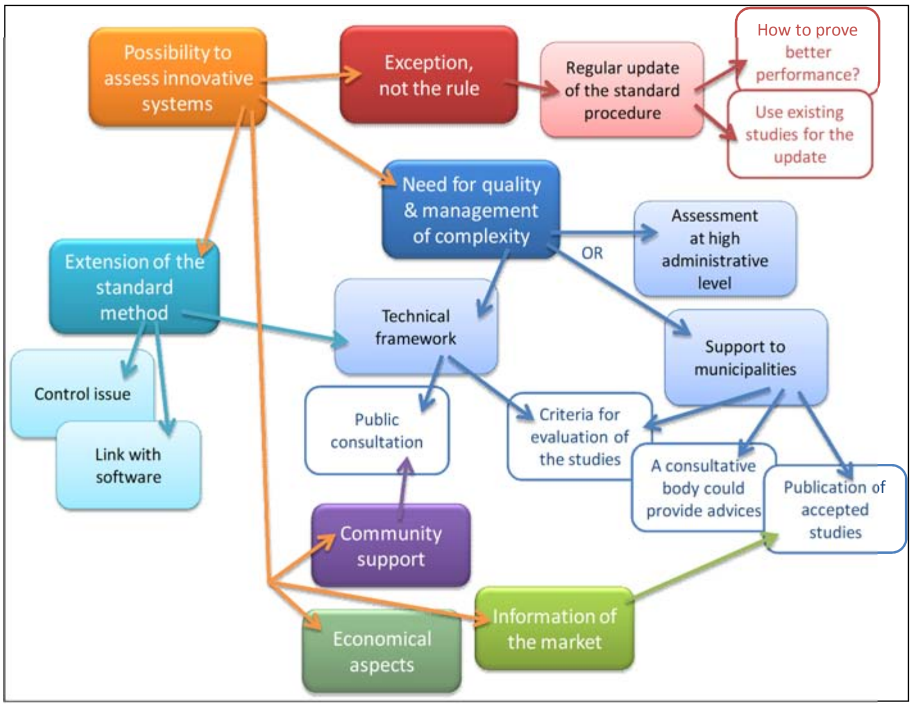
Article 3 could require Member States to have a legal framework for the assessment of building technologies that cannot be assessed by the national or regional calculation methodology. It must be noticed that such a legal framework, sometimes known as the "*Principle of Equivalence*", exists already in several Member States...

As a first suggestion, the following paragraph could be added to Article 3:

"In order to stimulate the market uptake of innovative technologies, Member States shall adopt a legal framework for an alternative assessment of building technologies that are not covered by the (national) calculation methodology set in accordance with the first subparagraph of this paragraph"

3 > Conclusions

From the various ways innovative systems are handled by the national EPB approaches, some key points of attention have been identified, as shown in the figure. These could inspire both the Member States that do not have a framework for the assessment of innovative systems and those that have one but would like to improve it.



The three main points of attention could be summarised as:

1. It is important that Member States explicitly foresee the possibility of assessing technologies not covered by the standard calculation procedure, so that their EPB regulation does not become a real barrier for innovation.

If a legal framework is defined, the extent of its application should be clearly defined. Is it applicable to systems not covered by the standard calculation procedure only? Is it also applicable to prove a better performance than the one included in the standard calculation procedure? Is there also an approach for "innovative buildings" (which are only valid for a single building)?

2. As this alternative assessment procedure should be the exception rather than the rule, different approaches should be combined (if legally possible) to limit its use. The standard calculation procedure should be updated on a regular basis (on basis of the equivalence studies) and should include the specifications to prove a better performance than the default value.

3. Given the need for quality and the complexity of a coherent assessment of innovative systems, it is important to have a framework that can ensure the quality of the studies. Several options have been identified to go in that direction: e.g. the assessment of the study should not be performed by the municipalities but by at sufficiently high administrative level, a technical framework could be defined,...

4 > References

1. Heijmans N., Wouters P., Caillou S., Stimulating innovation with EPBD - What countries can learn from each other, Information Paper P194, 2010.
2. EPBD (2002). Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings, Official Journal of the European Communities, 04.01.2003.
3. N. Heijmans, P. Wouters, Overview of national approaches for the assessment of innovative systems in the framework of the EPBD, ASIEPI project, 2009. *http://www.asiepi.eu/fileadmin/files/WP6/ASIEPI-WP6-Report1-Version1.pdf*.
4. ASIEPI WP6 - The EPBD as support for market uptake for innovative systems - "State-Of-The-Art" analysis - Questionnaire to ASIEPI partners, available on *www.asiepi.eu*.
5. M. Spiekman, Heijmans N., Wouters P., Caillou S., Stimulating innovation with EPBD - What countries can learn from each other, ASIEPI project, 2010. http://www.asiepi.eu/fileadmin/files/WP6/ASIEPI-WP6-Report2.pdf.

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National trends of innovative products and systems for energy-efficient buildings

- Barriers and strategies for an accelerated market uptake

On 3 and 4 March 2010, ASIEPI and AIVC organized an interactive workshop in Amsterdam [1] to discuss the challenges related to organizing a smooth market introduction of innovative energy-efficient products and systems as well as the energy needed to accelerate the change process towards a comfortable, healthy and energy-efficient built environment. Special attention was paid to 'best practice examples' with the emphasis on air-conditioning/cooling and ventilation technologies.

Within the context of the EPBD, there are many procedures dealing with innovations. The differences are partly due to the variations in national EP methods.

This paper presents, within the European framework, the barriers and alternatives identified by the IEE SAVE ASIEPI project and workshop.

1 > Innovative systems within EPBD framework

Reducing energy consumption and eliminating wastage are among the principal goals of the European Union (EU). EU support for improving energy efficiency will prove decisive for competitiveness, security of supply and for meeting the commitments on climate change of the Kyoto protocol. There is significant potential for reducing consumption. With 40% of our energy consumed in buildings, the EU has introduced legislation to ensure the reduction of energy consumption.

A key part of this legislation is the Energy Performance of Buildings Directive (EPBD [2]) which requires that all Member States of the EU define an Energy Performance (EP) method and corresponding EP requirement levels. The EPBD only imposes MS to set up EP requirements, it does not specify either the severity of these requirements, or the implementation and control of these measures.

Consequently, each country is required to overcome its own barriers against innovation, which will differ from the other countries. However, benchmarking between countries will facilitate the changes and the adoption of a European procedure.

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The definition of an innovative system also differs between countries. The following are the definitions often used for innovative systems or technologies within the context of regulations:

- Systems or technologies that improve the building's energy performance,
- New systems (not taken into account in the MS's regulation method)

Some countries do not discriminate between product improvement and new products, except for France and Germany where equivalence studies are only used for innovations [3], while improvements of existing products are measured and rated by qualified organizations, often following national or EN standards [3].

Three procedures were identified in the ASIEPI project [4] [5] to integrate innovative systems into the regulations; they concern:

1. Countries which have an open method: most innovations can be taken into account in the method itself (e.g. Denmark and Portugal),
2. Countries which have a light framework for equivalence, based on equivalence studies made by the market itself or by experts, with local control (e.g. Netherlands and France),
3. Countries which have a heavy framework for equivalence, based on equivalence studies made by a national committee and national control (e.g. Belgium).

The cost of technical studies is also an issue which differs between countries. In some countries this is controlled by the government, in others it is controlled by the manufacturer to prove the feasibility and efficiency of its new products. If the product can reduce the EP level significantly, this will be a selling point for the product.

2 > Barriers for innovative systems

In ASIEPI project [5] and during the workshop, different barriers against innovation were identified:

- Heavy procedures: consume effort, time and investment,
- Bad quality of equivalence studies: harm the support of innovations in general or even the support of the EP method as a whole.

These barriers are the main issues that the equivalence procedure needs to deal with:

- How to assure the quality of the assessment of complex techniques,
- How to deal with influential and partly arbitrary choices which are needed in the method, for example behavior(occupancy patters and operation schedules)
- How to manage these two issues with regard to effort, time and cost aspects.

Where some countries trust independent experts in the field and a relatively light control system at local level, others have introduced a heavy control system, using a national committee of experts (e.g. France).

In the Amsterdam workshop, European associations representing industries (REHVA, Eurima, EuroACE and VLA) participated and presented their points of view on the barriers. These associations are the leading professional organizations in Europe, dedicated to the improvement of health, comfort and energy efficiency in all buildings. They encourage the development and application of both energy conservation and renewable energy sources. In these areas, they have a significant impact on National and International strategic planning and research initiatives, as well as on the associated educational and training programs.

At the market level, three principal barriers were identified:

- Lack of uniform framework to asses innovative products and systems (positive rating in some markets, punished in others)
- Lack of uniform technical data for products
- Poor awareness of installation quality

3 > Are there incentive policies in MS contributing to facilitating the integration of innovative systems into regulation?

In general there are no incentives for the mere compliance with the EPBD. Incentives are only offered for buildings that go beyond the minimum requirements in most of the Member States except Denmark. These incentives include subsidies, zero interest loans, fiscal deductions, etc. Most of these economic supports for energy efficiency are focused on particular technologies (heat pumps, insulation of walls or roofs, photovoltaic panels, etc.). But in some regions of those countries, the subsidy allocated is based on the overall energy performance of the building and not on the particular systems.

Offering incentives to building owners will facilitate both the introduction of new innovations and also encourage manufacturers to develop new products.

4 > A unified framework for building energy performance

The European Commission decided, after consultation with Member States experts, interest groups and CEN, that there was an urgent need for standards to support the EPBD. A mandate was given to CEN (Mandate 343) to develop a set of standards. The set is based on a list of 31 topics covering calculation, measurement and inspection procedures, including methods for both building components and building services.

The CEN standards to support the EPBD were successively published in the years 2007-2008. However, the implementation of these CEN standards in the EU Member States (MS) is far from trivial: the standards cover a wide variety of levels and a wide range of interlaced topics from different areas of expertise. They comprise different levels of complexity and allow differentiation and national choices at various levels for different applications. It will be beneficial for Europe if all Member States use these standards as reference. However building regulation is an area where the EU Member States claim their national privilege to formulate the national legislation.

The CENSE project has prepared recommendations for CEN to develop a second generation of standards in the future. The main recommendations under preparation and discussion are:

- A more uniform structure for each of the standards in the package.
  - Distinction between common procedures and options to be chosen at national level; this will bring more clarity in the adoption of the procedures and the specific choices per country;
  - Fully documented equations and unambiguous links between input and output, making the standards ready-to-use for validation and software preparation;
- Use of the available common set of terms, definitions and symbols and subscripts, the latter also for all versions and national application documents in other languages.
- Reduction and clarification of the number of options given in the standards.

Final versions of these recommendations (including recommendations of a specific technical nature and identification of gaps) will be reported before the end of the CENSE project. The revision of the standards and a corresponding revision of national methods and regulations will, within the next five years, enable the EU Member States to make a more direct use of the harmonized CEN procedures.

ISO is also very interested in the subject, which culminated in the recent establishment of a Joint Working Group within ISO to develop ISO (EN ISO) standards on energy.

In some Member States the use of the EPBD – CEN package, as an option to fulfill the national building codes requirements, is already authorized (e.g. France for energy certificate).

This initiative can also be applied to evaluating innovative systems. It will represent the first step for the harmonization of the European framework.

A contribution to the perspective of EU-wide application of the EPBD-CEN standards was the announcement that one of the major Highlights of the Political Agreement [6] includes a harmonized calculation methodology. MS will have to justify the choice if the gap between current requirements and cost optimal requirements is more than 15%.

5 > Conclusions

On basis of exchanges during the workshop, some techniques to improve procedures were identified:

- The EPBD should act as a driver for innovation and not create barriers against innovation, this issue could be integrated in the next EPBD revision.
- Equivalence studies: It is important that Member States explicitly foresee the possibility of assessing technologies not covered by the calculation procedure in line with the way in which the EPBD is implemented.
- As the European standards cover a wide spectrum of the energy performance of buildings, Member States can specify in their regulations that all methods based on European standards will be directly accepted. This issue will be the first step to harmonize methods and framework.
- Quality and management of complexity: a framework should be defined to guarantee the quality of the studies. Technical guides describing the procedure with examples would facilitate this issue

ASIEPI partners:
BBRI (BE; technical co-ordinator), NKUA (GR; financial & administrative co-ordinator), TNO (NL), Fraunhofer IBP (DE), SINTEF (NO), CSTB (FR), Cete de Lyon (FR), REHVA (BE), ENEA (IT), AICIA (ES), NAPE (PL), VTT (FI), E-U-Z (DE), Enviros (CZ), SBi (DK)

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Kaunas University (LT), University of Budapest (HU), University of Bucharest (RO), BRE (UK), UCD (IE)

Link: www.asiepi.eu

Original text language: English

- Evaluation of studies: it should be approved at a sufficiently high administrative level to guarantee the quality

Concerning the Market uptake, attention should be paid to:
- Informing the market about the possibilities offered by the principle of equivalence and approved systems.
- The costs of carrying out studies of equivalence and the time for assessment of innovative systems.

6 > References

1. *http://www.asiepi.eu/wp-6-innovative-systems/workshop.html*
2. EPBD (2002). Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings, Official Journal of the European Communities, 04.01.2003.
3. N. Heijmans, P. Wouters, Overview of national approaches for the assessment of innovative systems in the framework of the EPBD, ASIEPI project, 2009. *http://www.asiepi.eu/fileadmin/files/WP6/ASIEPI-WP6-Report1-Version1.pdf*
4. ASIEPI WP6 - The EPBD as support for market uptake for innovative systems - "State-Of-The-Art"
5. M. Spiekman, N. Heijmans, P. Wouters, Stimulating innovation with EPBD what countries can learn from each other, ASIEPI project, 2009. *http://www.asiepi.eu/fileadmin/files/WP6/ASIEPI-WP6-Report2.pdf*
6. http://www.europarl.europa.eu/sides/getDoc.do?type=TA&reference=P6-TA-2009-0278&language=EN

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I E E S A V E   A S I E P I

Part D. Web events

on

The EPBD as support for market uptake for innovative systems

ASIEPI web event 3: Overview of national approaches for the assessment of innovative systems in the framework of the EPBD

ASIEPI web event 9: Stimulating innovation with EPBD

ASIEPI web event 3

Overview of national approaches for the assessment of innovative systems in the framework of the EPBD

25 February 2009, 10:00-12:00 GMT+1 (Paris time)

One of the goals of the IEE SAVE ASIEPI project is to investigate how the Member States handle the assessment of innovative systems.

Important remark: in the context of EPB regulations, and in particular in the context of ASIEPI, innovative systems are defined as:

- systems which most probably give a better performance in terms of the energy performance of buildings than the usual systems and,
- whose performance cannot be assessed by the standard EPB calculation methods. According to this definition, some systems may be innovative in some countries and not in other ones.

This third ASIEPI web event has given an overview of the approaches in place in different Member States for the assessment of such innovative systems.

Event page: http://www.asiepi.eu/wp-6-innovative-systems/web-events/web-event-3.html

Overview of national approaches for the assessment of innovative systems in the framework of the EPBD
Welcome *by Peter Wouters, INIVE, project coordinator*
Presentation of the ASIEPI project *by Peter Wouters,INIVE*
What is the potential problem with EPBD and innovative systems? *by Peter Wouters*
Overview of alternative assessment procedures across EU *by Nicolas Heijmans, BBRI*
Examples of national approaches
- Netherlands *by Marleen Spiekman, TNO*
- France *by Hicham Lahmidi, CSTB*
- Germany *by Heike Erhorn-Kluttig, IBP*
- Denmark *by Kirsten Engelund Thomsen, SBi*
- Belgium *by Nicolas Heijmans, BBRI*
The industry point of view, expressed by two ASIEPI sponsors
- ES-SO *by Dick Dolmans, ES-SO*
- EuroAce *by Jean-Luc Savin, AERECO (as member of EuroAce)*
Discussions
Questions
Conclusion and closure *by Peter Wouters, INIVE, project coordinator*

ASIEPI web event 9

Stimulating innovation with EPBD

3 February 2010, 10:00-12:00 GMT+1 (Paris time)

One of the most important aims of the introduction of the energy performance methodology is to make better buildings. By tightening the EP requirement levels building designers are encouraged to make better choices. But they will only be encouraged to choose energy saving measures which are taken into account in the methodology. Because this would be a barrier for innovation, it is extremely important to have a route which makes it possible to incorporate innovative systems. Within the Asiepi project we have investigated how countries deal with innovative systems in the context of the EPBD. We have examined the pros and cons of the national approaches. Please join our webevent and explore with us what we can learn from each other.

Event page: http://www.asiepi.eu/wp-6-innovative-systems/web-events.html

Stimulating innovation with EPBD
Welcome and introduction to ASIEPI *by Nicolas Heijmans, BBRI*
Importance of dealing with innovative systems in EPBD *by Nicolas Heijmans, BBRI*
Natinonal presentations
Advantages and disadvantages of the Danish approach *by Jorgen Rose, SBi*
Advantages and disadvantages of the Dutch approach *by Marleen Spiekman, TNO*
Advantages and disadvantages of the Belgian approach *by Nicolas Heijmans, BBRI*
Advantages and disadvantages of the French approach *by Charles Pele, CSTB*
Synthesis, problems and potential solutions *by Marleen Spiekman, TNO*
Practical experiences
What does industry see what goes right and wrong in their/other countries related to their market. What would they like to see? *by Rick Bruins, Zehnder*
Study on the use and control of the principle of equivalence in practice in the Netherlands: results and possible solutions *by Tom Haartsen, Climatic Design Consult*
Discussions
Questions
General guidelines, conclusion and closure *by Nicolas Heijmans, BBRI*

IEE SAVE ASIEPI

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Stimulation of better summer comfort and efficient cooling by EPBD implementation

Summary report

Main authors:

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National & Kapodistrian University of Athens

SUMMARY

Two of the main goals of the ASIEPI project were:

a) To accelerate the awareness raising in Member States and among stakeholders about the importance of a correct handling of summer comfort and efficient cooling.

b) To provide guidance towards effective solutions.

In order to assist in the work conducted for the ASIEPI project, information from Member States and other non-EU countries was collected and analysed. The analysis of this information helped in drawing conclusions and giving recommendations for better summer comfort and efficient cooling implementation in the energy performance (EP) of buildings national regulations.

The recommendations address the following audience categories:

- Policy makers
- Developers of calculation methods
- Building practitioners
- Associations of architects and building practitioners; and
- Building owners

The main recommendations on summer comfort and efficient cooling in buildings, which are described in more detail in part A, can be summarised into 3 main points:

(1) Protect the building against overheating and against the need to install active cooling in the future.

There are many techniques and methods available that have a great potential in limiting the chances of active cooling system installation and overheating emergence in buildings in the future. As energy efficiency and reduced energy consumption during the cooling season have only recently become a primary concern for many countries, these techniques and methods still do not receive the attention they deserve in national EP regulations. These methods are critical mostly for buildings with no active cooling and they include: fictitious consumption for cooling, overheating analysis, use of floating conditions, comfort indicators (e.g. Balance Point Temperature indicator), use of the Adaptive Approach in non-air conditioned buildings.

(2) Make alternative cooling techniques a top priority in national regulations and practical applications rather than conventional cooling systems.

Alternative cooling techniques have great potential for reducing the cooling load and the cooling energy consumption in buildings. However, their implementation in EP regulations is not very robust at the moment, a fact that constitutes a hurdle to their use. Ways of reversing the current trend towards the use of conventional cooling systems are: establishment of financial incentives for alternative cooling systems; inclusion of more alternative cooling techniques along with their performance calculation methods in national regulations; but also mandatory requirements for using alternative cooling techniques, such as solar and heat protection and modulation and dissipation cooling techniques before using conventional systems.

(3) Improve the current national EP procedures and thus enhance energy savings from cooling.

There are many requirements that if integrated in the national EP procedures can result in decreased energy consumption for cooling and enhanced energy efficiency. Requirements that can be considered are: reduction of the oversizing capacity of the A/C installations during the design phase; minimum COP requirements and consideration of the COP of cooling systems during the peak and part load conditions instead of only under the nominal conditions; restrictions on the use of cooling during the peak periods; application of modular pricing policy for big cooling consumers.

Other recommendations for the refinement of EP-procedures that involve summer comfort and cooling include: attention to proper setting of default values, integration of all aspects that have an impact on the cooling energy consumption in the procedures, avoidance of complex input data, make alternative cooling techniques part of the thermal balance equations but also integrate them in the global calculation method.

Part B gives an overview of all project material that is available on this topic.

Part C is a collection of all the Information Papers produced on this topic.

Finally, Part D presents the related organised web events.

Part A: Final recommendations

1. INTRODUCTION

The recommendations resulting from the study of summer comfort and efficient cooling in ASIEPI address the following audience categories:

- Policy makers
- Developers of calculation methods
- Building practitioners
- Associations of architects and building practitioners; and
- Building owners

During the span of the ASIEPI project, information was collected from Member States and other, non-EU countries. The analysis of this information helped formulate the conclusions and recommendations for a better implementation of summer comfort and efficient cooling in the energy performance (EP) of buildings national regulations.

2. GENERAL CONCLUSIONS & RECOMMENDATIONS

2.1 GENERAL CONCLUSIONS

Although a good deal of attention is already given to the consumption for cooling in the national/regional EP-regulations, the relevant calculation methods cannot usually fall back on the same decade-long and detailed experience as exists for space heating calculation methods. Generally speaking, the continued further refinement of the calculation methods is therefore warranted so as to better evaluate the energy consumption of all possible means of cooling, and to include in particular the low energy cooling methods.

About half of the countries surveyed already include some kind of evaluation of the risk for overheating in their EPB-regulation. Interestingly, none of them is a Mediterranean country.

The most dominant technique for cooling is currently the mechanical vapour compression refrigeration cycle. This technology is capable of achieving high cooling capacities and of meeting the cooling requirements at almost all times, something that makes this conventional cooling technique a tough competitor for most of the alternative cooling techniques. Not only is this technique dominant in practical applications, it is also considered by all MS in their EP-calculation methods.

Many benefits accrue from the use of alternative cooling techniques, the most significant of which are: considerable energy and cost savings, reduced peak power demand, improved indoor air quality, life cycle cost effectiveness, reduced pollution emissions, use of refrigerants with limited or zero ozone depletion potential (ODP) and global warming potential (GWP).

Overall, MS consider more alternative cooling techniques in their EP-calculations for non-residential buildings than they do in their EP-calculations for residential buildings. In many cases, when a cooling technique is considered for all types of buildings, for the same country, the calculation method is often more detailed in the case of non-residential buildings and a more simplified approach is followed for residential buildings.

There are modelling levels and assumptions inherent to the current calculation methods and recommended in some of the CEN standards concerned that are not sensitive to relevant design decisions in summer performance. It is proven through the ASIEPI project (1) that some common assumptions of the calculation methods can become a barrier to the penetration of passive cooling in buildings.

2.2 RECOMMENDATIONS

2.2.1 POLICY MAKERS

First of all, by not giving an extra allowance for the maximum allowed primary energy consumption in the case that active cooling is applied (as compared to the situation without active cooling), the countries can stimulate the application of an as efficient as possible cooling system and/or the compensation for the extra consumption for cooling by extra savings in other domains (heating, lighting etc).

In the case of no active cooling, a fictitious consumption for cooling can nevertheless be considered, in particular when the risk for overheating is high. This takes into account that cooling may be installed later on during the life cycle of the building. By considering a fictitious cooling consumption in the EP-methods, it is stimulated that in the design stage proper attention to the summer situation in buildings without active cooling is given. The inclusion of fictitious cooling also facilitates the application of the first advice above, namely that the EPB-requirement is made independent of whether or not active cooling is installed.

For countries that already have an overheating analysis for some types of buildings it is worth considering whether it is appropriate to extend it to all building types. Also, it is recommended to include as many forms of central passive cooling as possible, including central systems (e.g. seasonal geothermal storage).

Countries that do not yet have an overheating analysis in effect in their regulations are advised to investigate whether such an analysis would be useful for them too. It may be a way to draw attention to the passive cooling means to avoid overheating, thus reducing the probability that an active cooling system will be installed later on in the building life cycle.

In order to reduce the energy consumption for cooling, to promote the use of passive cooling concepts and strategies and to anticipate global warming, it is strongly recommended to set:

a) A global EP-requirement for energy consumption and/or CO_2 emissions in which cooling must obviously be included.

b) Additional requirements limiting the cooling needs for air-conditioned buildings.

c) Additional requirements for non-air-conditioned buildings and air-conditioned dwellings limiting the overheating risk or, in a complementary way, clear indicators that allow identifying the necessity or not of air conditioning (for both residential and non-residential buildings).

d) The inclusions of such indicators about summer comfort should be based on indoor temperature levels consistent with the adaptive comfort criteria of EN 15251.

e) If practically feasible in the context of the national EPB-regulation, the inclusion of such indicators about summer comfort should be based on hourly calculations of the indoor temperatures at a zone level, due to the huge temperature differences that can exist between zones of the same building.

It is considered that requirements that are too prescriptive reduce the freedom of design and when their benefit is evaluated in conjunction with other variables (global level) their contribution is not as beneficial. Therefore, the use of additional requirements on a component level, or the necessity of using certain strategies (e.g. ventilation rates or thermal inertia) is not recommended in general.

Also, financial incentives, similar to those given for renewable energy (e.g. photovoltaics) could be given for the use of alternative cooling techniques. The greater the benefit in:

- Energy savings
- Emissions reduction
- Life cycle cost effectiveness
- ...

compared to conventional cooling systems or techniques, the greater the funding could be.

It is also recommended that more alternative cooling techniques are considered by the MS in their national EPB-regulations in order to further motivate their use in buildings and to stimulate a market transformation.

It is strongly advised that conventional cooling systems are put in second place in EPB-regulations as opposed to alternative cooling techniques, by requiring a mandatory report that justifies the selection of an active cooling system instead of an alternative cooling technique.

The possibility of decreasing the oversizing capacity of the A/C installations during the design phase could be considered in EPB-regulations as well, to avoid operation of the system in part load and to decrease the energy consumption

Also, a modular pricing policy could be applied for big cooling consumers to promote energy conservation and enhance the potential of the consumers to apply energy saving measures.

It is strongly suggested that solar and heat protection, modulation and dissipation cooling techniques and good building design are made obligatory above the use of mechanical cooling and air-conditioning systems to prevent overheating and reduce peak electricity demand and the overall energy consumption for cooling. For example, the use of shading and natural ventilation could be made mandatory in order for the installation of AC system to be allowed.

It is recommended to MS policy makers to apply the Adaptive Approach in non air conditioned buildings. Through this approach, good building design coupled with slightly higher but acceptable temperatures, as advocated by the adaptive approach, can result in a negligible cooling energy consumption in all European regions. It has been proven through the IEE CommonCense project that use of the adaptive approach may reduce the (fictitious) cooling demand by up to 40 % (1). It is worth mentioning that in some countries (notably NL and BE), the use of the concept of fictitious cooling has been found to constitute an extra stimulus for good design for summer comfort, going beyond the legal minimum requirements.

Also it is worth considering the COP of cooling systems during the peak and part loads conditions and not just under the nominal ones. This is important in order to avoid an oversizing of the systems and long operation of the AC under part load conditions.

Furthermore, the application of restrictions to the use of cooling during the peak periods to avoid unnecessary increase of the installed electricity generating and distribution capacity is also recommended, mostly for warmer countries. This can be achieved through the use of demand side management techniques. If not, peak electricity demand will increase continuously and additional power plants will need to be built. This can also increase the cost of the electrical energy.

For residential buildings, it is recommended that the assesment of the summer comfort conditions is performed using free floating conditions. The use of the cooling load as an indicator for summer comfort problems is best avoided, in order to prevent from giving the implicit message that the installation of a mechanical cooling system is necessary.

Restrictions relevant to the system efficiency, (minimum required EER) are also advised to be set. This is to avoid the use of low EER systems that increase the absolute cooling load, the peak electricity demand and have a much higher operational cost for the user.

2.2.2 Developers of Calculation Methods

The continued further refinement of the cooling calculation methods is warranted so as to better evaluate the consumption of all possible means of cooling, including and in particular the low energy methods.

Also, it is advised that attention is paid to the proper setting of default values. In particular, a differentiated approach between the heating and the cooling season is often justified, certainly for the variables that have a major impact, e.g. air tightness and thermal bridges.

It is important that all aspects that have an impact on the cooling energy consumption are integrated in the calculation methods, in particular those variables that can contribute to the reduction of the consumption and that are cost-effective in a given country. Important techniques that require further development are:

- Active cooling devices
- Natural, passive cooling

If no cooling system exists, the minimum requirements can refer to a comfort indicator, the limit value of which will be to demonstrate that no cooling will be necessary. For example the Balance Point Temperature Indicator (3) could be used. However, it is also worth considering these requirements even for the case of active cooling installation in order to limit the overheating risk during cooling off and to prevent people from installing active cooling intentionally to avoid this requirement.

Calculation methods may often be complex by themselves. However, it is recommended that the number and complexity of input variables to calculation methods remain limited. This will encourage the use of alternative cooling techniques and summer comfort evaluation.

It is recommended that alternative cooling techniques are as much as possible integrated in the standard EP calculation methods. If not, designers will avoid the implementation of such systems, the performance of which is not defined.

Alternative cooling techniques change the thermal balance of the building. Thus, it is also worth including them in the calculation methods for both the overheating evaluation and the cooling consumption.

Furthermore, it is recommended that as more experience is gained in the operation and performance of such techniques, their calculation methods are further developed.

Furthermore, it is important that developers of calculation methods base their calculation methods on the same EN standards and use the same nomenclature so as to ensure consistency between MS national regulations and facilitate the inter-comparison of outcomes.

The remainder of this paragraph (§2.2.2) is mainly applicable to in analyses where extensive input data (i.e. room geometry) are required:

Passive cooling concepts and strategies are based on a zone or even whole building level approach. Therefore the revision of the treatment of some parameters such as the solar distribution factors or the indoor convective heat transfer coefficients is suggested.

Solar heat gains attenuation strategies require, and it is therefore recommended, that the solar distribution factors are considered at least as dependent on the season of the year in order to evaluate properly the effect of the thermal inertia of every enclosure.

Night cooling dissipation strategies require consideration not only of the flow rate of outdoor air entering the building but also of the air flow pattern. The air flow pattern can increase significantly the convective heat transfer coefficients at some of the internal elements of the room as compared to the fixed values proposed in the CEN standards. The efficiency of the ventilation strategy is a direct function of how the structural inertia of the building is distributed on the elements of the enclosure with higher convective heat transfer coefficients. It is therefore recommended that calculation methods consider the expected variation of the indoor convective heat transfer coefficients for typical air flow patterns for representative rooms.

It is suggested that the assessment of summer comfort and the risk of overheating are not based on fixed levels of acceptable indoor temperature. The influence of the outdoor conditions on the acceptable indoor set-points temperature as proposed in EN15251 are recommended for the identification of buildings which do not require air conditioning.

In warm and hot locations, there is a significant potential for energy savings linked to the use of variable set-point ranges depending on outdoor temperatures. The practical implementation of the control strategy to set the variable set-point approach in a building can be easy and cost-effective, something that suggests further research on adaptive comfort for air-conditioned buildings. The calculation tool should therefore, be able to deal with this new approach.

Finally, regarding zoning, it has been concluded that significant differences of indoor temperatures can be expected in different spaces of a building during summer period and that average building level temperature (single-zone approach) is not valid for comfort assessment in summer. Consequently, in order to promote the use of passive cooling concepts and strategies, calculation methods are suggested to consider a multi-zone approach, if this is feasible on national level.

2.2.3 Building Practitioners

In order to reduce the cooling requirements of a building and therefore ensure viability of alternative cooling techniques, it is important that building practitioners design the building in such a way that heat gains in internal spaces are minimised. This should also contribute to the minimisation of maintenance costs and the life cycle costs of the building.

Building practitioners are also advised to give priority consideration to passive cooling techniques for buildings in locations with reduced noise ingression and air pollution issues, and where in addition urban heat island occurrence is limited.

2.2.4 Associations of Architects/Building Practitioners

Associations of architects and building practitioners are advised to develop and distribute best practice guidelines on the use of alternative cooling techniques and summer comfort evaluation methods.

They are also advised to encourage the application of passive approaches referring to building design or elements that reflect the specific national building traditions and climate conditions. This means, however, that they cannot be fixed uniformly across Europe.

2.2.5 BUILDING OWNERS

Finally, it is not sufficient to declare that we want to conserve energy by means of e.g. higher thermostat settings (following the adaptive approach). Companies are advised to accompany this with a change in the acceptable dress code (example of 'Cool Biz' (4) and proper manual control of building services.

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3. REFERENCES

(1) S. Alvarez, Alternative cooling calculation methods: Comparative simulations. http://www.asiepi.eu/wp-7-summer-comfort/available-reports.html

(2) IEE CommonCense project. http://www.learn.londonmet.ac.uk/commoncense/

(3) M. Santamouris, D.N. Assimakopoulos (Eds) : Passive Cooling of buildings. James and James Science Publishers, London, 1996

(4) Cool Biz campaign. Ministry of Environment, Government of Japan. http://www.env.go.jp/en/press/2005/1028a.html

Part B: Bird's eye view of the project results

4. INTRODUCTION

People interested in the outcome of the ASIEPI project had many opportunities to become updated with the latest results throughout the length of the working process, through many means:

i. Technical reports

ii. Information papers

iii. Presentations-on-demand

iv. Web Events

v. Workshops

vi. Conferences

These means also served for the exchange of information between relevant IEE projects and between people involved in the work of ASIEPI.

All of the published results are available on the ASIEPI website (www.asiepi.eu)

5. PUBLISHED RESULTS

5.1 TECHNICAL REPORTS

Five technical reports have been produced (> link):

(1) **Report D7.1** *"Summer comfort and cooling determination methods"* is a compilation of 13 country approaches on how summer comfort and/or energy use for cooling are integrated in the overall calculation of the energy performance of a given building. The collection and analysis of these approaches was performed by the BBRI by means of an extensive questionnaire. Partners BBRI, Fraunhofer IBP, AICIA, CSTB, NKUA, ENEA, TNO and NAPE have contributed to this study, and the subcontractors reported on their country's status as well.

As the focus of the ASIEPI project is not on the development of new calculation methods, but on the optimization of the effectiveness of the building regulations, the survey focuses on the input variables and does not make an in-depth analysis of the details and formulas of each calculation method. At the end of the report conclusions are drawn and recommendations given on how the effectiveness of building regulations can be improved. These conclusions and recommendations are summarised in PART A of this report.

A summary of the results on the summer comfort and cooling determination methods along with further discussion and recommendations is also made in Information Paper IP163 "Summer comfort and cooling: calculation methods and requirements" (§5.2.1).

(2) The aim of **report D7.2** *"Additional requirements related to summer comfort and air conditioning"* is to analyze the information collected on the additional requirements related to summer comfort and air conditioning in line with Article 4 ("Setting of energy performance requirements") of the EPBD. It also gives guidance on how the effectiveness of these additional requirements can be enhanced. After some iteration and clarification 12 consolidated and clarified answers were received and processed by the AICIA.

The questionnaire on which this report is based is included in the Annex of the report.

A summary of the results on the additional requirements related to summer comfort and cooling along with further discussion and the summer comfort and cooling determination methods is also found in Information Paper IP163 "Summer comfort and cooling: calculation methods and requirements" (§5.2.1).

(3) In the context of the ASIEPI project, alternative cooling techniques are considered to be the cooling techniques that improve summer comfort substantially, without (or in a very limited manner) increasing energy consumption and which in general do not rely on the vapour compression refrigeration cycle.

Report D7.3 *"Handling of alternative cooling techniques"* aims to evaluate the extent to which alternative cooling techniques are covered by the procedures used by the MS and the way this is done. At the end conclusions are drawn and recommendations given on how alternative cooling techniques can be better implemented in national procedures and the benefits that may occur from this implementation.

The results are based on the questionnaire prepared for the purposes of the report *"Summer comfort and cooling determination methods"* (§5.1.1), complemented with an additional descriptive inquiry.

(4) The aim of **report D7.4.1** *"Evaluation of the calculation methods for summer comfort and cooling"* is first of all to analyse the existing experience of MS on alternative cooling and summer comfort calculation methods and to indicate the advantages and disadvantages of these methods, as well as the pros and cons from their actual use.

Experiences were gathered from 7 EU countries and from 2 non-EU countries in December of 2008 and their compilation forms the basis of this report.

Finally recommendations regarding the more effective implementation of alternative cooling techniques and summer comfort calculation methods in the national procedures are formulated.

(5) For **report D7.4.2** *"Alternative cooling calculation methods: Comparative simulations"* the AICIA performed comparative building simulations using the present regulatory calculation methodologies as well as the alternative methodologies. The aim of these simulations was to assess the benefits of the alternative methods involving:

- comfort criteria
- zoning
- solar control – Quality/scope of the solar control algorithms
- heat amortization – Thermal mass (influence of distribution and absorption of solar radiation)
- heat dissipation by intensive ventilation – Calculation of the air flow rates, role of the thermal mass

Emphasis was given on the assumptions typically included in the calculation methods that may be a barrier to the implementation of passive and low energy cooling.

5.2 INFORMATION PAPERS

Four Information Papers have been produced (> link):

(1) The Information Paper **P163** *"Summer comfort and cooling: calculation methods and requirements"* is a summary of the results of a survey on a dozen European countries with respect to the handling of summer

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comfort and energy consumption for cooling in the national/regional EPB-regulations.

(2) The Information Paper **P186** *"Innovative Solar Control Devices"* presents examples of innovative solar control devices and emphasizes their relevance to the energy performance of buildings.

(3) The Information Paper **P185** *"French handling of alternative cooling techniques: free cooling and ground heat exchanger"* focuses on providing general information on how EN 15241 and EN 15242 are implemented into the French regulations for the evaluation of passive cooling based on ventilation. An explanation of the calculation method with detailed information on input and output data is given.

(4) The Information Paper **P193** *"Experiences on passive cooling techniques for buildings"* presents relevant experiences on passive cooling techniques, showing their potential in mitigating the cooling energy consumption and in improving thermal comfort conditions in non-cooled buildings.

The experiences presented in this paper were selected according to the most relevant passive solutions for buildings, in particular:

- Night ventilation
- Ground cooling
- Evaporative cooling
- Cool roofs
- Green roofs

5.3 PRESENTATIONS-ON-DEMAND

Two presentations-on-demand were produced:

(1) **ASIEPI presentation-on-demand 5** "Stimulation of better summer comfort and reduced energy consumption for cooling by EPBD implementation" explains the drivers and objectives of the study on summer comfort and cooling and its relation to the EPBD.

The presentation also includes an overview of the work carried out and the recommendations and conclusions drawn at the time that the presentation was prepared concerning Member States' calculation methods and requirements on summer comfort and cooling.

(2) **ASIEPI presentation-on-demand 6** "*Main lessons learned and recommendations from the IEE SAVE ASIEPI project*" focuses on guidelines for Member States and it was translated in different European languages.

5.4 WEB EVENTS

Two web events were organised (> link):

(1) **ASIEPI Web event 5** *"Summer comfort and air conditioning in Europe: Current trends and future perspectives"* took place on June 17th, 2009. The aim of the web event was to provide an overview of the possibilities and barriers for the penetration of innovative and passive cooling techniques into the European market, including:

- discussion on the European thermal comfort standards.
- an analysis of the pro's and con's of the calculation methods emphasising the role of thermal mass, solar gains & shading, intensive night ventilation and the use of natural cooling techniques.
- major trends in the systems used and discussions about the existence of a framework for assessing passive cooling and low energy cooling systems.

The program of the web event was as follows:

Introduction
Welcome *by M. Santamouris, NKUA, WP7 leader*
Brief presentation of the ASIEPI project and Introduction into Summer Comfort and Cooling as covered in ASIEPI *by M. Santamouris*
Technical discussions
Thermal comfort standards for EU *by B. Olesen REHVA*
Common assumptions of the calculation methods that can become a barrier to the penetration of passive cooling in buildings *by S. Alvarez, AICIA-University of Seville*
The role of passive cooling in thermal comfort of buildings *by M. Santamouris, NKUA, WP7 leader*
The industry point of view
Trends and perspectives in innovative cooling techniques *by A. Thiemann, DAIKIN*
(See also the web event related to the assessment of innovative systems (http://www.asiepi.eu/wp-6-innovative-systems/web-events.html))
Discussions
Questions
Conclusion and closure *by M. Santamouris, NKUA, WP7 leader*

Program of the ASIEPI webevent n°5

The web event was attended by 66 people from 16 countries. The overall satisfaction was 4.2/5.0.

(2) **ASIEPI Web event 6** *"Thermal comfort and cooling demand in the air of climatic change"* was held on November 26th, 2009. The aim of the web event was to treat issues of thermal comfort and cooling emergence in the air of climatic change. The presentations provided an overview of the impact of climate change on thermal comfort and cooling demand in buildings. They also gave an overview of the available alternative technologies that may improve summer comfort along with the calculation methodologies that assess their impacts.

The program of the web event was as follows:

Introduction
Welcome *by M. Santamouris, NKUA (University of Athens)*
Brief presentation of the ASIEPI project and Introduction into Summer Comfort and Cooling as covered in ASIEPI *by M. Santamouris*
Technical discussions
Summer comfort and cooling: calculation methods and requirements, *by D.Van Orshoven, BBRI*
The role of climatic change and the impact of cooling in buildings *by M. Santamouris, NKUA*
The industry point of view
Solar shading: reducing the need for artificial cooling with quantifiable results *by D. Dolmans, ES-SO*
Energy certification of A/C - Results of the HARMONAC project *by Ian Knight, Cardiff University*
The energy cost of comfort and compatibility with EPBD *by Michael G. Hutchins, Sonnergy Ltd*
Discussions
Questions
Conclusion and closure *by M. Santamouris, NKUA*

Program of the ASIEPI webevent n°6

The web event was attended by 54 people from 20 countries. The overall satisfaction was 4.2/5.0

5.5 WORKSHOPS

The International Workshop **"Summer Comfort and Cooling"** was held in Barcelona, Spain on March 31st and April 1st, 2009 (> link). The workshop was an initiative of AIVC and was organized by INIVE EEIG, in collaboration with REHVA and with the European SAVE ASIEPI and SAVE BUILDING ADVENT projects.

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The main purpose of the workshop was to present and discuss the evolutions in the national regulations related to summer comfort and cooling.

The program of the workshop is given in the next table.

Opening of workshop – session 1 **Chairmen: M. Santamouris and J. Cipriano**
General welcome INIVE – AIVC – ASIEPI : P. Wouters, INIVE
Welcome from CIMNE as host of the workshop: J. Cipriano, CIMNE
Objectives of the workshop : M. Santamouris, NKUA
Presentation of activities on summer comfort and cooling in the IEE ASIEPI Program : S. Alvarez, University of Seville
Presentation of IEE ADVENT Program : A. Cripps, Buro Happold
Presentation of the current state in Portugal: E. Maldonado, FEUP
Presentation of the current state in Finland: O. Seppänen, REHVA
Session 2 - Chairmen: **E. Maldonado and O. Seppänen**
Presentation by EURIMA: J. Solé Bonnet, URSA Insulation, EURIMA
Presentation of the current state in Czech Republic: K. Kabele, Czech Technical University of Prague
Presentation of the current state in Israel: S. Hassid, Technical University of Haifa
Presentation of the current state in the Netherlands: W. Borsboom, TNO
Discussion
Session 3 - Chairman: A. Cripps – K. Kabele
Presentation by EUROACE: M. Geremias, URSA Insulation, EUROACE
Presentation of the IEE Cool Roofs Project : M. Santamouris, NKUA
Presentation of the current state in UK: R. Hitchin, BRE
Presentation of the current state in Belgium: D. Van Orshoven, BBRI
Discussion
Session 4 - Chairmen: M. Sherman and W. Borsboom
Active cooling and energy efficiency – the view of a manufacturer : A. Thiemann, Daikin
Presentation of the HARMONAC Project: R. Hitchin, BRE
Presentation of the current state in Greece: M. Santamouris, NKUA
Presentation of the current state in Spain: J. Marti, CIMNE
Presentation of the current state in Italy: L. Pagliano, Politecnico Torino
Discussion
Session 5 - Chairmen: P. Wouters – M. Atif
Presentation by IBPSA: J. Hensen, IBPSA
Presentation by ES-SO: W. Beck, ES-SO
Presentation of THERMCO Project: D. Kalz, Fraunhofer-ISE
Presentation of the current state in France: J.R. Millet, CSTB
Presentation of the current state in Germany: H. Erhorn-Kluttig, Fraunhofer-IBP
Synthesis on summer comfort and cooling : M. Liddament, IJV

Program of the ASIEPI workshop n°2

All presentations from the workshop are available on the AIVC website (> link)

5.6 INFORMATION EXCHANGE WITH OTHER INITIATIVES

(1) The EPBD Buildings Platform (BUILDUP, > link) is the official EU information channel for EPBD related issues. Most material produced from the ASIEPI project has been uploaded on the BUILDUP website and is available for public downloading. In addition, other documents relevant to the ASIEPI content have been uploaded to the website. The keywords ASIEPI and EPBD are used to help locate these documents easier, amongst all the other documents not relevant to the topic of this project.

(2) A webex session for CA participants took place on March 15th, 2010. The recommendations on the implementation of better summer comfort and efficient cooling in national procedures, resulting from ASIEPI were presented, along with the other recommendations of the entire ASIEPI project.

(3) A number of common meetings were organized among IEE projects CENSE, ThermCo, Commonsense and ASIEPI to discuss project results and exchange knowledge on summer comfort.

Information on summer comfort and cooling was also exchanged with the COMMONCENSE project (Michael Hutchins) and the HARMONAC project (Ian Knight) at the ASIEPI web event 6 “Thermal comfort and cooling in the air of climatic change”. Feedback on the ASIEPI results from presentations was given by the BBRI and the NKUA (§5.4.2).

5.7 CONFERENCES

An abstract on the work on summer comfort and cooling in the ASIEPI project has been submitted for presentation at the 3rd Passive & Low Energy Cooling for the Built Environment (PALENC) international conference (> link). The conference is jointly organized with the 5th European Conference on Energy Performance & Indoor Climate in Buildings (EPIC 2010) and the 1st Cool Roofs Conference. It will focus on the application of passive cooling techniques in the urban environment and in buildings with emphasis on heat mitigation techniques.

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I E E S A V E A S I E P I

Part C. Information Papers

on

Stimulation of better summer comfort and efficient cooling by EPBD implementation

P163
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ASIEPI

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More information can be found at the ASIEPI project website: *www.asiepi.eu*

Similar Information Papers on ASIEPI and/or other European projects can be found at the individual project websites and in the publications database of the BUILD UP Portal: *www.buildup.eu*

Summer comfort and cooling: calculation methods and requirements

Summer comfort and the energy consumption for cooling are a growing point of attention, not only in Mediterranean climates, but also in the more moderate summer climates of central and northern Europe. This paper summarizes the results of a survey of a dozen European countries with respect to the handling of these aspects in the national/regional EPB-regulations.

1 > Survey method

Until recently, the focus of many EPB-regulations and much standardisation work has more strongly been on the energy consumption for space heating. However, in recent years growing attention is being given to the aspect of summer comfort (if possible without active cooling) or to the energy consumption caused by cooling. Nevertheless, it is clear that, generally speaking, the methods for summer comfort and cooling are not yet as advanced as the methods for space heating, where several decades of operational experience have led to proven and mature calculation methodologies and requirements.

In the framework of the IEE-ASIEPI project an inventory has been made of the state of the following aspects in the EPB-regulations of several European countries:

- the way in which the energy consumption for cooling is calculated
- the way in which summer comfort is evaluated, if at all
- any explicit requirements that are imposed with respect to summer comfort and/or cooling

The main findings are summarized in this paper. The following countries have been surveyed: Belgium, Germany, Spain, France, Greece, Italy, the Netherlands, Poland (state in the summer of 2008), and in a second round additionally Hungary, Ireland, Lithuania, Romania and UK (state in the winter of early 2009). Sometimes the answers referred to draft calculation procedures or legislations that were not yet in force.

There were no Scandinavian countries in the survey, as it was thought beforehand that cooling and overheating were not an issue in this climate. Nevertheless, these countries afterwards orally reported that summer comfort is becoming a growing point of attention in this region too. They attribute this to different factors: larger glazing areas in recently constructed buildings, the mild outdoor summer temperatures that lower the acceptable indoor comfort temperature for overheating (adaptive comfort) and the long summer days with low solar positions generate a lot of solar gains.

Intelligent Energy Europe

It goes without saying that the EPB-regulations in the different countries are still in full change. This is all the more true for a relatively new domain such as summer comfort and cooling. This paper therefore gives only a snapshot of a rapidly evolving situation.

During the survey, it has been observed that a lot of misunderstandings occurred among the different countries when exchanging information. Although this is a more general experience when exchanging international experiences with respect to the EPBD, the problem proved to be particular difficult for cooling. In part, this can be ascribed to the fact that until recently there was little international standardisation that provided common concepts and uniform terminology. It is hoped that as the sector gradually becomes more familiar with the new European standards, this communication problem will become less severe.

2 > Calculation methods: cooling

This paragraph gives a succinct overview of the situation in the different countries at the time of the enquiry. The inventory has focussed on the variables that enter as input in the calculation methods: these determine the degree of design freedom and the stimuli that the EPB-regulation generates.

The full information collected on this topic can be consulted in ref. [1].

General features

At the time of the enquiry 9 out of 13 countries reported to have already an EPB-regulation in place. Countries without were mostly situated in southern and eastern Europe, but most of them were working intensely on the preparation of a regulation. In the remainder of this chapter only the 9 countries with an EPB-regulation will be considered. In a few instances, the EPB-regulation related only to housing but not (yet) to (all) non-residential buildings, or vice-versa.

In line with the EPBD, in the 9 countries with a regulation, the consumption for cooling is always taken into consideration, albeit sometimes in an incomplete way or in a manner that is to a greater or lesser extent simplified. Monthly calculations were used in 5 cases, hourly in 4. Each time, the same method (monthly or hourly) is used for both the building and the system calculations.

Only in 2 out of the 9 countries is the EPB-requirement relaxed if cooling is applied, i.e. an extra allowance for the cooling is provided. In the other countries, the extra consumption for cooling must thus be compensated by better energy efficiency in other areas such as heating, lighting, etc.

In 4 countries there is some form of fictitious cooling consumption considered if no active cooling system is installed, e.g. in the instance when the risk of overheating is considered to be too high. This may be a sort of anticipation that active cooling could be installed later in the course of the building life cycle when the overheating problems manifest themselves. Ref. [1] gives an English description of the method as applied in Belgium. By already including such fictitious cooling from the start, designers are stimulated to pay proper attention in each and every one of their projects to the summer behaviour of the building.

Calculation methods: energy needs

The input variables in the 9 countries are as follows:

- thermal mass: all countries consider sensible heat storage, albeit sometimes in a simplified manner. But none includes latent heat storage (through phase change materials) as yet.
- solar irradiation: apart from 1 country, all determine direct, diffuse and ground reflected radiation separately.
- solar gains through transparent envelope components: obviously, the g-value of the glazing, the area, slope and orientation of the windows and the shading by fixed objects are (quasi) always considered. All 9 countries also report that solar protection devices, both mobile and fixed ones, are taken into consideration.
- solar gains through opaque envelope components: 5 countries report that these are (partly) taken into account, e.g. for non-residential buildings and/or roofs only. In such instances, the absorptance and U-value are usually input variables (but sometimes the absorptance is fixed).
- transmission heat transfer: only 2 countries report that the calculation is different between winter and summer calculations. In Belgium, in the case of a simple penalisation of thermal bridges, the default value (which as a matter of principle is always negative) is different: high in winter, zero in summer. In the Netherlands, the ground losses are treated differently in winter and summer.
- heat transfer through the hygienic ventilation system: only 5 countries report that air handling units are calculated on the basis of a separate heat balance, although obviously this is physically important. If calculated by itself, sensible and latent cooling and reheat are then generally considered in detail. In both these and in the other countries, heat exchanger by-passing, direct or indirect evaporative cooling, night-time operation or ground heat exchangers are only occasionally considered.
- heat transfer through intensive ventilation: although this is a major means of removing excess heat (only at night on hot days, both during the day and at night on mild days), only 4 countries report to have it in the calculation method, but mostly in a strongly simplified, nearly fixed manner. Only France includes detailed input variables such as the area of the (supply and evacuation) openings (or stacks) and their flow characteristics, and mechanical extraction (including its electricity consumption).
- heat transfer through in/exfiltration: usually the airtightness is considered when calculating the consumption for cooling, and generally speaking a measurement of the airtightness can then serve as an input (instead of a default or estimated value). In only 3 countries the default value is reported to be different between heating and cooling calculations. In Belgium for instance, it is 12 $m^3/h/m^2$ of envelope area (i.e. very leaky) for space heating calculations and 0 $m^3/h/m^2$ (i.e. the theoretical limit value of perfect airtightness) for space cooling calculations, in line with the general philosophy of a default value.

Calculation methods: systems

The great variety of distribution and emission systems is not always included in the method, and if so, often in a simplified manner. Sensible thermal cold storage (e.g. chilled water tanks) is only considered in 2 countries, latent storage (e.g. ice banks) nowhere.

The generation efficiency of a cooling machine is usually included as a matter of principle, but sometimes in a very simplified manner such as a fixed value. Otherwise, a machine dependent EER or SEER is used.

If sorption cooling is considered at all, it is usually only for closed cycles. Open cycles (such as desiccant cycles) are only rarely integrated in the calculation method. In both instances, heat supply with conventional boilers or direct firing, cogeneration or district heating is commonly considered, but solar heating only rarely.

Passive means of centrally (i.e. in parallel with, or fully replacing cooling machines) disposing of excess heat are considered in a very variable manner. Surface water (from river or lake or sea) as natural heat dump is never considered in the standard calculation method. Heat rejection to the ambient air by means of a dry or wet cooling tower is only considered in 2 countries. Only 3 countries consider the ground (by means of ground water, closed-circuit boreholes, heat exchangers in pillar foundations) as heat dump in the standard method. Radiative cooling to the night sky (which is only effective in dessert-like conditions, with clear, dry night skies) is not considered in the calculation method of any European country.

Finally, the auxiliary energy consumed by pumps, fans and control & actuators is generally speaking more or less taken into account.

3 > Calculation methods: summer comfort

Of the 9 countries that had an EPB-regulation at the time of the enquiry, 5 reported that the regulation included some kind of evaluation of the summer comfort. But the summer analysis did not necessarily apply to all types of buildings. Usually, an explicit requirement was associated with the analysis. The detailed situation was as follows:

- Belgium:
  - dwellings only (whether with or without air conditioning)
  - a maximum allowable value is imposed
  - if the indicator is in the range between a threshold and the maximum, fictitious cooling consumption is taken into account
- France:
  - all non air-conditioned buildings
  - a maximum allowable value is imposed (namely that of a reference building with reference technological measures)
- Germany (in the form of a “solar gains indicator”):
  - dwellings only
  - a maximum allowable value is imposed
- Ireland:
  - both domestic and non-domestic
  - no maximum, only as indicator
- the Netherlands:
  - dwellings only (whether with or without air conditioning)
  - no maximum, only as indicator
  - there is always fictitious cooling, only depending on the cooling needs, independent of the overheating indicator

In several of these countries, there was work in progress to extend the method, e.g. to all types of buildings.

Apart from a few exceptions, the same variables as for cooling calculations are considered for evaluating the risk of overheating on "room" level. However, none of the countries incorporates as yet passive cooling techniques with a central heat dump (ground, surface water, ambient air through a heat exchanger etc.) in the overheating analysis.

4 > Requirements

In addition to an overall EPB-requirement, there may be requirements specifically related to summer comfort and air conditioning. These requirements can cover global, intermediate or individual aspects of the building performance. The actual values are commonly dependent on the climatic zone and/or the building type. The requirements of a certain country can include simultaneously limiting values of different aspects and/or at different levels.

The most global level refers to the overall energy performance of the building, in which the cooling energy (or CO_2 emissions for cooling) is included. The minimum requirement is expressed as a limiting value of the overall energy consumption (or of the CO_2 emissions) of the building.
The second level covers the energy efficiency use by use. In this case a minimum efficiency of the combined effect of the building envelope and the cooling system is fixed. Consequently, if the building is air conditioned, the minimum requirements, at this level, can be referred to limiting values of:

- Cooling energy consumption (final or primary energy).
- CO_2 emissions for cooling

In a third level the effect of the envelope and the HVAC systems can be independently limited. In this level, if the building is air-conditioned, the minimum requirements can refer to:

- Maximum cooling needs allowed.
- Minimum efficiency (probably nominal EER) of the cooling system allowed.

Alternatively, if no cooling system exists, the minimum requirements can refer to an overheating indicator. In this case, the limit value of the indicator is used to demonstrate that cooling will not be necessary.

Another possible requirement at this level is to fix a certain percentage of the cooling needs that have to be covered by renewable energies.

In the fourth level, the cooling demand (or the overheating) is limited in a very indirect way, by limiting some relevant parameters that influence them, such as:

- A reduction of the solar gains
- A modulation of the solar gains
- A dissipation of the solar and internal gains via ventilation losses.

In the ASIEPI project, a survey has been made regarding present summer comfort and energy requirements in the national building regulations. A summary of the results can be seen in the table below, for the four levels of requirements previously described. A more detailed description is given in ref. [3].

In general, it can be seen that cooling is included in the global requirement as a source of energy consumption or CO_2 emissions.

However, no country has specific requirements regarding cooling as an independent energy use and only two countries (Spain and Portugal) include a limitation of the cooling needs of the building. Greece is the only country that states specific requirements with respect to the efficiency of cooling machines (i.e. a minimum EER for each type of device, e.g. for split units, for air cooled chillers, etc.). In Spain, there is under certain conditions an obligation to incorporate free-cooling and/ or recuperation of the energy in the exhaust air.

	Spain	Netherlands	Belgium	France	Portugal	Germany	Poland	Italy	Greece	U.K.	
1. Limitation of the overall energy performance or CO_2 emissions of the building including cooling	NO	YES	YES	YES	YES	YES	NO	NO	YES	YES	7/10
2. Independent limitations for cooling	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	0/10
3.1 Limitations of the cooling needs	YES	NO	NO	NO	YES	NO	NO	NO	NO	NO	2/10
3.2 Prescriptions regarding the use of renewable energies for cooling	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	1/10
3.3 Requirements regarding the efficiency of cooling system	YES	NO	NO	NO	NO	NO	NO	NO	YES	NO	2/10
3.4 Requirements regarding summer comfort in case of non-air conditioned buildings	NO	NO	YES	YES	NO	YES	NO	NO	NO	NO	3/10
4.1. Limitations of the glazed area	YES	NO	NO	NO	NO	NO	NO	NO	NO	NO	1/10
4.2 Requirements regarding solar protection	YES	NO	NO	YES	YES	YES	YES	YES	YES	YES	8/10
4.3 Other requirements for summer comfort	NO	NO	NO	NO	NO	NO	NO	YES[1]	NO	NO	1/10

An issue warranting particular attention is the treatment of summer comfort. Only Germany (for non-air conditioned buildings) and Belgium (for dwellings) have explicit limitations of the overheating. France addresses an indirect limitation of the overheating risk via the reference building.

In other countries, for non-air conditioned buildings, avoiding overheating is vaguely treated in the form of recommendations but not as a mandatory issue. In some countries when overheating appears, there is a penalty of the energy consumption via a virtual cooling system.

Although solar control is mentioned in most questionnaires, specific mandatory solar control requirements are only explicit in two of the countries, namely Germany and Portugal.

In general, it seems that although the concepts to be dealt with regarding summer comfort and cooling are known, fixing them as mandatory requirements is a very difficult (or unnecessary) task and recommendations are largely preferred. This is the case for issues such as night ventilation or thermal inertia which do not appear as requirements but as recommendations except in Italy where thermal mass is required beyond certain levels of mean irradiance during the hottest month. This position is quite understandable due to the fact that both issues are time dependent and very difficult to quantify in a consistent way.

Even the relative approach which defines the requirements via the reference building can also be seen as a way of providing recommendations about how to get the target. The real building can completely ignore such recommendations and compensate the extra cooling with other energy uses.

From the table it is clear that the countries strongly focus on solar protection as requirement. All other potential levels get much less attention.

[1] See in the text for further explanation.

5 > Summary and recommendations

Cooling calculation methods

Although a good deal of attention is already given to the consumption for cooling in the national/regional EPB-regulations, the methods usually cannot fall back on the same decade-long experience and detail that exists for space heating calculation methods in the framework of regulations. Generally speaking, the continued further refinement of the methods is therefore warranted so as to better evaluate the consumption of all possible means of cooling, including and in particular the low energy methods.

By not giving an extra allowance for the maximum allowed primary energy consumption in the case active cooling is applied (as compared to the situation without active cooling), the countries can stimulate that a cooling system as efficient as possible is applied and/or that the extra consumption for cooling is compensated for by extra savings in other domains (heating, lighting, etc.). All but 2 of the surveyed countries report to already follow this approach.

In addition, nearly half of the countries also consider a kind of fictitious cooling in some way or another. In this instance, even though no active cooling is installed, a (fictitious) consumption for cooling will nevertheless be considered, in particular when the risk of overheating is high. This takes into account that cooling may be installed later on during the life cycle of the building. It thus stimulates that also in buildings without active cooling proper attention is given to the summer situation, and that the design does not focus exclusively on minimising space heating needs in winter (through maximising solar gains), to the detriment of summer comfort. The inclusion of fictitious cooling also facilitates the application of the above rule that the EPB-requirement is made independent of whether or not active cooling is installed. It can thus be advised to all countries to consider whether integrating such fictitious cooling could also be productive in their country.

With respect to the calculation procedures, it is important that all aspects that have an impact on the cooling consumption, are integrated in the methods, in particular those variables that can contribute to the reduction of the consumption and that are cost-effective in a given country. Practically speaking, the following techniques are not yet well developed in the calculation in many countries and these techniques may deserve priority attention:

- Intensive ventilation, taking into account the sizing and real performance characteristics of the components (e.g. the flow features of ventilation openings). The new European standards that have been developed in recent years on this topic may provide a good starting base for national procedures.
- Active cooling devices (whether electrically or thermally driven) often still deserve better treatment by the inclusion of real product characteristics in the methods (EER, or better SEER) instead of simple, fixed performance numbers.
- Also, natural, passive cooling is not yet well developed for central heat dumps (thus discharging the cooling machines, or even making them superfluous).
- Further more, a great number of smaller variables are not yet systematically considered in the methods. These should not be forgotten in any future update of methods.

Attention should also be paid to the proper setting of default values, which by nature are on the negative side in most countries. However, what is negative may differ between heating and cooling calculations, and so a differentiated approach is often justified, certainly for the variables that have a major impact, e.g. air tightness and thermal bridges. In this manner, the right rewards continue to be given to proper design choices.

Evaluation of the summer comfort

About half of the countries surveyed already include some kind of evaluation of the risk of overheating in their EPB-regulation, but none of these countries is a truly Mediterranean country. However, the analysis was rarely systematic for all types of buildings.

It can be recommended that those countries already having an overheating analysis evaluate whether it isn't appropriate to extend it to all buildings (if not yet done so) and to include forms of central passive cooling.

The other countries can be advised to investigate whether an overheating analysis could not be useful for them too. It may be a means to strongly stimulate the attention which is being paid during design to the summer situation. In addition, it will draw attention to the passive cooling means to avoid overheating. Thus, the chance that an active cooling system will be installed later on in the building life cycle, can be reduced, and if it happens nevertheless, the cooling consumption will be much lower if the building has been designed with due attention to the summer situation.

Requirements

In order to reduce the energy consumption for cooling and to promote the use of passive cooling concepts and strategies and in order to anticipate undesirable effects of global warming, it is strongly recommended to set:

- A global requirement of energy consumption and/or CO_2 emissions in which cooling must be obviously included.
- Additional requirements limiting the cooling needs for air-conditioned buildings.
- Additional requirements for non-air conditioned buildings limiting the overheating risk or, in a complementary way, clear indicators that allow identifying the necessity or not of air conditioning (for both residential and non-residential buildings).
- The inclusion of such indicators about summer comfort should be based on indoor temperature levels consistent to the adaptive comfort criteria of EN 15251.
- If practically feasible in the context of the national EPB-regulation, the inclusion of such indicators about summer comfort should be based on hourly calculations of the indoor temperatures at a zone level, due to the huge temperature differences that can exist between zones of the same building.

The use of additional requirements on a component level (shading factors) or the necessity of using certain strategies (ventilation rates or thermal inertia) is not recommended in general. It is considered that requirements that are too prescriptive reduce the free choice for alternative methods that may achieve the same result and that may be better feasible in a given individual project (in terms of practical application, cost effectiveness, personal preferences of the owner, etc.).

The use of the absolute (fully performance) approach or the relative (reference building) approach to state the requirements have no specific aspects for cooling or summer comfort. Consequently, there are no special recommendations about the way of defining the requirements.

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Link: www.asiepi.eu

Original text language: English

6 > References

1. D. Van Orshoven, "ASIEPI survey of the EPB-determination methods for cooling and summer comfort." XL-file. Published February 2010.
   see: *www.asiepi.eu*
2. A. Van Eycken, D. Van Orshoven, G. Flamant, P. Wouters
   "Some Aspects Regarding Summer Comfort and Cooling in Belgium"
   Presented at the international workshop, "Summer comfort and cooling", Barcelona, Spain - 31 March & 1 April 2009
   see *http://www.asiepi.eu/wp-7-summer-comfort/workshop.html*
3. Servando Alvarez , ASIEPI report "Additional requirements related to summer comfort and air conditioning" Published January 2010.
   see: *www.asiepi.eu*

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French handling of alternative cooling techniques: free cooling and ground heat exchanger

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More information can be found at the ASIEPI project website: *www.asiepi.eu*

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There are a lot of alternative cooling techniques that improve substantially the summer comfort without (or in a very limited manner) increasing the energy consumption. For example solar and thermal control techniques, heat amortization and heat dissipation techniques. Most used techniques in France are free cooling in office buildings and ground heat exchanger in dwellings.

This paper focuses on providing general information describing the implementation of EN 15241 and EN 15242 into French regulation to evaluate passive cooling based on ventilation. It contains an explanation of the calculation method with detailed information on input and output data.

1 > Handling of free cooling due to windows opening by implementing EN15242

In the past, buildings were ventilated naturally. With an increased awareness of the cost and environmental impacts of energy use, natural ventilation is again becoming an increasingly attractive technique for reducing energy use and cost and for providing comfortable indoor climate.

During practically all the summer period, the outside air can be a source of coolness from evening to morning. So, in the case of a building with an important inertia, a night over-ventilation enables the evacuation of heat stored up in daytime. Figure 1 presents the effect of inertia for different types of buildings in France.

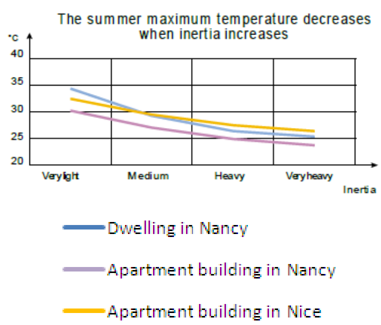

Figure 1: Effect of inertia.

The EN 15242 standard describes the methods to calculate ventilation airflows rates for buildings to be used in applications such as energy calculations, heating and cooling load calculations, summer comfort and indoor air quality evaluations. This standard is implemented into French regulation for new buildings called RT2005.

The method is meant to be applied to:

- all types of buildings;
- not directly applicable to buildings with a height greater than 100 m or for rooms where the vertical air temperature difference is greater than 15K;
- not applicable to kitchens preparing food that is not for immediate consumption;
- not applicable to industry process ventilation;
- automatic windows opening are not considered by this standard.

The input parameters and the calculation method can be adjusted or complemented for these different applications. Clause 7 of the standard explains what must/can/should be taken into account for each application, and which method should be used in each case.

Three methods are proposed in the standard:

1 - Direct method

The calculation of mechanical airflows, combustion airflows and window opening airflows, are all based on systems characteristics, external conditions and design airflows. They do not depend on the internal pressure condition: the interaction between the ventilation systems and the leakages is neglected.

2 - Iterative method

The iterative method is required when the interaction between the ventilation systems and the leakages cannot be neglected. It is therefore proposed for passive duct ventilation.

3 - Statistical analysis for energy calculation

This method can be specified at the national level for energy calculations. The requirements for the methods are given in § 7.2.3.3 of the present standard.

As described below, the method proposed in the standard, and followed by French building regulation to calculate air flow through opening windows area and bottom hung windows are obtained through the **direct calculation method** (see: §6.5 of the present standard). It takes into account:

- the wind turbulence;
- the wind speed;
- stack effect;
- the inside and outside temperature;
- user behaviour.

For a single side impact, the airflow is calculated by:

$$q_{vairing} = 1800 * A_{ow} * V^{0.5}$$
$$V = C_t + C_w.(V_{met})^2 + C_{st}.H_{window}.abs(\theta_i - \theta_e)$$

With:

q_v (m³/h): air flow;

A_{ow} (m²): window opening area;

$C_t = 0.01$ takes into account wind turbulence;

$C_{st} = 0.0035$ takes into account stack effect;

$C_w = 0.001$ takes into account wind speed;

H_{window} (m): is the free area height of the window;

$V_{met}(m/s)$: meteorological wind speed at 10 m height;

θ_i : room air temperature;

θ_e : outdoor air temperature.

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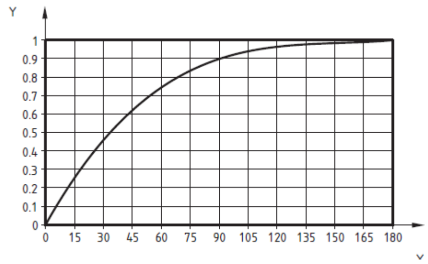

α [°] (X)	$C_k(\alpha)$ [-] (Y)
0	0.00
5	0.09
10	0.17
15	0.25
20	0.33
25	0.39
30	0.46
45	0.62
60	0.74
90	0.90
180	1.00

Figure 2: A polynomial approximation for $C_k(\alpha)$

Table 1: Constant values.

Cross ventilation	0.01
Ventilation	0.001

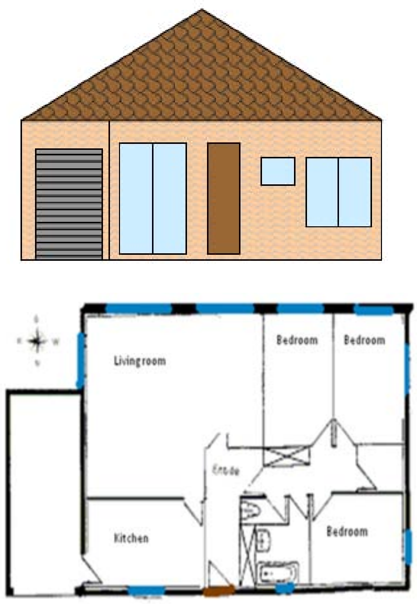

Figure 3: Studied house.

For a bottom hung window, the ratio of the flow through the opened area and the totally opened window is assumed to be depending only on the opening angle α and independent of the ratio of the height to the width of the window.

$$A_{ow} = C_k(\alpha).A_w$$

Where A_w is the window area totally opened.

For $C_k(\alpha)$, a polynomial approximation is proposed in the standard (see Figure 2).

In France, the opening area evolves linearly against operative temperature inside the interval $\theta_{op\,\min}$=20°C and $\theta_{op\,\max}$=24°C, with:

For $\theta_{op} < \theta_{op\,\min}$, $A_w = 0$

For $\theta_{op} > \theta_{op\,\max}$, $A_w = A_{window}$

Cross ventilation is taken into account thought constant values for $C_t.(V_{met})^2$ (see Table 1).

$C_k(\alpha)$ depends on building type, maximal opening, noise and time. The values used in the French regulation RT 2005 are identical for residential and sanitary buildings and are summarized in the table below.

Table 2: $C_k(\alpha)$ values for residential and sanitary buildings.

Noise's category	From 8 p.m to 7 a.m	From 7 p.m to 9 a.m	From 9 a.m to 8 p.m
BR1	0.7	0.7	0
BR2-3	0.21	0.49	0

For all other building types, values are presented below.

Table 3: $C_k(\alpha)$ values for other building types.

Noise's category	Inoccupation	Occupation
BR1	0	0.3
BR2-3	0	0.3

To present the effect of windows opening using this model, we performed a calculation for a typical French dwelling in Carpentras (See Figure 3). The useful surface of this building is 100 m² and the surface of windows is 16.74 m². Results obtained are summarized in Table 4.

Table 4: Results of simulations in Carpentras.

Inertia	$C_k(\alpha)$	Maximum indoor temperature
light	0.7-0.7-0	32.6
medium	0.7-0.7-0	30.4
heavy	0.7-0.7-0	28.9
light	0.21-0.49-0	33.2
medium	0.21-0.49-0	31.3
heavy	0.21-0.49-0	29.8

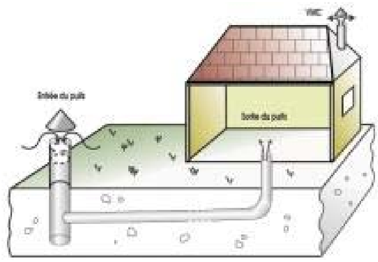

Figure 4: Principle of ground heat exchanger

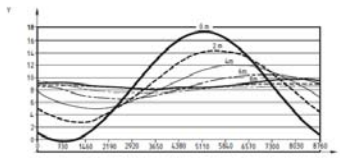

Figure 5: Ground temperatures for several duct depths (X: annual hour, Y: Temperatures)

As expected, to ensure comfortable conditions, the maximal opening and a heavy inertia are the most efficient combination.

2 > Handling of ground heat exchanger by implementing EN15241

The earth remains much more cooler than the air in summer. This coolness can be used by means of earth cooling tubes (see Figure 4). These are underground tubes through which ventilation air is circulated. The ventilation air is hereby reheated in winter and cooled down in summer.

An earth cooling tube must be correctly designed for better efficiency and for easier maintenance in order to avoid any health risk related to the quality of air.

Annex A of this standard describes a simplified model to calculate air precooling due to supplying air through ducts lying in the ground. The model calculates:

- leaving air temperature of the heat exchanger;
- heat flux between ground and air in duct.

The model takes into consideration the specific duct parameters and the inertia of the ground, depending on the depth of the ducts in the ground. Also the ground material is taken into account by a correction factor for the ground temperature. This model will be implemented into the next French regulation scheduled for 2012.

In this model the ground temperature depends on two parameters:

- the annual mean outside temperature;
- air temperature and the depth of the ducts.

The ground temperature is modelled as a sinus curve based on the annual mean outside air temperature. The depth of ducts corrects the sinus curve in two ways:

- the amplitude decreases in function of the depth;
- the ground temperature is retarded in function of the depth. It means the inertia of the ground increases in function of the depth.

The ground temperature depends on the annual mean and the amplitude of the annual swing of the outside air temperature at the building location, and on the depth of the duct in the ground (see Figure 5). To take into consideration the inertia of the ground, the outside air temperature is corrected by *AH*, *VS* and *gm*.

AH corrects the amplitude, depending on the depth of the ducts lying in the ground.

$$AH = -0.000335.depth^3 + 0.01381.depth^2 - 0.1993.depth + 1$$

VS corrects the ground temperature by a time shift, depending on the depth of the ducts lying in the ground.

$$VS = 24.(0.1786 + 10.298.depth - 1.0156.depth^2 + 0.3385.depth^3 - 0.0195.depth^4)$$

Table 5: gm values.

G. material	gm
Moist soil	1
Dray sand	0.9
Moist sand	0.98
Moist clay	1.04
Wet clay	1.05

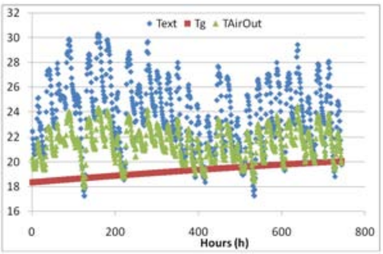

Figure 6: Potential of heat ground exchanger in Nice during August

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Finally, the air ground temperature is calculated as follow:

$$T_G = gm.\left[T_{AM} - AH.\Delta T_A.\sin\left[\frac{2\pi}{8760}.[JH - VS + 24.25]\right]\right]$$

with ΔT_A being the amplitude of the annual outside air temperature swing.

Some *gm* values for soil materials are proposed in this standard (see Table 5).

The leaving air temperature is calculated with the formula:

$$T_{AirOut} = T_G - (T_G - T_{AirIn}).e^{\left(\frac{-U_e.AS}{M_{air}.Cp_{air}}\right)}$$

With:

U_e : Transfer coefficient of the air duct
Cp_{air} : specific heat capacity of air
M_{air} : Dry air mass flow rate

Finally, the air ground temperature and leaving air temperature can be calculated. Figure 6 presents an example of potential of this technique in the south of France during August. The air outlet from the duct is much cooler than external temperature.

3 > Acknowledgements

Different national contributions were made by many of the project partners. The partners are all listed on *www.asiepi.eu*.

4 > References

1. EN 15241: Calculation methods for energy losses due to ventilation and infiltration in commercial buildings.
2. EN15242 Calculation methods for the determination of air flow rates in buildings including infiltration.

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Advanced solar shading devices can include a redirection of daylight into the depth of the room.

Innovative Solar Control Devices

Buildings are the EU's largest energy users, consuming over 40 % of Europe's total primary energy. One way of cutting this consumption is by avoiding or reducing cooling energy through proper solar shading. This paper presents examples of innovative solar control devices and emphasizes their relevance for the energy performance of buildings.

1 > The impact of solar control devices on the energy performance of buildings and indoor comfort

In its simplest form, solar shading is any device which excludes sunshine from a building, like a curtain or an awning for example. However, there is an extremely wide variety of solar shading products available which range in function and sophistication.

Solar shading controls the amount of heat and light admitted to a building. By doing so, solar shading devices contribute to saving energy in various areas. They can reduce the need for heating or air conditioning by maintaining a more even temperature despite varying climatic conditions. They can also cut the amount of energy required for lighting, by admitting more light during overcast conditions for example.

Besides the thermal and energy aspects, solar shading leads to better visual comfort. Glare reduction will improve working conditions in offices, reduce sick leave, increase productivity and contribute to health and safety at work. Solar control devices are also necessary on the North facade on certain buildings in order to prevent glare problems.

The Energy Performance of Buildings Directive *[1]* requests to include solar shading devices into the general framework for the calculation of the energy performance of buildings in the Annex as follows:

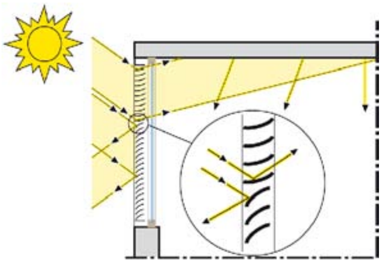
> *1. The methodology of calculation of energy performances of buildings shall include at least the following aspects:*
>
> ...
>
> *(g) passive solar systems and solar protection;*
>
> ...

2 > The range of solar shading products

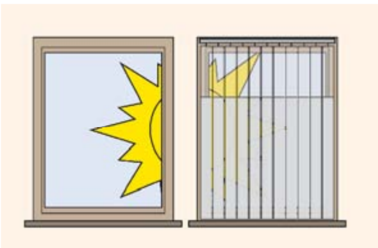
There is a wide range of solar shading products on the market. They're available for both external and internal installation and can be fitted to new buildings or retro-fitted to existing buildings during a renovation.

The best known exterior products include sun awnings, vertical roller blinds and roller shutters, but the industry makes other products to measure depending on the requirements of the individual application.

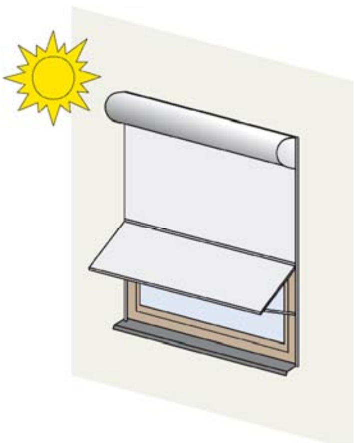
Intelligent Energy Europe



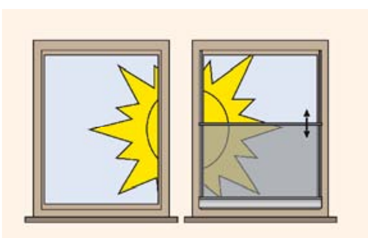
Scheme of blinds with daylight redirection function.



Scheme of a two-section vertical interior blind which allows daylight transmission in the upper part while shading in the lower part.



Markisolette, a combination of screen and awning, allows a direct view to the outside while the shading device is in function



Translucent foil closed from the bottom to the top to allow for daylight penetration.

Internal products come in an even wider variety of types and comprise venetian blinds, roller blinds, pleated and Roman shades and blackout blinds to name a few.

Some systems are designed to provide insulation as well as shading, and all can be automated to offer optimum performance.

3 > Innovative developments

Innovative systems are distinguished by their ability to optimally ensure the required solar protection in combination with other functions of the window, like supplying the rooms with daylight and allowing the view to the outside. Preferably, they also reliably protect the workplace from glare. In the following, a selection of innovative solutions is presented. The sample is not exhaustive but shall demonstrate the diversity of innovative solutions in practice.

Blinds with daylight redirection function

Using a two-section slatted blind, incident light can not only be excluded or reduced, it can also be controlled in a differentiated way and even be guided into a desired direction. On the one hand, these systems provide sun-free and glare-free zones, on the other hand they grant sufficient luminance. They combine privacy (protection from curious glances) with a view to the outside.

Blinds operated from the bottom to the top

Some manufacturers offer metallic external venetian blinds that push up from the bottom edge of the window instead of lowering from the top. The advantage of this system is that the upper part of the window, which is ideal for daylighting, is free of shading. Daylight access in the room can thus be optimized.

Markisolette

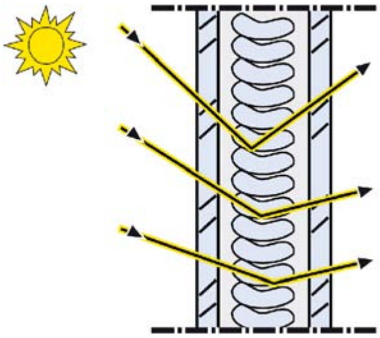
A markisolette combines the functions of a window awning with those of a screen. It drops vertically to the required height, then it is angled out from the facade. The advantage is that the upper part screens the disturbing light and heat, while the lower part allows open views to the outside. The system can be used with high windows, extends a short distance from the wall (usually about 60 cm) and is relatively wind resistant [2].

Translucent foils

High-reflectance embossed foils are mounted on the interior side of the window frame. The metallic coatings are so fine that it is possible to see through the material. The foils are operated from the bottom to the top. Thus the shading effect is perceived at first in the field of vision, which prevents glare effects (for office working spaces and similar). The upper part of the window can still be used for supplying daylight to the room. The foil systems are available with electric drives and controls or for manual operation. Sun shading and glare protection devices blend in with the panoramic view - despite effective solar and glare protection the panorama remains visible through the closed foil and the daylight can still be used.

Solar control devices in combination with daylight redirecting glazing

In addition to the two-section blinds there are also other solutions, which combine blinds with a static daylight-redirection element. This is usually realised in a window element that is split in two parts. In the upper part (with about 50 cm height) daylight redirecting glazing is installed while the lower part is a regular window with a standard solar control device.



Schematic drawing of daylight redirecting glazing.

Photo of a combination of blinds with daylight redirecting glazing.

A semi-transparent shading system.

Photo of the Berlaymont building; headquarter of the EU Commission in Brussels. The façade of the building features glass slats that can be arranged similar to a double glazed façade.

Semi-transparent shading systems

Semi-transparent blinds and shutters function in analogy with translucent foils. One application is a rollable curtain made of stainless steel with slits to let through the light, further applications are roller-shaped, double-walled aluminium sections with light and ventilation slots. Sunshade and roller shutters in one.

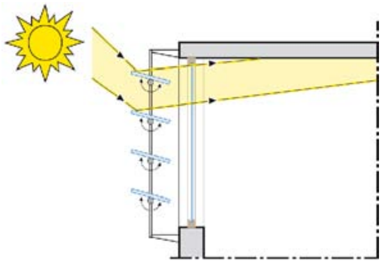
A similar effect can be achieved with stainless steel woven mesh. Due to its micro-texture the mesh blocks solar rays with a much smaller incident angle (at angles of around 30° to normal position) as compared to a standard glass pane (typical for standard glass types a drop of transmission is observed at angles of around 60° to normal position). This allows for selecting a glass type with a high light transmission coefficient while still keeping solar energy transmission low.

During the day, it is possible to have a good view to the outside through the fabric, reducing the feeling of being shut in. Remember, however, that this works the other way round at night. With the lights switched on, people can look inside just as well.

Coated glass slats

Another type of transparent shading device are coated glass slats (lamellas), which are mounted in front of the facade. The coatings can be used for different functions. Depending on the inclination of the slats, the reflective coatings can exclude direct solar radiation or redirect it to the ceiling of the room behind the device. This allows for a variable control of the daylight in the room. Additionally, the slats can be used to save energy by adjusting them to a vertical position, thus creating an air buffer space similar to a double skin façade. By applying infrared-coating on the second surface of the glass slat, this effect can be significantly increased during cold winter nights as the heat emission to the cold outer space is reduced.

Photovoltaic foils can also be used for glass slat coatings. Using this option, part of the incident solar radiation can be converted into electricity. However, this usually results in a considerable heating of the glazing. Therefore the glass lamellas have to be ventilated well in order to ensure a



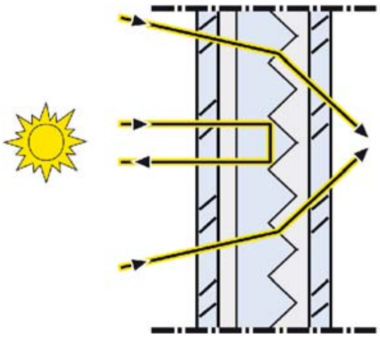
Schematic drawing of movable glass slats.

high efficiency of the PV elements and to prevent an indirect heat load of the rooms behind the shading device.

Thermotropic and photochromic glazings

The flow of radiation energy and lighting within the glazing can be dynamically adapted to the user-dependent requirements by using actively switchable layers. Self-acting switchable glazings fulfill their protective function without complex control equipment. So-called thermotropic or thermochromic materials change their optical properties when a certain temperature threshold is exceeded. With most systems, the clear layer at low temperatures will become white and light dispersive and reflects the incident radiation in a diffuse way. When integrating a thermotropic layer into a glazing it is possible to adapt the transmission of the glazing to the climatic situation. In a situation with undesirably high solar radiation and heat, the transmission property of the glazing is self-actively reduced. Themotropic layers can be realised with multiple different materials.

Electrochromic glazing represents a different type of switchable glazing. It is one of the best examples of “glass of the future”. In just a few seconds, it becomes either completely transparent or darkens in order to protect from the sun or to give a more subdued light. Switching is realised by a voltage change applied to a special foil on the glazed pane. Thus the systems require electrical power supply. When performing an energy efficiency assessment of the system, the necessary electrical energy has to be part of the balance.



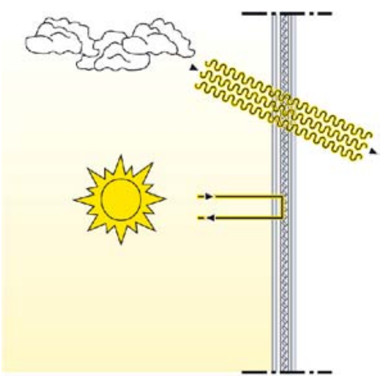
Schematic drawing of prismatic glazing.

PV coated slats

A further innovative development in the field of solar shading devices are slatted blinds with photovoltaic elements on the outside. The excluded solar energy is utilised for electricity production. Similar to the coated glass slats attention has to be paid that the slats are well ventilated in order to ensure high efficiency of the PV elements and to prevent the rooms from overheating.

Prismatic glazing

Prismatic glazing allows the total reflection, the redirection or the transmission of light depending on the radiation angle. To ensure the desired function, these systems have to be tracked according to the position of the sun. Due to the light refraction within the prism a shift of the colours of light may happen.



Total reflection of direct radiation with holographic optical elements.

Holographic films

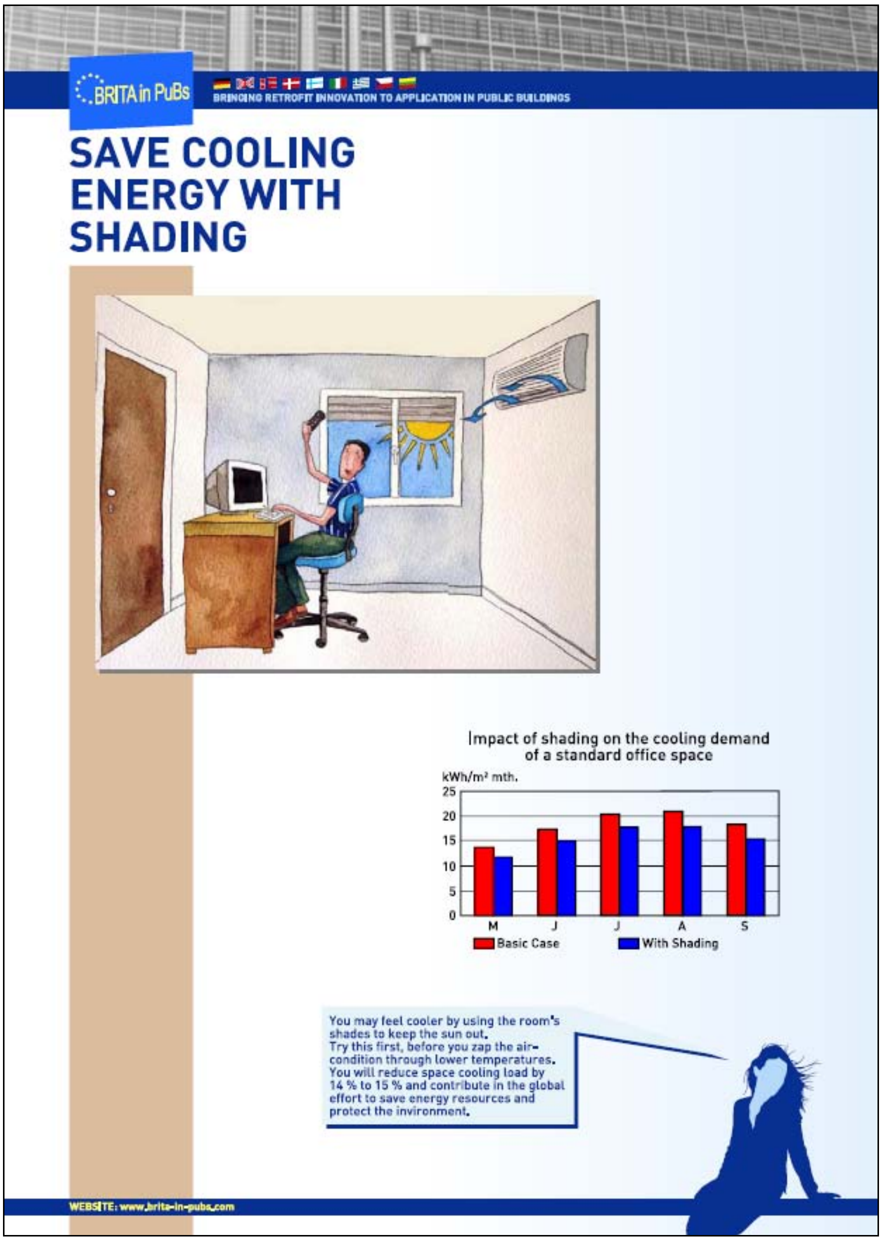
The use of holography makes it possible to transform solar shading devices into foil constructions that result in total reflection, redirection or transmission of sunlight, depending on the angle of incidence angle. The systems can only be applied in a static way and therefore have to be tracked according to the position of the sun.

4 > Motivation of the building users to operate shading systems correctly

It is useful to provide information on the correct handling of the shading system to the staff/tenants who will be using the building. If this is not done, experience shows that there is a real risk of complaints [2]. People do not always understand why the system behaves in a particular way, and this can cause irritation. But if people know why the system does certain things and that the reason is to save energy and improve the indoor climate, their criticism can usually be overcome. People can be informed in a meeting or by putting the information on an intranet. An effective longterm strategy is to use blackboard information sheets to inform everyone who may be affected.

Bringing Retrofit Innovation to Application – BRITA in PuBs. An EU FP6 ecobuildings project that among other things developed blackboard information sheets to support the improvement of users' behaviour. Website: www.brita-in-pubs.eu

The blackboard information sheet (BISH) on the next page was developed within the EU FP6 demonstration project BRITA in PuBs [3] and shall guide the building users to improve their behaviour in order to save cooling energy. A similar BISH is available for the use of daylight in combination with solar shading.



5 > Requirements for energy performance assessment methods

In order to deliver a reliable result, but also to allow for a bigger market penetration of innovative and high performance shading devices it is important that the national energy assessment methods can correctly assess innovative solar control devices, not only regarding the impact on the cooling energy need, but also regarding the influence on the available daylight and therefore the electrical lighting. A holistic approach within the energy performance assessment method is therefore required.

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6 > Summary and recommendations

Innovative solar shading and anti-glare protection can make an important contribution to energy saving in modern private and commercial buildings, whilst simultaneously improving the well-being of the occupants. Intelligent control systems ensure comfort and maximum benefits [4].

While designing a building (new or retrofitted) it is fundamental to analyse the users' needs and the building's necessities concerning solar protection. Then the shading device that fits best to the requirements has to be chosen from the available systems, either conventional or innovative. Is it possible to combine the shading element with other functions? Does it have to be a switchable system? Is an automatic system, a self-active control or manual operation to be preferred? Which system proved to be efficient under a certain climate?

National policy makers and standardisation bodies have to ensure that the energy performance calculation methods allow for correctly assessing high performance shading devices in terms of cooling energy need and over-heating problems, but also regarding the available daylight and the necessary electrical lighting.

It is recommended to provide information on the correct handling of the shading system to the staff/tenants who will be using the building in order to reduce the risk of complaints and to tap the full potential of energy saving and indoor comfort improvement of shading devices. Blackboard information sheets are a good example for user information and motivation.

7 > References

1. EPBD (2002). Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings, Official Journal of the European Communities, 04.01.2003.
2. Hall, A.: Planning, purchasing and installing solar shading in public buildings. Gothenburg April 2008. Available for download at *http://www.es-so.eu/documents/HandbooksolarshadingAH08.pdf*.
3. Blackboard information sheets – BISHes for improving the buildings' user behaviour. EU FP6 Ecobuildings project "Bringing Retrofit Innovation to Application in Public Buildings – BRITA in PuBs" (TREN/04/FP6EN/S07.31038/503135). Available for download in several languages at *www.brita-in-pubs.eu*.
4. ES-SO: Solar shading – Energy savings and comfort. Brochure, 2005. Available for download at *http://www.es-so.org/documents/ES-SO-Flyer.pdf*.

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Experience on Passive Cooling Heat Techniques for Buildings

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The EU energy consumption trend for cooling is continuously increasing. Once essentially limited in southern countries and in non-residential buildings, today cooling demand is an issue in central and northern countries, as well as in dwellings. This paper presents relevant experiences on passive cooling techniques, showing their potential in mitigating the cooling energy consumption and in improving thermal comfort conditions in non-cooled buildings.

1 > Introduction

Energy statistics show the increase of cooling demand throughout Europe, from Mediterranean to northern countries, the former with an impressive increase of the domestic cooling consumption. Beside the energy aspects, the global warming and the new constructions standards make the assessment of thermal comfort in not cooled buildings, necessary?/essential?. The *Energy Performance of Buildings Directive* [1] general considerations take note of this in paragraph (18). The relevant aspects to be included in the general framework for the calculation of energy performance of buildings are specified in points (g), (h), (i) of the Annex.

The aim of this paper is to present some experiences on passive cooling techniques and strategies, able to reduce cooling loads or improve the thermal conditions in buildings. The experiences presented in this paper were selected according to the most relevant passive solutions for buildings, in particular:

a. Night ventilation
b. Ground cooling
c. Evaporative cooling
d. Cool roofs
e. Green roofs

It should be noted that for many applications that were carried out throughout Europe, the results on the impact of such applications were often missing. Moreover some important techniques, like radiative cooling, are not presented in the paper because the lack of real experiences.

2 > Night ventilation

Night ventilation strategies use the cool external air to decrease the indoor air temperature as well as the temperature of the building's structure. The cooling efficiency of night ventilation is based mainly on the relative difference between the indoor and outdoor temperature during the night period, the air flow rate as well as on the thermal capacity of the building

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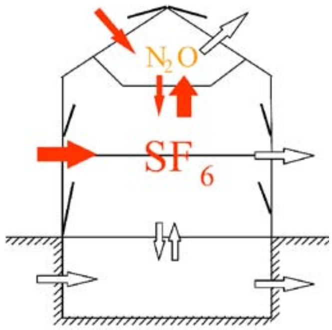
and the efficient coupling of air flow and thermal mass. Positive effects include: reduction of the indoor peak temperatures, reduction of the daily temperatures, especially in the morning; creation of a time lag between outdoor and indoor temperatures. Many applications were carried out during the past years, including direct and indirect night ventilation. The former is the direct cooling of air and structure surfaces temperature by the night fresh air, the latter the air circulated in a thermal storage at night.

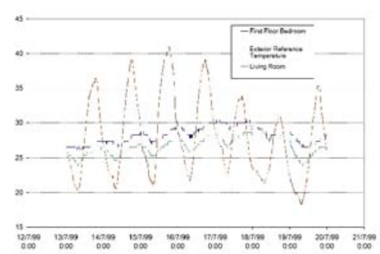


Gas tracer techniques for the night ventilation assessment in Pleaide, Belgium.

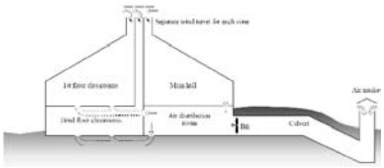
The Pleiade dwelling in Belgium is a typical example of direct night ventilation, one of the passive cooling solutions to be adopted in such buildings, which makes extensive use of passive solar gains in winter [2]. Horizontal and vertical structures of the building have an important thermal mass to optimise the night ventilation, while the windows are manually operated. The unoccupied building was monitored in August 1997, according to the typical building use: bedrooms and toilets closed, common rooms, office and staircase open, attic space open. The building was equipped with temperature, heat-flow and air velocity sensors, and active tracer gas techniques were implemented in order to measure the main airflow rates. The average airflow rate was 1900 m^3/h during the monitoring period, which corresponds to an air change rate of about 3 volumes per hour. In the bedrooms the rate decreased to 1°C. The temperature difference between the indoor and outdoor air was 5.2°C and the average wind velocity 0.9 m/s. The monitoring campaign was characterised by an unusual warm weather with respect to the Belgian standards, with daytime outdoor temperatures reaching 30°C. Despite this, the indoor temperatures remained below 25°C ensuring a comfortable indoor climate at all times. This result proves the good performances achieved through night ventilation, mainly activated by stack-effect, combined with other solutions such as accessible thermal mass and solar protection, to achieve thermal comfort without cooling systems in residential buildings in the Belgian climate.

The night ventilated Open House in Seville, Spain.

The Open house in Seville is another example of successful night ventilation [3] application. The building is surrounded by other single family houses of the same size and there are no obstructions to the solar radiation or the prevailing winds. The climate zone presents hot summers with average daily maximum temperature of around 35ºC, but with a diurnal temperature variation of about 17ºC with a considerable potential for night-time ventilation. The house has 250 square meters of useful floor area and it is open to the winter sun with the two main facades facing south and southwest respectively, with a global window area of 37 square meters. The angular shape of the house acts as a catcher of the southwest night breezes. The depth is about 5m with no internal partitions in the ground floor to favour cross ventilation. External walls are made of two layers of massive brick with intermediate air layer and 4 cm of polyurethane foam. All thermal bridges have been eliminated so that the columns of the structure are incorporated to the internal inertia of the building. Solar control in the summer is guaranteed by a combination of vegetation, canvas and overhangs. The building has no mechanical cooling system, which is extremely unusual for buildings of this geometry and climate. The monitoring was carried out in July and August 2000 demonstrated the usefulness of the night ventilation strategy, see figure on the left. The average indoor and outdoor temperature during the last two weeks of July were respectively 29.6 and 29.7°C, with the windows being closed and the thermal mass being the only means of supporting indoor temperatures mitigation. The outdoor temperature was 28.6°C during the first two weeks of August but the indoor average dropped to 27°C with the windows open for the purposes of night ventilation. Comfort analyses suggest the application of ceiling fans in those rooms, like the kitchen, where for a significant number of hours the temperature was above 28°C.



Indoor and outdoor temperature profiles of Opera house.



The concrete ground duct in Jaer School, Norway.

The ground cooled Aggelidis building in Athens, Greece.

3 > Ground cooling

The technique is based on the use of the ground as a heat sink during the summer and winter period. The deeper in the ground, the more the temperature is attenuated, after a certain depth the ground remains at an almost steady temperature level, slightly higher than the yearly mean air temperature. The ground can be used as a heat sink either through direct contact of the building envelope (the floor and part of the walls, like in many examples of the vernacular architecture in the Mediterranean area) or by means of properly positioned buried pipes and air/water driven heat exchangers. It should be noted that in winter the pipes are used for preheating of the ventilation air, reducing thus the heating load of buildings.

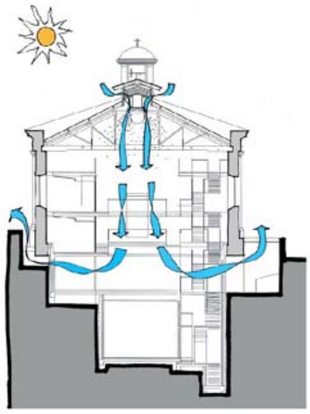
This technique was applied in the Jaer primary schools in Norway [4]. A 20 meter long ground-coupled duct (culvert), with a 1.6 m diameter, connects an air intake tower with the ventilated building. The duct is made of concrete and it is accessible for inspection and cleaning. The system has two parts: the first part transports air from the air-intake to the building, while the second distributes the air to the vertical shafts which lead to different rooms. A fan is situated in the duct providing an additional pressure to be coupled to the stack-effect. Air and surface temperatures and air flow rates were monitored in the culvers for extended periods between 2000 and 2002. It has to be noted that even though the cooling loads in the Norwegian climate are relatively small and the outdoor temperature remains in the comfort range, nevertheless some cooling loads arise during warmer days in combination with internal and solar gains. The measurements show that the buried ducts provided significant cooling effects. In cold climates with cool night temperatures, the cooling flux from the culvert surfaces stabilizes at around 100 Wh/m^2 after a long warm period. The value were doubled by increasing the airflow rate at night, with no use of electricity and no risk for emission of toxic or harmful greenhouse gases. The use of such concrete culverts ensured, together with suitable airflow regulation, that the supply air was colder than room air, which was crucial for displacement ventilation. Conservative calculations showed that the duct provides 4 kW of cooling with an outdoor temperature of 18°C at 0.9 m^3/s.

The Aggelidis building is a paper warehouse placed on a site of 10.900 m^2, in the outskirts of Athens [5]. It has three levels: the basement where the parking and central mechanical equipment are placed, the ground floor for the main storage room and lifting platforms, and the first floor for special products storeroom, platform and offices. Along with several energy efficient techniques, the building is equipped with an earth to air heat exchanger, combined with simple ceiling fans for air conditioning in the office areas. The earth to air heat exchanger has two tubes of 0.315 m diameter buried at a 2 m depth around the building. The length of each pipe is 50 meters. They are designed to provide 4500 m^3/h of air (with an air velocity of 8 m/s). The building was monitored in 2004 to assess the effectiveness of the energy saving techniques. The mean temperature drop at the exit of the temperature was close to 5°C. The use of the earth to air heat exchangers has permitted to keep indoor temperature inside the comfort levels without the use of air conditioning.

The Slunakov Ecological Education Center (SEV) in Olomouc, Czech Republic, was designed to educate the public about the environment and its processes and to support the public environmental awareness [6]. The building was designed as an inhabitable mount – a dune that fluently blends into the surrounding terrain. The earth-covered roof was an important part of the urban concept. The earth heat exchanger pro is unique in the Czech Republic. The system provides cool filtered air in the summer, 2750 m³/s corresponding to an exchange rate of 0.77 h^{-1}. Several pipes are horizontally were placed one above the other, due to the limited available space. The control of the outdoor air was implemented as follows if the outdoor air temperature is between 12ºC and 22ºC, the intake of fresh air enters directly into the building through the openings located on the sidewalls of the building. When if the external air temperature is above 22ºC, the intake of external air goes through the earth heat exchanger, where is cooled before entering into the building.

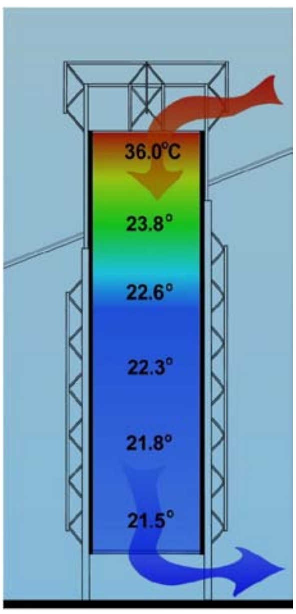
4 > Evaporative cooling

Evaporative cooling is a technique based on the effect of evaporation as a heat sink. The cooling of air is obtained as an amount of sensible heat is absorbed by the water and used as a latent source for evaporation. Evaporative cooling can be direct or indirect. In the former, the water content of the cooled air increases, being the air in contact with the evaporated water. In the latter, the evaporation takes place inside a heat exchanger, without a change in the water content of the air. Modern systems combine the evaporation effects with the movement of the cooled air. This can happen naturally (passive evaporative cooling) or with mechanical integration (hybrid evaporative cooling).



The evaporative cooling scheme in the Stock Exchange, Valletta, Malta.

The Stock Exchange building in Valletta, Malta, was originally a church dating back to the 19th century [7]. It is exposed to solar radiation on the south-west edge and to prevailing north-western winds, which typically blow during the day and leave the nights calm. The building was refurbished creating a 5 storey atrium surrounded by office spaces. Evaporative cooling was ensured for dry air conditions, while the cooling demand was satisfied by chilled water coils in humid air conditions.
The large central space was managed by four strategies in summertime, the first one is the automated natural ventilation with aperture at the top of the building and at the lower ground levels. A chiller based on downdraught cooling by means of two chilled waters circuits serves coils adequately tilted in order to encourage the airflow, the natural ventilation is set to the minimum aperture when the coils are switched on. Night time convective cooling useful when temperatures goes below 23°C, is activated by wind or buoyancy forces through the dampers at the ground floor. Passive downdraught cooling implemented by 14 hydraulic nozzles operating in dry air conditions. This last strategy requires for a total volume of water of 90 litres per hour at a pressure of 25 bar. The system works in conjunction with the vents on the top level and the dampers to maximise the apertures, unless the wind goes above a threshold value.
The building started operating in August 2001 and some performance assessments of the cooling system were performed. The period was very humid, hence not very useful information about the passive evaporative systems were collected.



Temperature profile in the evaporative tower in Midershet Ben Gurion, Israel.

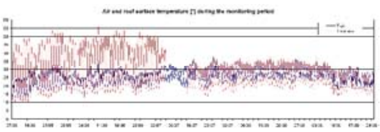
Another evaporative cooling experience was implemented in Midershet Ben Gurion, Israel for the Blaustein Institute for the Desert research [7].
The site has strong daily and seasonal temperature excursions, with hot and very dry summers, with advantage of extended thermal comfort range of up to 28°C. This is a three storey 800 square meters building, hosting a number of activities typical of a big university, from classrooms to offices and a cafeteria. The prevalent orientation is north/south and the plan is characterised by a large atrium, figure on the left. All the rooms are open to the atrium, source of fresh air and natural light, witch was conceived ad an to an enclosed courtyard. Here the downdraught cooling was built, thanks to a shower tower incorporated in the centre of the atrium.
The first floor is below the ground level, which partly protect the walls from the harsh thermal conditions. All the walls are concrete masonry with additional insulation. Water at low pressure is pumped to the top of the

tower and sprayed as droplets into the open shaft. The downdraught forces cool air into the atrium, but because of the low pressure the water does not evaporate and it is collected by a pool below the tower. Offices are equipped with conventional air conditioning that also takes advantage of the downdraught pre-cooling of the supply air. The monitoring showed that the tower supplied 100 kWh of cooling in a typical summer day without significant energy consumption and that most of the cooling took place in the first two meters of the tower height. Temperature and humidity were measured in the atrium space at different heights in July 2008. The results showed that the first two floors presented acceptable comfort conditions, with the air temperature having small excursions whatever the outdoor air temperature was, while the cooling affect at the second floor was practically negligible. The system also provided an increment of the relative humidity, with respect to the low outdoor levels. The satisfactory comfort conditions were also confirmed by a post occupancy evaluation.

5 > Cool Roofs

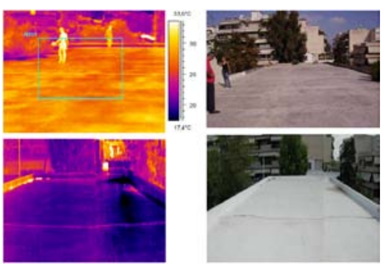
Cool roof coating in a public building in Trapani, Italy.

Construction materials are characterised by high solar absorptances, which enhance high solar gains through the opaque envelope components in summer. Cool materials are characterised by high solar reflectances, which reduce the solar gains during daytime, and high emittances, which help the buildingradiate away the stored heat. They are effective on roofs, because of the high solar radiation levels on horizontal and sloped surfaces in summertime. Cool materials include several categories of products and their performance on buildings depends on several parameters (among them: climate, building use, building geometry and insulation).



Roof surface temperatures before the application of the cool coating in Trapani building.

A cool roof application was carried out in Trapani, on the Sicilian west coast in Italy [8]. The single floor building hosts offices and laboratories of a public secondary school and hasa flat roof with a surface greater than 700 square metres. The original roof was made of concrete tiles with an average estimated solar reflectance of 0.25. The dark roof was one of the reasons that caused the very warm conditions in the non- cooled building in summertime. The roof surface was treated with a white coating in the summer of 2009. The solar reflectance was raised to 0.85 and the building was monitored in order to evaluate the impact on the indoor thermal comfort. The monitoring started in May and lasted until the end of September. The cool roof application was made in early July. The monitoring included the air temperature evolution in a room dedicated to office activity, actually under renovation. Considering only the days with an outdoor temperature higher than 25°C, it was found out that before the cool roof applications the indoor air temperature was 1.8°C higher than the outdoor one (26.2 and 24.4°C, respectively). After the cool roof application the indoor temperature was 1.1°C cooler than the external one (27.1 and 28.2°C, respectively). The roof surface temperatures were strongly reduced as presented in the aside figure, where the temperature of the original roof, the cool roof and the external air are plotted. The cool roof surface temperature (blue line) is a few degrees higher than the outdoor air temperature (black line) during daytime, becoming several degrees cooler in August because of the radiative thermal losses. The original concrete tiles (red line) reach up to 20°C higher than the white coating, even if at night they get cooler than the air temperature. It is worth noting that the limited thermal stress of the cool material, generally not higher than 15°C, will increase the building component life span. The study also included an estimation of the potential energy savings in the same building if cooled. With the building not being insulated, the impact of the cool roof is very strong; in fact it was found that by increasing the solar reflectance by 0.6 (from .25 to 0.85), the cooling energy demand would be reduce by 54%.



Thermal Images before and after the cool roof application in school in Kaisariani, Athens, Greece.

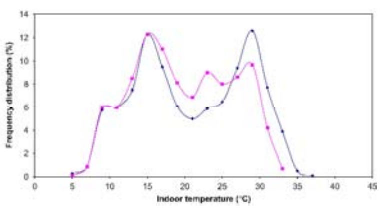
Another interesting cool roof application was carried out in a primary school building in Kaisariani, Athens, Greece [8]. The 2 floor building is not cooled and suffers from overheating during the warm season. The structure dates back to 1980 and in accordance to the period techniques it is not insulated. The flat roof is 400 square meters and the initial surface was finished with cement and gravel screed, whose albedo was estimated to be 0.2. The cool coating increased the solar reflectance to 0.89. The impact of this change is shown in the aside figure, where the thermal images of the roof before (above pictures, left false colour and right natural pictures) and after the cool coatings are presented. Surface temperature differences are around 12°C, significant result since the pictures were not taken during the peak solar conditions when the cool effect reaches its maximum. The indoor air monitoring was carried out during spring and summer of 2009, with the building working in the free floating conditions. The findings of the monitoring were used to calibrate a numerical model in order to estimate the potential benefit of a cool material application under the same climatic conditions and for the same building. The study demonstrated that the first floor average temperature decreases by 1.8°C when reducing the solar absorptance from 0.8 to 0.1, with a maximum and a minimum temperature reduction of 2.8 and 0.7°C respectively. Positive effects were estimated also at the ground floor, which is not directly coupled with the roof. The average temperature reduction was 0.5°C. The analysis also demonstrated that the potential cooling energy savings of the building were about 40% with respect to the initial demand and that the cooling peak was reduced by 20%. This study also described the achievable results in case that the building was insulated. As expected, savings were still significant, even if their magnitude was reduced with respect to the non-insulated configuration.

6 > Green Roofs

The green roof on the University Library, Delft, The Netherlands.

Green roofs, or ecoroofs, are becoming an appealing technique because they affect building aesthetics, improve of the air quality in urban areas and mitigate the urban heat island. Green roofs improve the building insulation thanks to the soil layer thermal resistance but also improve the building solar control, with most of the incident solar radiation being absorbed by the vegetation layer for photosynthesis, respiration and evapo-transpiration. The result is the reduction of the thermal load to the indoor environment with respect to a standard roof. Performances of green roof are strongly affected by the used materials, building characteristics and use and climatic conditions.

The famous Italian architect Renzo Piano designed the new California Academy of Sciences building, according to energy efficiency and sustainability criteria. Among them, a 10.000 square meters green roof. One of the architect's objectives was to design a building that did not need to be cooled. A complex system of sensors manages the aperture of the windows to allow fresh air inside, but the contribution of the green roof in mitigating the indoor air temperature is significant. The figure on the left shows another building in which an important application of green roofs was implemented the Technical University Delft Library, accomplished in 1998. Even though many experiences are collected until today, the availability of results in terms of energy savings, as well as thermal comfort improvements are still missing.



Frequency distribution comparison of the indoor temperature in a school with and without a green roof application, Athens, Greece.

The performance of green roofs installed on the top of various buildings were analysed in Athens [9]. The experience of a nursery school in Athens is of particular interest to demonstrate the potential of the technique. The overall area of the building is 855 square meters for two floors and the building is not insulated. A typical local wild plant was chosen as vegetation layer, according to: length of blooming, site conditions and

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watering demand. The implementation required a daily irrigation quantity of 1.2 kg/square meters for the latter. The leaf area index (ratio of the foliage surface to the soil surface) was set to 0.4. The external climatic conditions (air temperature and relative humidity) and the indoor air temperature were continuously monitored. A detailed building model was implemented starting from the collected data, with the aim of comparing the energy performance of the building in that climatic context and equipped with the standard roof and the green roof. The figure on the left shows the cumulative distribution of the indoor air temperature without (blue line) and with (red line) green roof. The green roof resulted in a noticeable reduction in discomfort hours, typically above 26°C. The positive effect also arose when dealing with potential cooling energy savings. The cooling load reduction varied between 15 and 49% for the whole building during the summer months. When referring the zone below the green roof, these savings increased and varied between 27 and 87%. The extreme benefits were predicted for May, when the absolute cooling demand is the smallest. The cooling savings were not associated with remarkable heating penalties for this application, because of the additional insulation provided by the soli layer.

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7 > References

1. EPBD (2002). Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the energy performance of buildings, Official Journal of the European Communities, 04.01.2003.
2. Monitoring of the PLEIADE dwelling – Final report for the period 1/9/1996 to 30/06/1998
3. Personal communication
4. P. G. Schild Hybrid ventilation of Jaer School: results of monitoring, Proceedings of Hybrid Ventilation 2002 : 4th International Forum, May 14-15, 2002, Montreal, Canada
5. M. Santamouris, Use of Earth to Air Heat Exchangers for Cooling. AIVC - Ventilation Information Paper, n° 11, January 2006
6. M. Lain and J. Hansen, Passive and low energy cooling techniques for the Czech Republic, Proceedings of International Conference “Passive and Low Energy Cooling for the Built Environment”, May 2005, Santorini, Greece
7. Promotion and Dissemination of Passive and Hybrid Downdraught Cooling Systems in Building Project, Design Sourcebook, Draft version, May 2009
8. EU Cool Roofs Project, Deliverable D7 - Report on the five case studies and analysis of the results, February 2010
9. M. Santamouris, C. Pavlou, P. Doukas, G. Mihalakakou, A. Synnefa, A. Hatzibiros, P. Patargias, Investigating and analysing the energy and environmental performance of an experimental green roof system installed in a nursery school building in Athens, Greece, Energy 32 (2007) 1781–1788

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I E E   S A V E   A S I E P I

Part D. Web events

on

Stimulation of better summer comfort and efficient cooling by EPBD implementation

ASIEPI web event 5: Summer comfort and air conditioning in Europe: Current trends and future perspectives

ASIEPI web event 6: Thermal comfort and cooling demand in the air of climate change

ASIEPI Web event 5

Summer comfort and air conditioning in Europe: Current trends and future perspectives.

17 June 2009, 10:00-12:00 GMT+2 (Paris time)

Whereas in the past a major challenge was to keep our buildings sufficiently warm, recently and in new buildings the challenge is to guarantee reasonable comfort conditions in summer with no, or at least minimum, cooling energy.

The main objectives of ASIEPI are to create or increase awareness of the MS around available alternative techniques and technologies that improve thermal comfort without increasing the energy consumption and how to assess the energy performance of such techniques. The activities within this WP cover a collection and analysis of the situation of the EPBD implementation in those MS who already have specifications regarding summer comfort and A/C. In parallel, studies have been performed regarding how the implementation of alternative cooling techniques and the respective advanced calculation methods into the existing calculation methods are addressed.

The web event on June 17th has provided an overview of the possibilities and barriers for penetration of innovative and passive cooling techniques into the European market, including:

- a presentation of the European thermal comfort standards,
- an analysis of the pro's and con's of the calculation methods emphasizing the role of thermal mass, solar gains & shading, intensive night ventilation and the use of natural cooling techniques,
- major trends in the systems used and discussions about the existence of a framework for assessing passive cooling and low energy cooling systems.

Event page: http://www.asiepi.eu/wp-7-summer-comfort/web-events/web-event-5.html

Summer comfort and air conditioning in Europe: Current trends and future perspectives.
Welcome *by M. Santamouris, NKUA, WP7 leader*
Brief presentation of the ASIEPI project and Introduction into Summer Comfort and Cooling as covered in ASIEPI *by M. Santamouris*
Technical discussions
Thermal comfort standards for EU *by B. Olesen REHVA*
Common assumptions of the calculation methods that can become a barrier to the penetration of passive cooling in buildings *by S. Alvarez, AICIA-University of Seville*
The role of passive cooling in thermal comfort of buildings *by M. Santamouris, NKUA, WP7 leader*
The industry point of view
Trends and perspectives in innovative cooling techniques *by A. Thiemann, DAIKIN*
(See also the web event related to the assessment of innovative systems (WP6))
Discussions
Questions
Conclusion and closure *by M. Santamouris, NKUA, WP7 leader*

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ASIEPI web event 6

Thermal comfort and cooling demand in the air of climate change

26 November 2009, 10:00-12:00 GMT+1 (Paris time)

Climate change is a common fact for all Member States (MS) and in recent years significant effort is being made to tackle its impacts in the building sector. In this effort, the EU, through various incentives including the EPBD, has imposed very stringent energy policies to buildings and on the same time has stipulated improved indoor climate conditions.

One of the objectives of ASIEPI is to create or increase awareness of the MS around available alternative techniques and technologies that improve thermal comfort without increasing the energy consumption and how to assess the energy performance of such techniques. The activities related to this issue cover a collection and analysis of the situation of the EPBD implementation in those MS who already have specifications regarding summer comfort and A/C. In parallel, studies have been performed regarding how the implementation of alternative cooling techniques and the respective advanced calculation methods into the existing calculation methods are addressed.

The web event on November 26th provides an overview of the impact of climate change on thermal comfort and cooling demand in buildings and the available alternative technologies that improve summer comfort and the calculation methodologies that assess their impacts. This includes:

- a presentation of the calculation methods and requirements on summer comfort and cooling currently in effect in the MS,
- an analysis of the reasons why the need for artificial cooling has increased over the past years and ways of minimizing it,
- an analysis of how summer comfort can be achieved through alternative techniques and technologies.

Event page: http://www.asiepi.eu/wp-7-summer-comfort/web-events.html

Thermal comfort and cooling demand in the air of climate change
Welcome *by M. Santamouris, NKUA (University of Athens)*
Brief presentation of the ASIEPI project and Introduction into Summer Comfort and Cooling as covered in ASIEPI *by M. Santamouris*
Technical discussions
Summer comfort and cooling: calculation methods and requirements, *by D. van Orshoven, BBRI*
The role of climatic change and the impact of cooling in buildings *by M. Santamouris, NKUA*
The industry point of view
Solar shading: reducing the need for artificial cooling with quantifiable results *by D. Dolmans, ES-SO*
Energy certification of A/C - Results of the HARMONAC project *by Ian Knight, Cardiff University*
The energy cost of comfort and compatibility with EPBD *by Michael G. Hutchins, Sonnergy Ltd*
Discussions
Questions
Conclusion and closure *by M. Santamouris, NKUA*

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OVERALL PROJECT SPONSORS

www.euroace.org

www.eurima.org

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PARTNER ASSOCIATIONS

www.fiec.eu

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NATIONAL COFINANCING

BELGIUM

BBRI's contribution was cofunded by:

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Association of Energy Auditors

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Energia i Budynek

Journal Energy & Building

www. energiaibudynek.pl

PRESENTATION OF THE 4 ASIEPI SPONSOR ORGANISATIONS

ES-SO, the European Solar-Shading Organization, is the non-profit umbrella trade association of the solar shading industry in Europe. ES-SO's objective is to support and promote the interests of the solar shading and roller shutter industry and to provide permanent contacts, both between its members and with the European authorities. ES-SO's higher objective is to show that its products can help the building trade realize energy savings and reduce CO2 emissions, while at the same time providing better indoor comfort and avoiding overheating in summer.

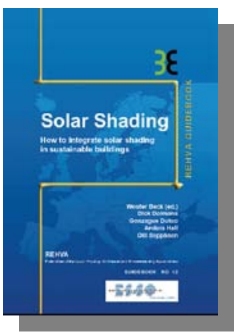
Solar shading is a term used for many different products, ranging from the humble internal venetian blind or the traditional roller shutter to complex structural louver systems on the outside. They all have one thing in common: they have been designed to control the entry of heat and light from the sun. They reduce the need for active cooling and enhance the use of free, natural daylight.

ES-SO members. Like in other umbrella organizations, ES-SO members are mainly the national solar shading trade associations. In countries where no trade association exists, leading manufacturers of the industry may be recruited. Presently, ES-SO counts members from 16 countries: Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Netherlands, Poland, Spain, Sweden, Switzerland and UK.

ESCORP study. To express the quantitative contribution of solar shading to energy savings and reduction of greenhouse gas emissions, ES-SO commissioned an independent and specialized buildings physics consultant. This ESCORP-EU25 study can be downloaded from the ES-SO website.

ES-SO and ASIEPI. ES-SO has been actively involved in the ASIEPI project as a sponsor and has participated as a panelist in several of its innovative Webex-events. ASIEPI has delivered many clear, attractive papers, neatly organized per technical topic and ES-SO has appreciated the open communications on these reports as well as the possibility for the sponsors to comment on the content.

ES-SO and REHVA. Sustainable building requires a holistic approach to the building's concept. This means that the various building technologies work together in an early design stage, so that the interaction between these technologies and the influence of one on the other are recognized and taken into account. Solar shading, as a passive cooling method, has an influence on the cooling needs of a building. This is recognized by REHVA, the Federation of Heating, Ventilation and Air-Conditioning Associations. In a cooperative effort, REHVA and ES-SO have recently published a book, n° 12 in REHVA's series of Guide Books, under the title *How To Integrate Solar Shading In Sustainable Buildings.* Available via www.rehva.eu.



Visit ES-SO at www.es-so.eu.

Eurima is the European Insulation Manufacturers Association. Eurima members manufacture mineral wool insulation products. These products are used in residential and commercial buildings as well as industrial facilities. Glass and stone wool insulation secure a high level of comfort, low energy costs and minimised CO_2 emissions. Mineral wool insulation prevents heat loss through roofs, walls, floors, pipes and boilers, reduces noise pollution and protects homes and industrial facilities from the risk of fire.

The Eurima Ecofys studies

Since 2002, Eurima has been working with Ecofys, an independent and international consultancy specialised in energy saving and renewable energy solutions, to develop a deeper understanding of the energy savings and climate change mitigation potential of buildings.

Eurima and ASIEPI

The ASIEPI project was closely followed by Eurima's Technical Committee (TC). Eurima's TC members appreciate the selection of topics and the ability of ASIEPI documents to explain complex technical issues in an understandable language. The TC members also value the participatory process of the ASIEPI and the accuracy of its papers.

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Eurima Affiliated Members:

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EuroACE, the **Alliance of Companies for Energy Efficiency in Buildings**, was formed by twenty of Europe's leading companies involved with the manufacture, distribution and installation of a large variety of energy saving goods and services for buildings. The mission of EuroACE is to work together with the European institutions to help Europe move towards a more sustainable pattern of energy use in buildings, thereby contributing to the EU's commitments on carbon emission reductions, job creation and energy security.

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PCE is an European group of manufacturers and sales organisations of cellular glass thermal insulation, world-wide known under the name FOAMGLAS®.

FOAMGLAS® as cellular glass thermal insulation combines and ensures high performance, durable & ecologically sustainable thermal insulating in building applications.
Cellular glass offers outstanding system advantages that achieve a very favourable cost-benefit ratio over the service life of a building. Due to its hermetically sealed cell structure, cellular glass is extremely in-compressible, absolutely waterproof and sealed against vapour diffusion, and does not absorb any moisture. FOAMGLAS® is the only insulating material in which the vapour barrier, due to its material structure, is already “built in”.

PCE and ASIEPI
During the ASIEPI process, PCE contributed with its expertise especially to find solutions with regards to the thermal break so as to contribute the energy savings and a better comfort in preventing superficial condensation. Also the airtightness and vapour control applications with cellular glass contributes to better insights and positive long-term solutions.

Cellular glass applications, specified by PCE, fulfils even the most stringent requirements for building physics combining also fire protection and mechanical performances, ensuring a economical and ecological long term applications.

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- Interior insulation, effective and flawless in terms of building physics
- Flat roof insulation, long-lasting and compact
- Metal roof insulation, aesthetic and safe
- Thermal break solutions, limits energy losses and prevents moisture

PCE affiliates and members are:
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AIVC

AIVC

Air Infiltration and Ventilation Centre

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1. THE AIVC - AIR INFILTRATION AND VENTILATION CENTRE

Established for nearly thirty years, the **Air Infiltration and Ventilation Centre** (AIVC) provides a high quality international technical and information forum covering the areas of ventilation and air infiltration in the built environment with respect to efficient energy use, good indoor air quality and thermal comfort. The main drivers for this work are the national and international concerns in the areas of sustainable development, responses to climate change impact and healthy buildings.

The aim is to promote an understanding of the complex behaviour of air flow in buildings and to advance the effective application of associated energy saving measures in both the design of new buildings and the improvement of the existing building stock. The main role of the AIVC is to disseminate research results presented in accessible and informative publications. The prodigious output of this annex is available in electronic format on CD-Rom and on the AIVC website (www.aivc.org).

The Air Infiltration and Ventilation Centre is operated under Annex V of the Energy Conservation in Buildings and Community Systems (ECBCS – www.ecbcs.org) implementing agreement of the International Energy Agency (IEA). The Annex is a partly task shared and partly jointly funded activity. The participating countries are represented on the Steering Group.

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Korea	Netherlands	Norway	United States	

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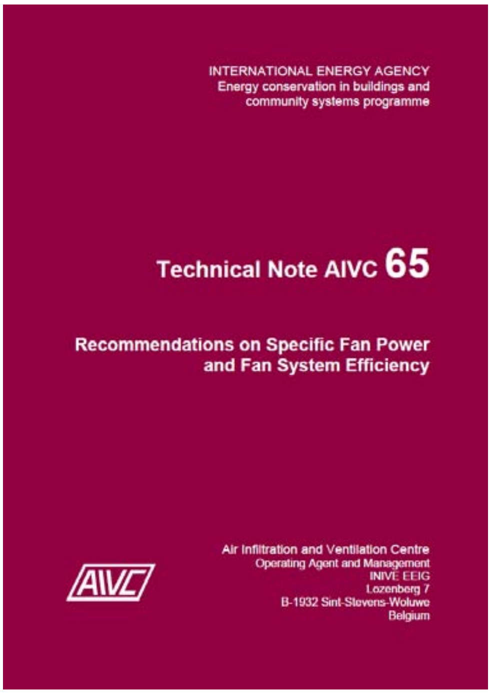
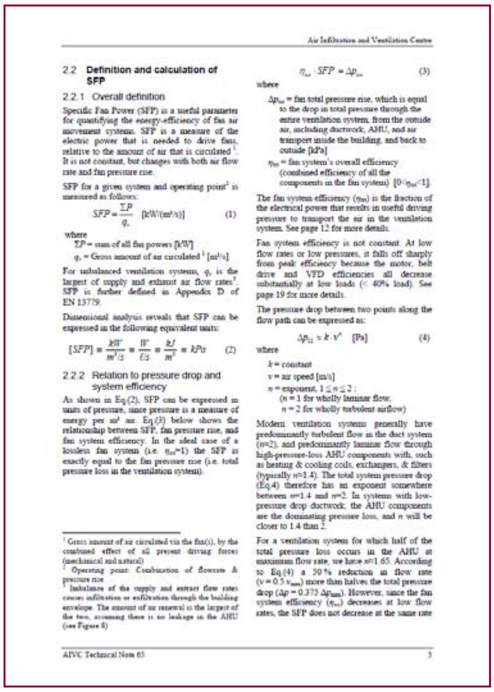
2. AIVC'S MEANS OF DISSEMINATION

2.1 TECHNICAL NOTES

The AIVC's collection of technical notes on subjects including ventilation, infiltration, indoor air movement and measurement techniques.





Air Infiltration and Ventilation Centre

2.2 Definition and calculation of SFP

2.2.1 Overall definition

Specific Fan Power (SFP) is a useful parameter for quantifying the energy-efficiency of fan air movement systems. SFP is a measure of the electric power that is needed to drive fans, relative to the amount of air that is circulated [1]. It is not constant, but changes with both air flow rate and fan pressure rise.

SFP for a given system and operating point[2] is measured as follows:

$$SFP = \frac{\Sigma P}{q_v} \quad [kW/(m^3/s)] \qquad (1)$$

where

ΣP = sum of all fan powers [kW]

q_v = Gross amount of air circulated [1] [m³/s]

For unbalanced ventilation systems, q_v is the largest of supply and exhaust air flow rates[3]. SFP is further defined in Appendix D of EN 13779.

Dimensional analysis reveals that SFP can be expressed in the following equivalent units:

$$[SFP] = \frac{kW}{m^3/s} = \frac{W}{l/s} = \frac{kJ}{m^3} = kPa \qquad (2)$$

2.2.2 Relation to pressure drop and system efficiency

As shown in Eq.(2), SFP can be expressed in units of pressure, since pressure is a measure of energy per m³ air. Eq.(3) below shows the relationship between SFP, fan pressure rise, and fan system efficiency. In the ideal case of a lossless fan system (i.e. η_{tot}=1) the SFP is exactly equal to the fan pressure rise (i.e. total pressure loss in the ventilation system).

$$\eta_{tot} \cdot SFP = \Delta p_{tot} \qquad (3)$$

where

Δp_{tot} = fan total pressure rise, which is equal to the drop in total pressure through the entire ventilation system, from the outside air, including ductwork, AHU, and air transport inside the building, and back to outside [kPa]

η_{tot} = fan system's overall efficiency (combined efficiency of all the components in the fan system) [$0<\eta_{tot}<1$]

The fan system efficiency (η_{tot}) is the fraction of the electrical power that results in useful driving pressure to transport the air in the ventilation system. See page 12 for more details.

Fan system efficiency is not constant. At low flow rates or low pressures, it falls off sharply from peak efficiency because the motor, belt drive and VFD efficiencies all decrease substantially at low loads (< 40% load). See page 19 for more details.

The pressure drop between two points along the flow path can be expressed as:

$$\Delta p_{12} = k \cdot v^n \quad [Pa] \qquad (4)$$

where

k = constant

v = air speed [m/s]

n = exponent, $1 \le n \le 2$:
(n = 1 for wholly laminar flow,
n = 2 for wholly turbulent airflow)

Modern ventilation systems generally have predominantly turbulent flow in the duct system (n≈2), and predominantly laminar flow through high-pressure-loss AHU components with, such as heating & cooling coils, exchangers, & filters (typically n≈1.4). The total system pressure drop (Eq.4) therefore has an exponent somewhere between n=1.4 and n=2. In systems with low-pressure drop ductwork, the AHU components are the dominating pressure loss, and n will be closer to 1.4 than 2.

For a ventilation system for which half of the total pressure loss occurs in the AHU at maximum flow rate, we have n≈1.65. According to Eq.(4) a 50 % reduction in flow rate ($v = 0.5\, v_{max}$) more than halves the total pressure drop ($\Delta p = 0.375\, \Delta p_{max}$). However, since the fan system efficiency (η_{tot}) decreases at low flow rates, the SFP does not decrease at the same rate

[1] Gross amount of air circulated via the fan(s), by the combined effect of all present driving forces (mechanical and natural)

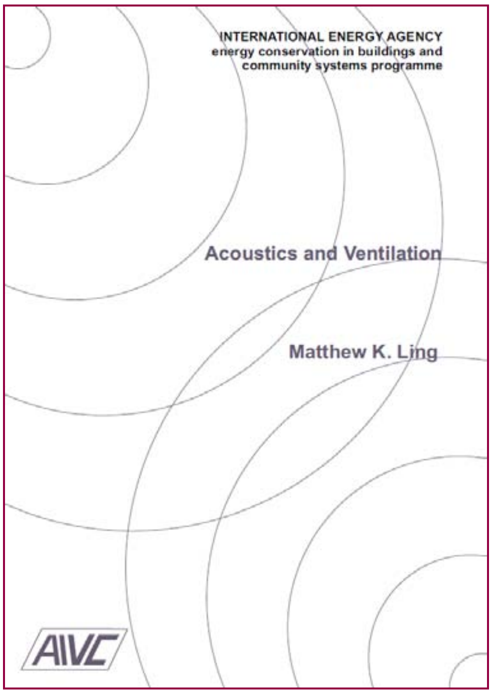
[2] Operating point: Combination of flowrate & pressure rise

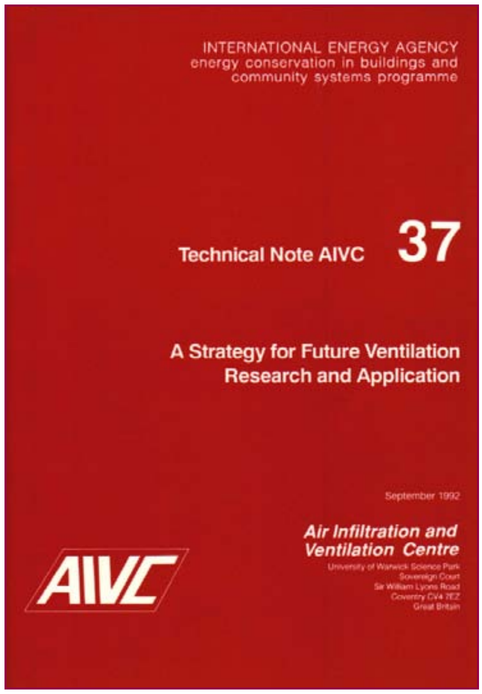
[3] Imbalance of the supply and extract flow rates causes infiltration or exfiltration through the building envelope. The amount of air renewal is the largest of the two, assuming there is no leakage in the AHU (see Figure 8)

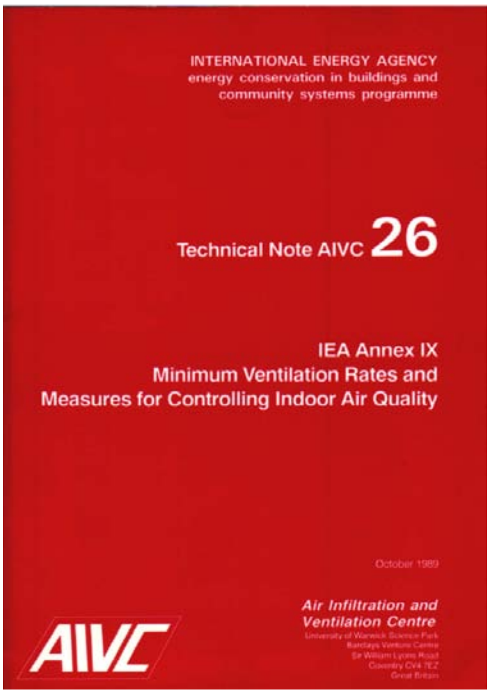
AIVC Technical Note 65 5

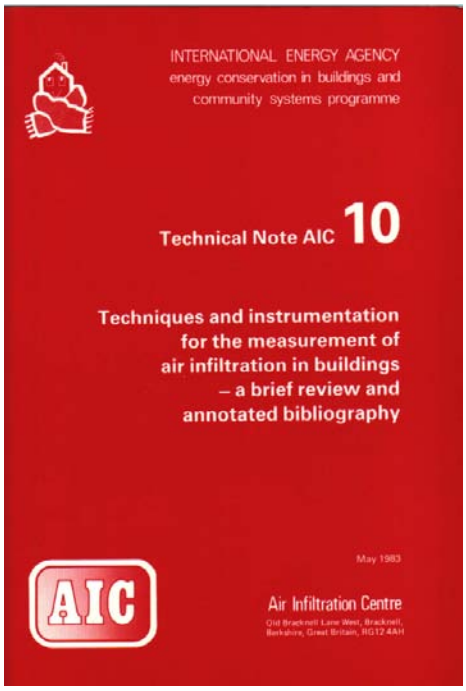
AIVC

TN 49	Energy impact of ventilation: estimates for the service and residential sectors
TN 48	The role of ventilation in cooling non-domestic buildings
TN 47	Energy requirements for conditioning of ventilating air
TN 46	Survey of current research into air infiltration and related air quality problems in buildings
TN 45	Air to air heat recovery in ventilation
TN 42	Current ventilation and air conditioning systems and strategies
TN 41	Infiltration data from the Alberta Home Heating Research Facility
TN 40	An overview of combined modelling of heat transport and air movement
TN 39	A review of ventilation efficiency
TN 34	Air flow patterns within buildings: measurement techniques
TN 32	Reporting guidelines for the measurement of airflows and related factors in buildings
TN 29	Fundamentals of the multizone air flow model - COMIS
TN 28.2	A guide to contaminant removal effectiveness
TN 28	A guide to air change efficiency









TN 26	IEA Annex IX: Minimum ventilation rates and measures for controlling indoor air quality
TN 24	AIVC measurement techniques workshop: proceedings and bibliography
TN 23	Inhabitants' behaviour with regard to ventilation
TN 20	Airborne moisture transfer: New Zealand workshop proceedings and bibliographic review
TN 10	Techniques and instrumentation for the measurement of air infiltration in buildings
TN 36	Air infiltration and ventilation glossary
TN 05.4	Air Infiltration Glossary - Dutch
TN 05.3	Air Infiltration Glossary - Italian
TN 05.2	Air Infiltration Glossary - French
TN 05.1	Air Infiltration Glossary - German

2.2 ANNOTATED BIBLIOGRAPHIES

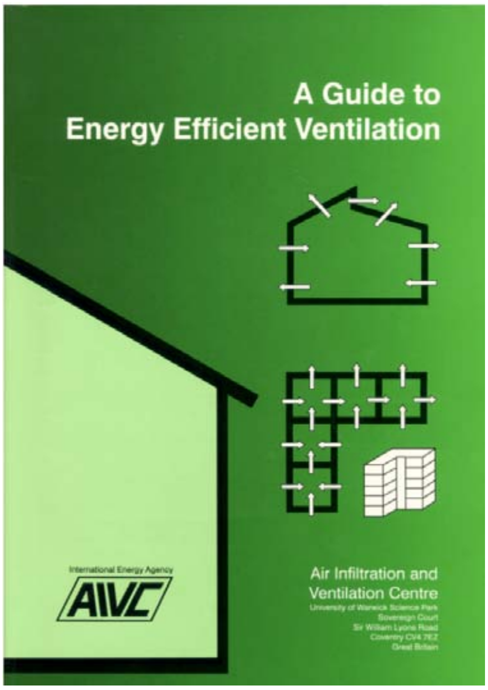
The AIVC's collection of bibliographies.

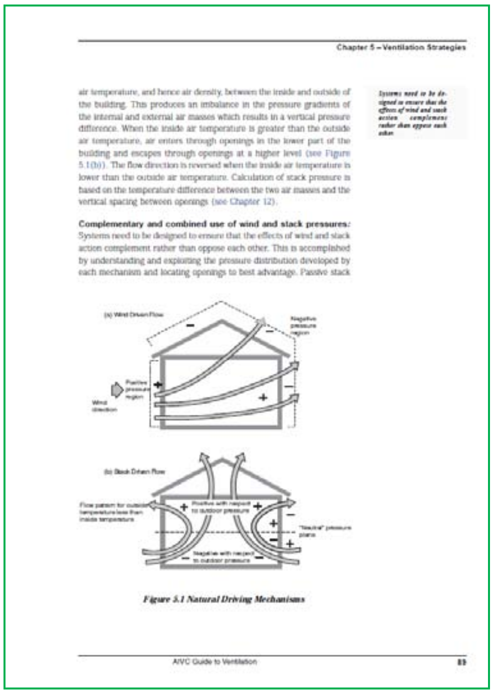
BIB 13	Review of Literature Related to Residential Ventilation Requirements
BIB 12	Review of Airflow Measurement Techniques
BIB 11	Balancing Ventilation systems - An Annotated Bibliography
BIB 10	Annotated Bibliography: Ventilation System Duct Cleaning
BIB 09	An Annotated Bibliography: Impact of Urban Air Pollution on the Indoor Environment
BIB 08	Passive Cooling Technology for Office Buildings: An Annotated Bibliography
BIB 07	Ventilation and acoustics in buildings: an annotated bibliography
BIB 06	Ventilation in schools: an annotated bibliography
BIB 05	An annotated bibliography: heat pumps for ventilation exhaust air heat recovery
BIB 04	Ventilation and infiltration characteristics of Ventilation and Infiltration Characteristics of Lift Shafts and Stair Wells - A Selected Bibliography
BIB 03	An annotated bibliography: air intake positioning to avoid contamination of ventilation air
BIB 02	An annotated bibliography: natural ventilation
BIB 01	An annotated bibliography: garage ventilation

2.3 GUIDES AND HANDBOOKS

A series of carefully researched and readily accessible publications giving detailed coverage on a range of important topics.

GU 5	Ventilation modelling data guide
TP 1999:4	Improving ductwork: a time for tighter air distribution systems
GV	A guide to energy efficiency ventilation
AG	Air exchange rate and airtightness measurement techniques - An application guide
CT	Air infiltration calculation techniques - An applications guide
HNBK	Air Infiltration Control in Housing. A Guide to International practice





Chapter 5 – Ventilation Strategies

air temperature, and hence air density, between the inside and outside of the building. This produces an imbalance in the pressure gradients of the internal and external air masses which results in a vertical pressure difference. When the inside air temperature is greater than the outside air temperature, air enters through openings in the lower part of the building and escapes through openings at a higher level (see Figure 5.1(b)). The flow direction is reversed when the inside air temperature is lower than the outside air temperature. Calculation of stack pressure is based on the temperature difference between the two air masses and the vertical spacing between openings (see Chapter 12).

Systems need to be designed to ensure that the effects of wind and stack action complement rather than oppose each other

Complementary and combined use of wind and stack pressures: Systems need to be designed to ensure that the effects of wind and stack action complement rather than oppose each other. This is accomplished by understanding and exploiting the pressure distribution developed by each mechanism and locating openings to best advantage. Passive stack

Figure 5.1 Natural Driving Mechanisms

AIVC Guide to Ventilation

AIVC

2.4 CONTRIBUTED REPORTS

A series of republished documents which are of interest to the field, but have not been reviewed by the AIVC for errors or omissions.

CR 12	Indoor air quality in French dwellings
CR 11	Air Leakage of U.S. Homes: Model Prediction
CR 10	Ventilation Behavior and Household Characteristics in New California Houses
CR 09	Source Book for Residential Hybrid Ventilation Development
CR 08	Occupant behaviour and attitudes with respect to ventilation of dwellings
CR 07	State-of-the-art of low-energy residential ventilation
CR 06	Low-pressure-drop HVAC design for laboratories
CR 05	Considerations concerning costs and benefits with application to ventilation
CR 04	Contrasting the capabilities of building energy performance simulation programs
CR 03	Ventilated Double Skin Façades - Classification & illustration of façade concepts
CR 02	Flow-Generated Noise in Ventilation Systems
CR 01	Aerodynamic Noise of Fans

2.5 VENTILATION INFORMATION PAPERS

Ventilation Information Papers (VIP) are a series of short AIVC publications (6 to 8 pages) intended for giving a basic knowledge of some aspects related to the air infiltration and/or the ventilation.

VIP 31 Humidity Controlled Exhaust Ventilation in Moderate Climate

VIP 30 An overview of national trends related to innovative ventilation systems

VIP 29 An overview of national trends in envelope and ductwork airtightness

VIP 28 IAQ and Ventilation Efficiency with Respect to Pollutants Inside Automobiles

VIP 27 Trends in the Czech building ventilation market and drivers for change

VIP 26 Trends in the Korean building ventilation market and drivers for change

VIP 25 Trends in the Japanese building ventilation market and drivers for changes

VIP 24 Trends in the Polish building ventilation market and drivers for changes

VIP 23 Trends in the Brazilian building ventilation market and drivers for changes

VIP 22 Trends in the US building ventilation market and drivers for changes

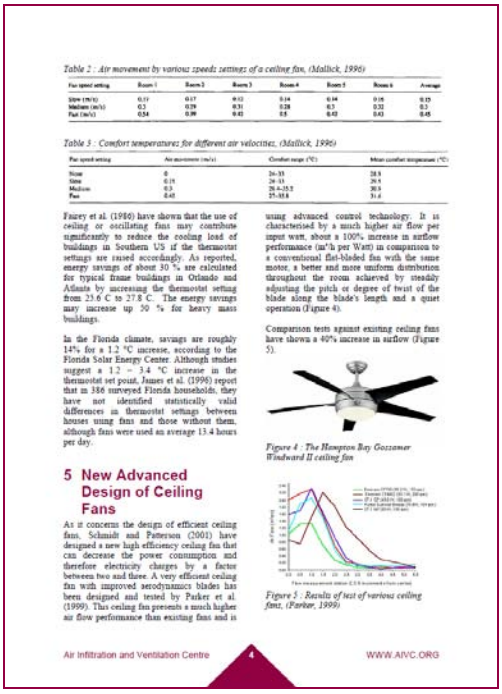
VIP 21 Trends in the Norwegian building ventilation market and drivers for changes

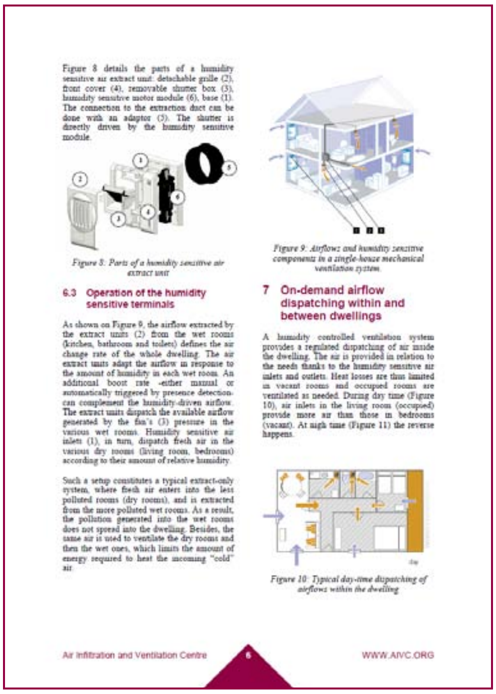
VIP 20 Trends and drivers in the Finnish ventilation and AC market

VIP 19 Trends in the French building ventilation market and drivers for change

VIP 18 Trends in the Belgian building ventilation market and drivers for change

VIP 17 Trends in the building ventilation market in England and drivers for change

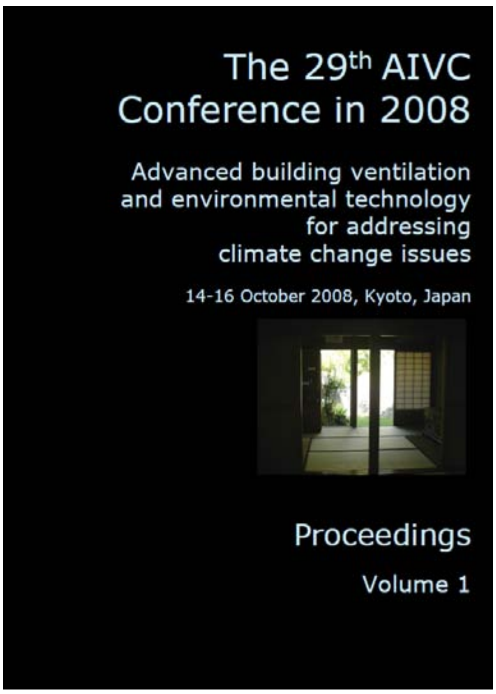




2.6 CONFERENCE PROCEEDINGS

Since 1980 the AIVC has held a conference each year in September/October in one of the AIVC participating countries, presenting around 50 to 100 papers on a variety of topics in air infiltration or ventilation fields.

2009	Germany, Berlin	Trends in High Performance Buildings and the role of Ventilation
2008	Japan, Kyoto	Advanced building ventilation and environmental technology for addressing climate change issues
2007	Greece, Crete Island	Building Low Energy Cooling and Advanced Ventilation Technologies in the 21st Century
2006	France, Lyon	Technologies & Sustainable Policies for a Radical Decrease of the Energy Consumption in Buildings (Volume 3)
2005	Belgium, Brussels	Ventilation in Relation to the Energy Performance of Buildings
2004	Czech Republic, Prague	Ventilation and Retrofitting
2003	USA, Washington	Ventilation, humidity control and energy
2002	France, Lyon	Energy efficient and healthy buildings in sustainable cities
2001	UK, Bath	Market opportunities for advanced ventilation technology
2000	Netherlands, The Hague	Innovations in ventilation technology



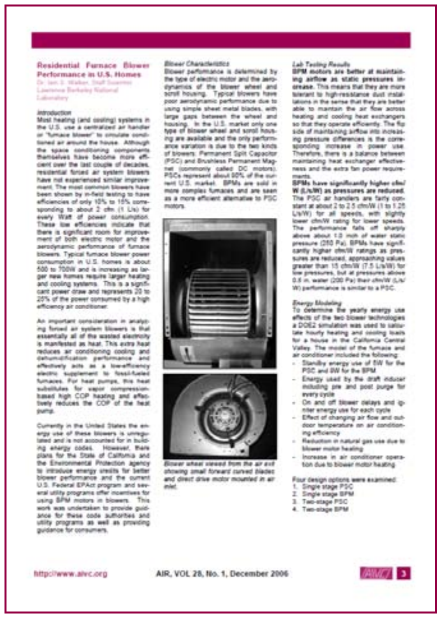
1999	Scotland, Edinburgh	Ventilation and indoor air quality in buildings
1998	Norway, Oslo	Ventilation Technologies in Urban Areas
1997	Greece, Athens	Ventilation and Cooling
1996	Sweden, Gothenburg	Optimum ventilation and air flow control in buildings
1995	USA, Palm Springs	Implementing the results of ventilation research
1994	UK, Buxton	The role of ventilation
1993	Denmark, Copenhagen	Energy impact of ventilation and air infiltration
1992	France, Nice	Ventilation for energy efficiency and optimum indoor air quality
1991	Canada, Ottawa	Air movement and ventilation control within buildings
1990	Italy, Belgirate	Ventilation system performance
1989	Finland, Espoo	Progress and trends in air infiltration and ventilation research
1988	Belgium, Gent	Effective ventilation.
1987	West Germany, Ueberlingen	Ventilation technology research and application
1986	UK, Stratford-upon-Avon	Occupant interaction with ventilation systems
1985	Netherlands	Ventilation strategies and measurement techniques
1984	USA, Nevada, Reno	The implementation and effectiveness of air infiltration standards in buildings
1983	Switzerland	Air infiltration reduction in existing buildings
1982	UK, London	Energy efficient domestic ventilation systems for achieving acceptable indoor air quality
1981	Sweden	Building design for minimum air infiltration
1980	UK	Instrumentation and measuring techniques

2.7 BIBLIOGRAPHIC DATABASA - AIRBASE

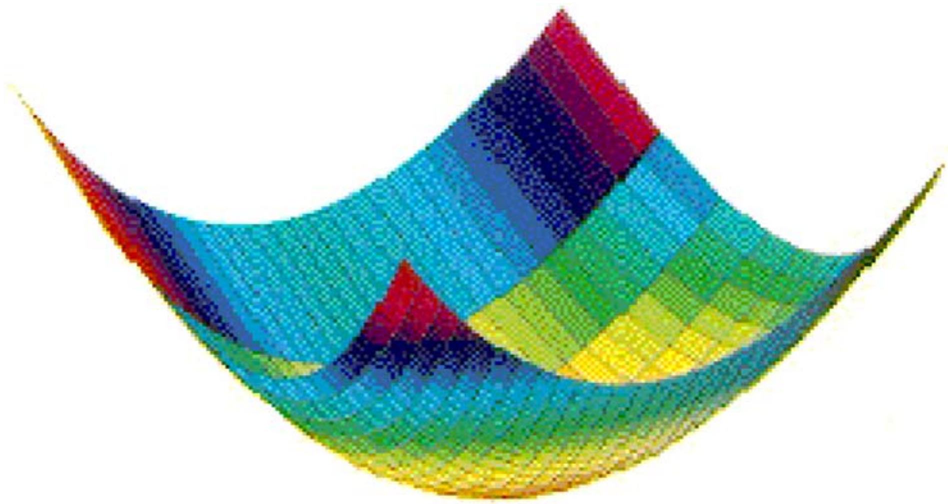
Contains references and abstracts of more than 17 000 articles and publications related to energy efficient ventilation. Where possible, sufficient detail is supplied in the bibliographic details for users to trace and order the material via their own libraries.

2.8 AIR INFORMATION REVIEW

Quarterly newsletter of the AIVC containing topical and informative articles on air infiltration and ventilation research and application. Most of the articles are linked to a more detailed feature on the AIVC website (www.aivc.org)



DYNASTEE



Dynamic Testing, Analysis and Modelling

www.dynastee.info

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DYNASTEE

EXECUTIVE SUMMARY

DYNASTEE

DYNamic Analysis, Simulation and Testing applied to the Energy and Environmental performance of buildings

The DYNASTEE Network

DYNASTEE stands for: "**DYN**amic **A**nalysis, **S**imulation and **T**esting applied to the **E**nergy and **E**nvironmental performance of buildings". DYNASTEE is an informal grouping of organisations actively involved in the application of dynamic tools and methodologies relative to this field. DYNASTEE functions under the auspices of the INIVE EEIG and constitutes a sustainable informal networking mechanism, which is intended for those who are involved in research and applications related to the energy performance assessment of buildings.

The objective of DYNASTEE is to provide a multidisciplinary environment for a cohesive approach to the research work related to the energy performance assessment of buildings in relation to the Energy Performance for Buildings Directive (EPBD).

1. GENERAL PROJECT/NETWORK DESCRIPTION

1.1 WHAT CAN THE DYNASTEE NETWORK DO FOR YOU?

Over the years, the Grouping of Outdoor Test Centres (formerly PASLINK EEIG), has actively supported activities and initiated European research projects related to the energy performance assessment of buildings. A real experimental set-up for the outdoor testing of building components provided high quality dataseries for the estimation of thermal characteristic parameters. Often statisticians and mathematicians do not have the technical knowledge to correctly apply dynamic analysis techniques to physical processes, whilst engineers may not have adequate knowledge of the complex statistical and mathematical processes. The objective of DYNASTEE is therefore to provide a multidisciplinary environment, by bringing together the scientific community in the field, to add further momentum to many years of applied research, to identify feasible approaches for the practical implementation of dynamic techniques, and to instil the necessary continuity for a cohesive approach to the research work related to the energy performance assessment of buildings in relation to the EPB Directive.

The building sector in the European Union continues to account for approximately 40% of final energy consumption. Whilst the energy intensity of consumption is declining as a result of technological advancements and proactive energy policy, the standard of living in society as a whole, as well as the expectations for an improved indoor environment, continue to rise. Building envelope technologies, such as double facades, transparent insulation and integrated photovoltaics, to name just a few, remain a topic where scientific research is of considerable importance. This applies not only to the development of new, innovative, efficient and effective products of reduced environmental impact, but also of tools and methodologies for analysing the performance of these products and the buildings into which they are integrated. Furthermore, such tools are required in order to develop simplified methods for practical applications, such as the energy performance assessment of existing and new buildings. On this merit, the recast of the Energy Performance of Buildings Directive of the European Union will become a reality, coming into force across the European Union from 2010 onwards and a second generation of CEN energy standards will be developed.

The DYNASTEE network aims to provide a forum for the study of the above mentioned themes by creating an environment of scientific collaboration and awareness, bringing together the scientific community in the field, and adding further momentum to many years of applied research, thus bringing ideas into application.

DYNASTEE

1.2 WHAT IS THE BACKGROUND OF THE DYNASTEE NETWORK AND ITS COMPETENCE?

1985

After the oil crisis in the seventies, Europe started to rethink the energy situation. Buildings were recognised as a sector where energy consumption could be reduced by improving insulation. The application of passive solar technology was also an interesting option for building designers. An international effort was supported by DG XII (now DG Research) to develop policy, technologies and tools in the building sector. One of the RTD activities launched in 1985 was the PASSYS project. Seven Member States joined the consortium, which aimed at creating an environment for outdoor testing of building components including analysis techniques for performance assessment under real climatic conditions. An additional objective was to develop modelling of building energy performance by simulation techniques. The interaction with architects and building designers lead to the development of simplified design tools. At the same time, the European Commission was preparing a

Directive for Construction Products which was finally adopted in 1989 [1]. A general characteristic of the period until 1995 was the development of a common infrastructure in terms of computer technology, software and hardware.

A series of successful projects was carried out during that period, including PASSYS I and PASSYS II, COMPASS and PASCOOL. Meanwhile, three Mediterranean countries and Finland joined the consortium. A further project, named PASLINK, aimed to make the expertise gained through these research actions available to industry. In February 1994, the legal entity PASLINK EEIG was founded. The consortium also supported standardisation activities, such as those of CEN TC89, with the development of a standard for "In-situ measurement" which incorporated analysis through the application of dynamic calculation techniques.

1995

Global political interest in a more environmentally-conscious use of available energy resources came into the spotlight. The White Paper [2], the Green Paper [3] and the Kyoto Agreement [4] are well known to all. More and more interest in solar technologies became evident and the market for solar collectors and photovoltaics was growing fast. The grouping profiled itself as a scientific community of experts on Testing, Analysis and Modelling. After ten successful years of European collaboration, the PASLINK EEIG started a new project on the application of photovoltaic technologies in the building envelope. This project, PV-HYBRID-PAS, aimed to study the overall performance assessment of this specific integrated technology in buildings. The use of the outdoor test facilities in several Member States situated in different climates, together with the available expertise on analysis and simulation techniques, offered the ingredients for a successful project.

Several other projects were started, for example IQ-TEST, DAME-BC and the expertise of the grouping was also offered to other European projects, such as ROOFSOL, PRESCRIPT, IMPACT and PV-ROOF.

The advancements in computer software and hardware were creating an environment for improved software tools for analysis and simulation. Several system identification competitions were organised to develop the level of skill for dynamic analysis methodology.

2005

European policy takes into account evidence of changes in global climate and is adapting its policy to reduce energy consumption and to stimulate the use of renewable energies up to 12% by 2010. It does so by defining a number of Directives, many more than the Construction Products Directive in 1989 [1]. The development of standards and national regulations is expected to contribute to achieving the goals set in the White Paper. The Directives cover the topics of energy efficiency [5], electricity from renewable energy technologies [6], energy labelling [7], energy performance of building [8], use of biofuels [9], cogeneration, etc. Increasing interest in research in energy technologies that result in the rapid transformation into a sustainable and secure energy future for Europe, together with further advancements in information technology (internet, fast computers and portable platforms), herald many opportunities for European research and industry and implicitly for the PASLINK community. The grouping offers its expertise to the new Member States that joined the European Union in 2004 and investigates the means to evolve through support of activities which adopt a global approach to energy and environmental design in the built environment, including the DYNASTEE network (an informal network created from the DAME-BC project), thus preparing for the changes in the next ten years.

2. PROJECT/NETWORK ACTIVITIES

2.1 WHAT ARE DYNAMIC MATHEMATICAL METHODS?

Roughly 1/3 of the energy consumed in Europe is in the building sector, mainly for heating and cooling purposes. Therefore it is important to achieve a proper assessment of thermal characteristics of building components (such as windows, walls etc.) under real conditions. Innovative and often complex façade construction elements require a careful study of their energy characteristics. Dynamic ventilated walls or building integrated photovoltaic elements are a few examples.

The main parameters of interest in the research area of energy in buildings are the thermal transmittance and the solar aperture as defined below. Whilst these parameters can be derived from tests with a relatively long duration using the averaging method, commonly used in laboratory experiments, the use of dynamic test sequences and dynamic system identification techniques can reduce the test period and improve accuracy. Such powerful methods for the identification of physical parameters can enable the construction industry to optimise their products for the efficient use of solar energy and to fulfil legislative requirements, like energy labelling.

Dynamic analysis methods are techniques to analyse dynamic processes and to identify typical parameters of the physical process. Dynamic methods take into account the aspect of time whereas a static analysis method does not. By dynamic evaluation techniques (parameter identification) dynamic effects due to accumulation of heat in the equipment, test room envelope and test specimen are properly taken into account. In general, parameter identification is needed to be able to derive the steady state properties from a short test with dynamic (e.g. fluctuating outdoor) conditions.

The application of system identification techniques to the energy performance assessment of buildings and building components requires a high level of knowledge of physical and mathematical processes. This factor, combined with the quality of the data, the description of the monitoring procedure and test environment, together with the experience of the user of the analysis software itself, can produce varying results from different users when applying different models and software packages. Past international system identification competitions (1994 and 1996) demonstrated the spread in results that can be expected regarding the application of different models and techniques to the same benchmark data. The PASLINK network has attempted to consolidate and strengthen knowledge and expertise of system identification techniques within the grouping by organising lectures and workshops and also to ensure that data analysis meets minimum quality levels.

Chapter 3.2 highlights the milestones in the development of practical software tools, defining data series for training and selected practical case studies. As an example, the spread in results from analysis will be discussed obtained during the previous competitions to that obtained during the recent workshops [10] carried out by the PASLINK network, following ten years of networking activities in the field. The objective was to identify the extent to which these activities have strengthened the position of the individual teams working in the field and to identify the areas where quality assurance is met and where further improvements can be made. In order to maintain the quality in analysis and modelling work a third system identification competition has been organised.

2.2 APPLICATION AREAS

The test methodology and analysis methods in the early days of the PASLINK network were based around steady state evaluations. However, as the project progressed it became increasingly clear that both dynamic testing and analysis methods were required to deliver high quality performance characteristics for building components tested in real climates [11]. During the '90's the PASLINK Network moved away from the original philosophy of prescribed common equipment to one of agreed quality procedures for testing which includes the calibration of instrumentation and the test cells, and also data processing and analysis.

The latest developments that have taken place in dynamic testing and analysis driven by the research activities of the PASLINK Network are described and reviews the historical development of the test and analysis procedures currently in use.

Definitions of the physical parameters of interest derived from the energy balance equation:

UA is the heat transmission coefficient: the heat flow rate in the steady state divided by the temperature difference between the surroundings on each side of the system or component, in W/K. For the 1-D case the U-value, in $W/m^2 K$.

gA is the total solar energy transmittance or solar aperture: the heat flow rate leaving the component at the inside surface, under steady state conditions, caused by solar radiation incident at the outside surface, divided by the intensity of incident solar radiation on the component, in m^2. For the 1-D case the g-value [-]

Energy performance concerning buildings can be divided in three research areas:

Building components (such as bricks, window systems, insulation material, wall components). The experimental conditions are well-known and the experiment is optimised to investigate one dependent parameter. Often these experiments are performed in laboratories (hot-box and guarded hot-plate experiments).

Test cells**.** The European outdoor test facility created under the PASSYS project offers to industry the possibility to perform research on complete building wall components under real climate (including effects of phenomena like rain, wind and sunshine) and well controlled conditions. Specific tools have been developed to analyse the obtained data.

Real buildings**.** A complex situation appears when occupied buildings have to be analysed. The behaviour of the occupants cannot be controlled (opening windows) and additional techniques have to be used for the analysis of the data. Interaction of simulation tools based on physical properties and system identification techniques are under investigation. However when carefully applied, system identification could offer the way for the energy labelling of buildings.

- Buildings; Improving Energy Efficiency
  - In-situ measurements for renovation (CEN)
  - Optimisation of district heating
  - Energy labelling by intelligent metering
  - Optimal integration of solar thermal for DHW
  - Double skin facades
  - Solar Control
  - Cool Roofs

Over the past decade the interest in renewable energy has increased. Analysis of complex dynamic energy flow systems that contain non-linear processes needs a skill. Considering the built environment, the focus has been mainly on utilising solar energy with promising developments in the integration of photovoltaic (PV) technology in buildings. Building Integrated Photovoltaic (BIPV) systems combine other functions of the building envelope with electricity generation. Examples include the following.

- External shading devices containing PV cells.
- Roofing tiles, directly replacing traditional pitched-roof materials and also being placed on low-sloped roofs in some climates.
- Rain-screen cladding and curtain walling.
- Ventilated facades where PV is used as the external cladding element. The larger part of the incident solar radiation on the PV elements is converted into sensible heat, which results in a warming-up of the PV elements, which may reduce their electrical efficiency. Ventilating the cavity behind the PV limits the temperature rise, and the warm air may be used for ventilation pre-heat in winter, or driving natural ventilation in summer. Such systems may be termed hybrid-PV components.
- Dynamic ventilated window systems
- CEN - dynamic methods for in-situ measurement analysis

As part of the building envelope the impact of any construction element on the whole building performance must be considered and in the case of PV panels the electrical performance as well. Various projects have investigated the impact of BIPV on building performance. The PV-Hybrid-Pas project [see www.dynastee.info] was concerned with thermal performance evaluation of hybrid-PV components (with both natural and forced ventilation), as well as the measurement of electrical performance under real climate conditions, using the PASLINK outdoor test facility. A number of case studies are discussed on the PASLINK web-site. A recent study [12 and 13] discusses non-linear models for BIPV heat exchange.

Apart from energy performance assessment for buildings, dynamic mathematical techniques as have been developed by the Network during several European research projects, can be applied to a wide range of applications; to mention some:

- Integration of Renewable Energies
  - Improved control of energy supply and marketing
  - Wind and Solar Power Prediction for the grid
- Medicines
  - Improving efficiency (Insulin dosing)
  - Pharmaceutical Kinetic and Dynamic Modelling [see Ref 33]

3. PROJECT/NETWORK RESULTS

DYNASTEE, being a network of competence in the field of outdoor testing, dynamic analysis and simulation has 25 years experience and would like to transfer its knowledge to industry, decision makers and research. Specific outdoor experimental work needs knowledge of the analysis process in order to optimise the dynamic information in the measurement data. Simulation requires results from analysis in order to be able to scale and replicate the results from analysis and testing.

3.1 TESTING

A brief introduction to outdoor testing. The test cells were designed and installed during the EU PASSYS and PASLINK projects. In the nineties 38 test cells at 13 sites in Europe were available for testing. Over the years the test facility has been improved to produce high quality data for dynamic analysis methods. Figure 1 gives an idea of an outdoor test facility with two test cells and climate sensors positioned around its south-facing wall. A schematic view of different energy flows is given in figure 2. The tests are carried out under real outdoor weather conditions. For obtaining dynamic information from the components a dynamic heating and cooling strategy inside the test cell is needed to ensure that the data obtained from the test contain at least the minimum of information needed to derive the required characteristics. An auxiliary resistive heater is used for that purpose and is controlled applying a pseudo randomly ordered on/off sequence. In general, the thermal and solar characteristics of the test specimens are a function of the indoor and outdoor environment conditions, such as temperature level, temperature difference, solar radiation level and position of the sun and sky conditions (clear, overcast). This implies that in case the intention of the test is to obtain results in terms of product information, the characteristics derived from the test may require conversion from actual test conditions to certain standard conditions, such as conditions specified in European standards.

Figure 1. Homogeneous opaque insulated panel and a simple window system placed in the south wall.

It is well known from theoretical analysis that the solar aperture is influenced by the season and the geophysical position of the building component of interest. For general applications the following steady state equation (the energy balance equation) can be used:

$$UA * (\theta_i - \theta_o) - gA * Qsolar - Qheater = 0 \quad (3.1.1)$$

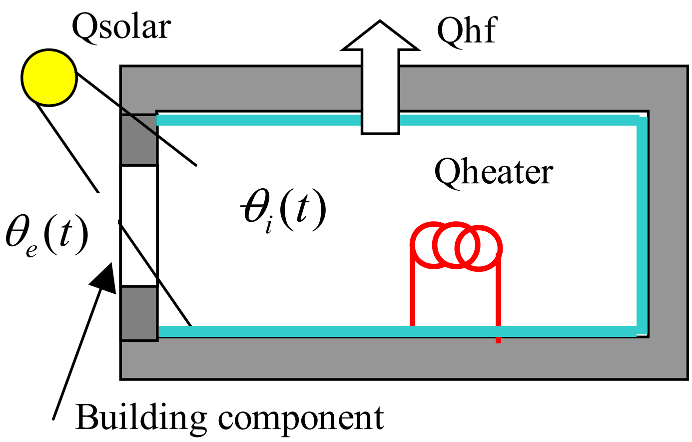

Figure 2. Schematic view of energy flows.

The input signals are: $\theta_i(t)$, the internal air temperature at time t, in °C and $\theta_e(t)$, the external air temperature at time t, in °C respectively, the solar radiation, Qsolar and the auxiliary heat, Qheater, applied to disturb the system. The flow of heat, Qhf through the envelope (excluding the component under test) is measured also. All flows are in W/m^2.

3.2 ANALYSIS

During the last 20 years with the development of computing hardware and software, a huge advancement has made been made in assessing the specific characterisation of the energetic behaviour of buildings and building components (see also reference [14]). Computer technology has made calculation as well as monitoring of thermal processes in buildings much easier than ever before. However the implementation of hardware and software tools and the proper design of experiments require a certain skill. During 20 years of international research dedicated to the energy characterisation of buildings and components through several EU funded projects expertise has been made available. In 1994 the PASLINK EEIG focused on outdoor testing, analysis and modelling of buildings and components. A good example was recently published on testing and analysis by the PASLINK network [15]. The development of dedicated software tools to identify thermal parameters from physical systems has gone hand in hand with the fast development of computing hardware. Software tools like CTSM [16], LORD [17] or the SIT in the MATLAB environment [18] are good examples. Also modelling software tools like TRNSYS and ESP-r show a similar progress and user friendly interface.

System identification techniques have been developed in order to assist researchers in obtaining a better and more accurate knowledge of the thermal characteristics of building components [4]. System identification is the field of modelling dynamic systems from experimental data (see also [19]). A good academic book is given in reference [20] and [21]. A dynamic system has a number of input variables, *u(t)*, it is affected by disturbances *N(t),* and it has output signals *y(t)*. The general form of a dynamic system is shown in Figure 3.

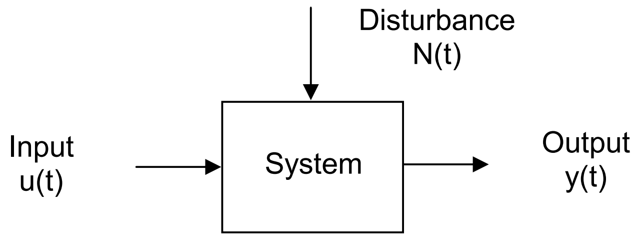

Figure 3. General form of a dynamic system

System identification is applied by the following procedure:

1. An experiment is performed by exciting the system and regular observing its input and output signals over a specific time interval.
2. These signals are recorded for subsequent "information processing".
3. A parametric model is developed to process the recorded input and output sequences. Several models can be applied.
4. An appropriate form of the model is determined (typically a linear differential equation of a certain order).
5. A statistically based method is used to estimate the unknown parameters of the model.

Applying system identification techniques on physical systems requires at all stages knowledge of the physical system. For buildings it is important to know what the impact is of cold-bridges, corner effects, etc. The researchers goal is to estimate physical parameters by using mathematical models.

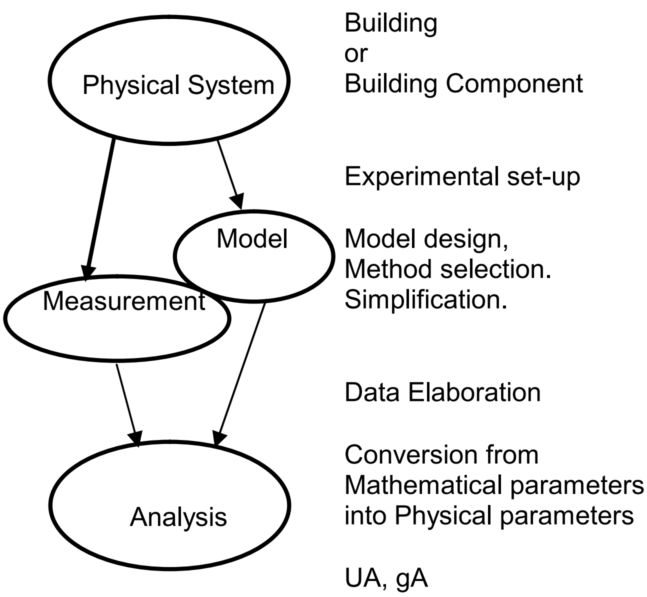

Figure 4. Overview of process steps.

In most cases the calculation from mathematical parameters, which are derived from the chosen model, to physical parameters, in this case the heat resistance and solar aperture, introduces another point for discussion between physicists and mathematicians. Physicists like to compare the obtained values of the estimates from different methods, however they do not always realise that the way they are obtained from mathematic procedures might be different.

On the other hand, for the determination of the thermal and solar characteristics the knowledge of the heat flow through the test room envelope is an absolute must, in order to be able to obtain the properties of the test component decoupled from the test cell. This asks for a separate calibration test. For the characterisation of different approaches it is necessary clearly to the following terms: tools, methods and models will be introduced briefly.

A *model* is a mathematical description of a physical system or process. By definition it is a simplification of the reality. Models can be categorized in different ways. A list of possible models to be used is the following:

- thermal models or lumped parameters models
- state-space models
- modal models
- linear regression models
- frequency domain models
- neural network models

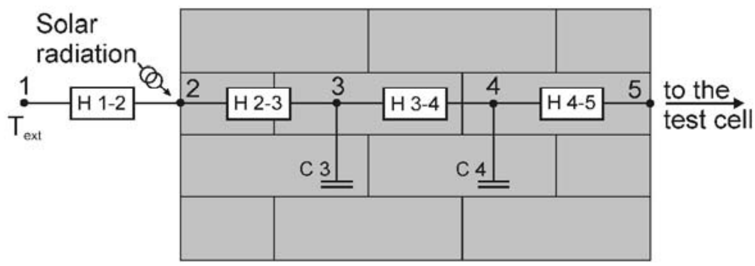

Figure 5. Lumped model for a simple wall

A *method*, here a system identification technique, consists of two major parts: the mathematical model (e.g. an ARMAX model) and the routine to estimate the parameters by a specific algorithm (e.g. least squares method). Minimisation is used in the context of minimising the difference between measured and corresponding data obtained from the model. Optimisation is used in the context of optimising the mathematical parameters of the model to fit the data obtained from the model with the measured data.

A *tool* is a sophisticated software program which allows the user to use a method in a user friendly way. It is a ready-to-use product. Often these types of tools come with pre-processing routines and statistical information about the identification process and accuracy of the estimates. The selection and creation of models is one of the items which is simplified in a graphical way. Toolboxes are popular among researchers. It offers the freedom of the creation of own methods using reliable algorithms and routines. The system identification toolbox [22] in MATLAB is a good example of such an environment.

The following six points can be distinguished in the general approach of solving the problem of energy performance assessment using identification techniques.

1. design the experiment. In a first phase the experiment must be designed taking into account the objective, all available physical knowledge and all possible errors must be reduced to a minimum.

2. perform the experiment. The duration of the experiment must be long enough to fulfil all objectives. Special attention needs to have the interval for data acquisition. Collect data

3. pre-processing. Check for irregularities by having a global look at the data. This can be achieved in different ways. One way is to plot some of the important input signals. Another way is to apply the average method and to examine statistical information of the data.

4. analysis by estimation. Choose and apply a model and method that you are familiar with. Determine model structure. There are several ways to classify models, methods or tools.

   - available software; general purpose software like MATLAB, MathCad, programming languages and mathematical libraries.; some examples of special purpose software are given below.

   - categories in prediction or output error method, deterministic or stochastic.

   - the minimization criteria. Least Squares Method (LS) and the Maximum Likelihood (ML).

5. post-processing of the results. The most important is the validation of the applied model. Criteria that can be used for that purpose can be the following (in [23], Norlen, 1993):

1. Fit to the data	Residuals are 'small' and 'white noise'
2. Reliability	Same results with different data
3. Internal validity	Cross-validation; The model agrees with other data than those used for estimation
4. External validity	Results are in general not in conflict with previous experience
5. Dynamic stability	From a steady state, the response from a temporary change in an input variable fades out
6. Identifiability	Model's parameters are uniquely determined by the data
7. Simplicity	The number of parameters is small

   Special attention needs to be applied to the conversion from mathematical parameters into the required physical ones. This is often a cause for problems, misunderstanding and errors.

6. feedback should be made in every phase of the process. Is the model accepted? It is advisable to apply more than one method to get a better understanding of the whole problem. Common sense should always be used and all available physical knowledge should be applied whenever possible.

   Based on the experience from the analysis of test cell data a closer look at the properties will be given. In general two types of criteria for parameter identification can be distinguished:

   the Prediction Error Method (PEM) and the Output Error Method (OEM)

The OEM is a special case of the PEM when takes the following formula in consideration:

$$Q(t) = G(q)u(t) + H(q)e(t) \quad \text{when} \quad H(q) = 1 \qquad (3.2.1)$$

1. The Prediction Error Method

PEM (e.g. CTSM, linear models) based on statistical models finds parameters by minimising the error between a k-step (usually k=1) ahead prediction and the measured output. Some characteristics are:

- more sensitive to high frequency parameters

- too optimistic on low frequency (steady state) parameters

- disturbed if residuals are auto correlated

2. The Output Error Method (OEM)

Simulation or Output Error Method (e.g. LORD) based on deterministic models finds parameters by minimising the error between simulation and measurement over a whole test period. Some characteristics are:

- more sensitive to low frequency parameters

- too optimistic confidence intervals if residuals (here simulation errors) are auto correlated

- but due to inertia these are "always" auto correlated

- the application of a correction factor in the minimization algorithm.

one can ask if different types of parameters need different correction for auto correlation?

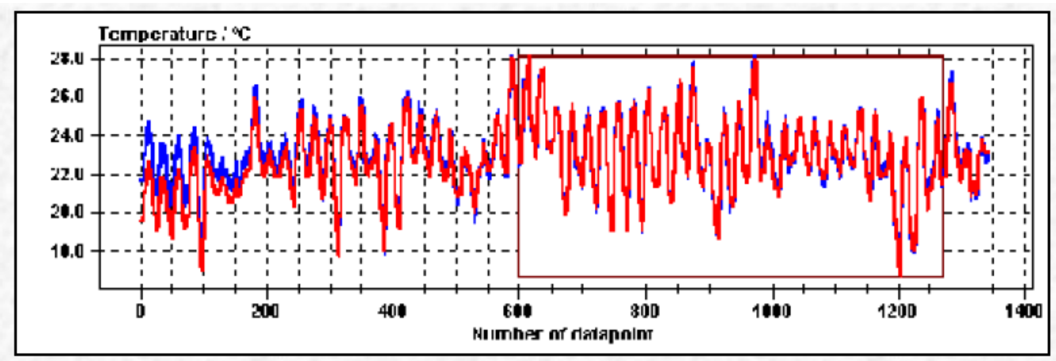

Fig 6. Measured and simulated output from a mathematical model

If the Prediction Error Method is used then we have reliable methods for model validation and for finding the optimal model - this is not the case for OEM. The PEM approach offers methods for identifying functional relations – this is not the case for OEM. The PEM approach used the data efficiently - this is not the case for OEM. (it is known that the PEM or MLE approach is an efficient estimator - see also [21]).

Within the frame of pre-normative research the PASLINK grouping developed a performance test aiming to offer for the CEN standard on "in-situ measurements of thermal resistances" a series of reliable dynamic analysis tools. This activity has gained renewed interest from CEN by a new WG for this topic.

3.2.1 IN-SITU MEASUREMENTS FOR RENOVATION

It has been estimated that in the UK around 70% of the houses in 2050 exist now. Whilst the ageing housing stock has the advantage that it already embodies carbon, it presents a major challenge to meet carbon emissions targets and improve energy efficiency. The refurbishment of traditional buildings is of particular interest to heritage agencies in order to respond to this challenge and maintain our architectural heritage. *In situ* U-value measurements have an important role to play in the assessment of the actual thermal performance of traditional building envelopes both before and after refurbishment.

Glasgow Caledonian University has been carrying out such measurements for Historic Scotland [24] and English Heritage since the winter of 2007/08 with the objective of contributing to guidance for energy performance assessments and implementing energy efficiency measures in traditional buildings. The test method uses data loggers equipped with Hukseflux HFP01 [25] heat flux and temperature sensors. The heat flux sensors are 80mm in diameter and 5mm thick. The sensors are mounted by firstly applying a layer of double sided adhesive tape to the back of the sensor. Secondly, low tack masking tape is applied to the wall. Finally, the heat flux sensor is applied firmly to the masked area. This arrangement is generally satisfactory for two or more weeks monitoring on painted or plastered surfaces only. Wallpapered surfaces are not generally used in case of damage. Sensor locations are chosen to avoid possible thermal bridges near to windows, corners, etc., with the sensor ideally located about half-way between window and corner, and floor and ceiling. A thermal imaging survey is recommended. Generally two heat flux sensors are used on each wall.

Stainless steel-sheathed thermistors are used internally and externally to measure air temperature. Internal sensors are mounted in a simple shield to minimise the influence of solar radiation, heat sources, etc. External temperature sensors are placed in a radiation shield mounted either on the exterior wall surface or attached to a drainpipe, etc. if there is concern about penetrating the structure. Thermocouples are used to measure surface temperatures.

Monitoring should be carried out over the heating season to maximise the temperature difference between inside and outside. The normal heating schedule provided by the occupants is generally satisfactory.

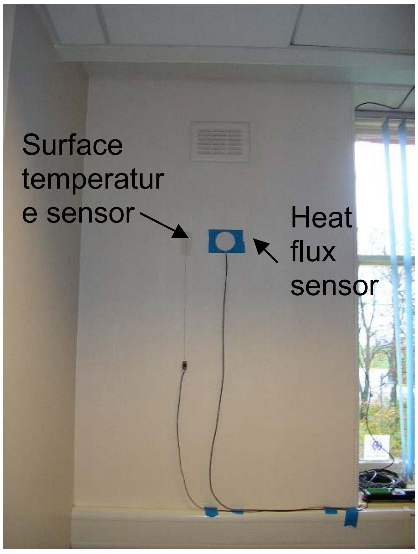

Figure 7: Typical heat flux sensor and temperature measurement locations

Figure 8: Mounting of shielded external temperature sensor strapped to drainpipe using cable ties.

Given that the monitoring conditions are non-steady state, it is considered necessary to monitor for a minimum of two weeks to allow for thermal inertia, in order to collect sufficient data to estimate *in situ* U-values by a simple averaging procedure. Figure 9, shows the results from longer term monitoring of a wall in a 18th Century building constructed of brick with a timber panel internal lining. The Figure 9 shows the U-value and its uncertainty estimate (the RMS measurement errors and confidence interval) with increasing monitoring period using the simple averaging method and the dynamic analysis software tool LORD [2]. For two weeks' data the uncertainty is 13% for the averaging procedure, whilst LORD gives an improved uncertainty of 7%.

Using the dynamic analysis tool enables the effect of thermal inertia to be fully considered and the monitoring period optimised.

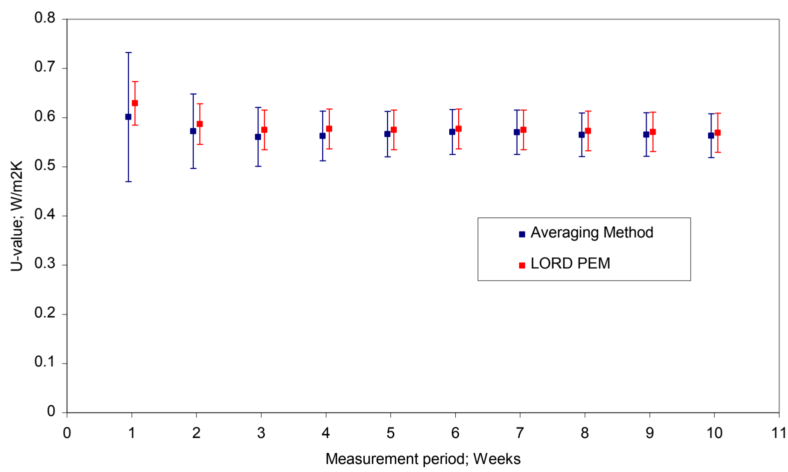

Figure 9: The effect of increasing the monitoring period and the uncertainties in the U-value estimates for a simple averaging procedure and using LORD (PEM).

3.2.2 DYNAMIC MODELLING AND ENERGY METERING.

Soon energy meters will allow for simultaneous and frequent readings of power, heat and water consumption also in family houses, and the readings will in most cases be transferred by the IP protocol to a central facility for energy managements.

Energy meters give possibilities for obtaining time series of actual energy consumption in households with readings say every 10 minutes. At the same time meteorological services will facilitate possibilities for obtaining local time series of relevant and local meteorological parameters.

To clarify the difference between smart and intelligent meters the following brief definitions can be applied:

Smart meters are, compared to traditional electricity, water or gas meters, taking readings in more and regular detail and communicate them electronically through some network to the utility (and end-user) for monitoring and billing purposes (often referred as automated meter reading).

Intelligent meters can in addition, analyse these observations, identify characteristics and make decisions aiming to improve further the optimisation of energy efficiency. The utility as well as the end-user can communicate with the intelligent meter also (two-way communication).

Readings from smart meters might be analysed on a central server and so become a part of an intelligent metering environment, for example for district heating management or an energy service company (ESCO).

In the near future these time series will provide the background for using the developed methods for dynamical modelling for:

1) Automatic energy labelling of buildings.

2) Improved control of the energy supply to buildings, eg. by use of MET forecasts.

3) Using buildings to facilitate the integration of large fractions of renewable energy.

4) Providing advises on the best ways of improving the energy performance of a building.

In this chapter the status of energy metering in EU is outlined followed by a discussion on methods for the use of dynamic modelling for calculating energy labelling of buildings. The other subjects, ie. subjects 2) to 4) above, are only briefly discussed here; some important references will however be given.

3.2.2.1 Plans on rolling out energy meters in EU

Smart and intelligent meters are one of the big energy saving hopes by reducing the energy used in family houses, lowering your energy bill, and carbon emissions. These energy meters are the next generation of electricity, heat or gas meters. They are different from the old-style metering devices as they are able to transmit data to eg. the energy supplier, say every 10 minutes or even more frequently. Intelligent meters can in addition analyse the observed readings.

It is expected that by 2020 almost every UK home will have a smart meter, and similar plans are observed in many other European countries. More specifically the foundations for rolling out smart meters in Europe were laid down in a 2006 EU directive on energy end-use efficiency and energy services. The directive required member states to ensure that consumers of energy and water are provided with individual meters and accurate billing, including time-of-use information.

The gas and electricity directives of the third energy package, adopted in 2009, require member states to prepare a timetable for the introduction of intelligent metering systems.

According to EurActiv.com EU legislation on buildings has also sought to pave the way for the introduction of smart meters. In April 2009, the European Parliament voted to add a provision to the Energy Performance of Buildings Directive that would have required the installation of smart meters by default in all new buildings as well as when renovating older ones.

3.2.2.2 Energy Labelling.

Today the energy performance of a building is more or less subjectively judged by an expert in building physics. It is however well known that these judgements are rather not precise and of a subjective nature. This is partly due to the fact that detailed information about the construction of the building is either non-precise or lacking.

Dynamic modelling can be used to process time series from smart meters and time series of relevant meteorological data to provide a non-subjective and automatically generated values characterising the energy performance of the building. Once the software is Integrated in a smart meter, the device becomes an intelligent energy meter.

In Denmark the Electricity Savings Thrust initiated research on the use of dynamic methods and smart meters for energy savings. In Ref [34] data from smart meters from 56 households in Denmark has been used to derive rather simple models for the energy transfer, which provides estimation of the coefficients characterising the response of the building to changes in air temperature (UA-value), solar radiation (gA-value), and wind (wA-value). The effect of wind is characterised both in terms of wind speed and wind direction, and the effect of wind can be represented as an increase in the UA-value given a high-wind situation.

The methods do not require measurements of the indoor air temperature, as the methods proposed in Ref [34] also delivers estimates of the indoor air temperature as an integrated part of the procedure. For the 56 households quite reasonable values (from 17.7 to 25.7 °C) were observed.

The heating of the 56 households is provided by district heating, and in the report the estimation has been performed both based on the total energy consumption (district heating and electricity), as well as on the district heating consumption alone. Overall, the estimated UA-values only change marginally (up to 10 W/°C) depending on which variable was used for modelling. However, it is recommended to use the total energy consumption for calculating the energy characteristics of the buildings.

Regarding the dynamic response it is concluded that on the time scale considered the dynamic effect of temperature and solar radiation are well described by a single time constant.

Figure 10. Experimental FlexHouse at RISØ in Denmark

The lumped parameter models and methods for estimating the thermal performance of buildings as developed during the DYNASTEE related projects are described in a number of articles. In figure 11 a representation of the model that has been identified using the software tools developed by the Dynastee grouping.

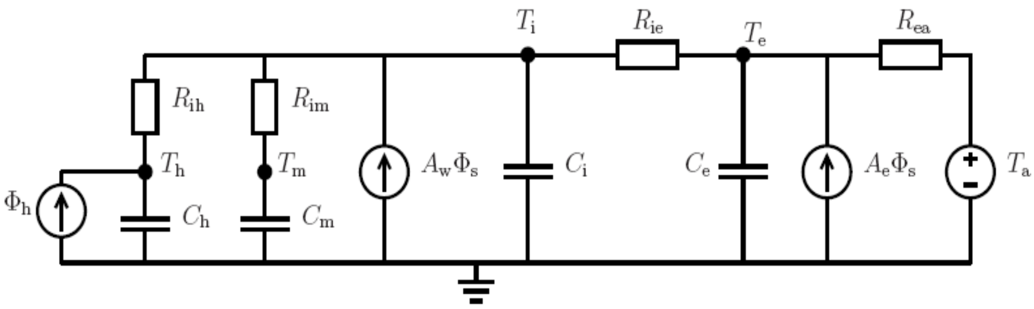

Figure 11. Model used for identification.

In Ref [35] the main principles are described for a single room building. Models for the energy performance of a green house is considered in Ref [36]. Models for multi-room buildings are the focus in Ref [37]. The used of MATLAB for estimating the main thermal characteristics is described in Ref [38]. A non-linear model is needed for instance for modelling buildings with PV integration on the facade as described in Ref [39].

3.2.2.3 Improved Control of the energy supply.

Adequately calibrated dynamic models are also needed for the next generation of control of the energy supply. This includes optimal use of night set back systems, time varying temperature zones, air temperature and solar radiation compensations, etc.

In future versions of control systems meteorological forecasts may be used as an input to provide forecasts of the heat load of building and optimal control of the heat supply. This includes a next generation of forecast based temperature compensation controllers as well as optimal planning of the local energy production.

As an example it is demonstrated that dynamic models can lead to significant savings in district heating systems. In Ref [40 and 41] dynamic models developed under PASSYS are suggested for predictive control of the heat supply using some controllers described in Ref [42]. Similar controllers are suggested for green houses in Ref [43]. In Ref [44] these controllers are considered for more complex systems.

The potential for energy saving using the controllers based on dynamic models is large; in [Ref 45] it is demonstrated that the heat loss in district heating systems can be reduce with 10 to 20 %. by using dynamic models for predictive control of the temperature level.

3.2.2.4 Integration of large fractions of renewable energy

It is expected that buildings in the future will play an active role in the integration of renewable energy in the energy system, and in order to operate such a system in an optimal way it is essential to have access to dynamical models for the heat dynamics of the building as well as reasonable forecasts of the heat and electricity load for the household. In some new research projects in Denmark, where today 23 % of the electricity is from wind, the use of dynamic models for buildings for integration of up to 50 % of renewable energy will be studied. This is the goal set for 2020 by the Danish Government.

In some areas it is expected that a large share of the households will integrate some sort of solar or wind power related to their heating system. An optimal operation of such a system requires on-line forecasts of the expected solar or wind power production, and dynamical models for on-line prediction of the solar power production is described in [Ref 46]. Similar models for on-line forecasts of the wind power productions using dynamic models are described in [Ref 47 and 48].

3.2.2.5 Advises for energy savings

The developed dynamical methods will enable new methods for providing guidelines for improving the building with the purpose of obtaining energy savings. The tool will indicate the most beneficial subject of improvement, as eg. further insulation in the walls, tighten the building, change the windows, or insulate the roof.

3.3 MODELLING

The Role of Simulation

Researchers in the DYNASTEE network and its precursors have been involved with measurement and analysis of building components and buildings. As described elsewhere in this document, system identification techniques have been employed to extract key energy performance characteristics that can be used to quantify the thermal performance of the energy system.

In parallel with the system identification analysis techniques, model calibration and scaling procedures have been developed that make use of the experimental data to formulate simulation models of the building components and then apply them to full-scale application. Over the last 30 years, dynamic simulation programs have improved in functionality and are becoming more routinely used in design and energy performance compliance checking of buildings. There have been numerous international validation projects (organised through the International Energy Agency (IEA), in particular) to check the predictions from leading simulation programs. Although validation is a never-ending task, the current situation is that, in the hands of a skilled user, the major simulation programs that are in common use today can be used with some confidence in predicting the energy and environmental performance of buildings.

However, new building components (e.g. advanced glazing, building-integrated renewables, phase change materials, new insulation products, ventilated constructions, to name a few) are constantly being developed, most of which have significant interactive effects on building performance. As an example, a double facade construction with integral blinds, when configured for pre-heating of ventilation air, will have significant direct impacts on the heating and cooling loads, on the lighting levels (and therefore electricity consumption of artificial lighting and indirectly on heating and cooling loads) and on indoor air quality and facade acoustic performance. To study the energy and environmental performance of such a facade, perhaps with different building orientations and with different airflow configurations, requires simulation modelling. However, it is first necessary to have confidence in the ability of the simulation program to model such performance – this is where the use of measured building component data in a controlled but realistic outdoor environment has a role.

A procedure has been developed, and applied within several major European projects, that consists of calibrating a simulation model with high quality data from the outdoor tests and then applying scaling and replication to one or more buildings and locations to determine performance in practice of building components. The procedure has three elements:

> *Calibration*. This involves creating a simulation model of the test component and the test environment, undertaking simulations using the measured climatic data, and then comparing predicted performance with measured performance (heating and cooling energy consumption, temperatures etc.). If successful, it gives confidence that the simulation program can correctly model the component characteristics when that component is subject to dynamically varying outdoor conditions. In many cases, it is difficult or too time-consuming to measure all the required model parameters – a good example is the flow of air in double facades which is very difficult to measure accurately. In such cases sensitivity studies can be undertaken to determine the impact of the input uncertainties and to determine the most appropriate values to use. The advantage of using outdoor test cells is that the experiments are well-controlled, so the number of uncertain parameters is significantly less than for whole buildings, particularly when they are occupied.
>
> *Scaling*. This step requires the modelling of selected full-scale buildings for deployment of the building component under test. Simulations are undertaken of a base case of the building without the component, and then with the component included. Comparisons are made over a range of appropriate performance metrics such as energy consumption, thermal comfort and visual comfort. The technique allows a more realistic estimate of how the component will perform when it is fully integrated into a building, taking account of, for example, the utilisation of passive solar heating. In essence, it uses calibrated simulation models to extrapolate the test component measured performance, obtained from outdoor test cell experiments, to the full scale.
>
> *Replication*. This (optional) step involves repeating the simulations with different climate datasets and, perhaps, different local operational regimes to determine performance in different locations.

This use of simulation models to investigate the full-scale building-integrated performance has been applied to a number of new building components. Several examples are summarised in the papers [26] and [27], such as advanced glazing components, a sunspace, ventilated roof and hybrid photovoltaic modules. Other studies which have involved detailed comparisons of simulation models and measured data from controlled experiments on test cells have been undertaken as part of validation research projects – examples include those from the recent IEA International Energy Agency Task 34/43 on program validation, with work on shading/blind systems and double facades [28], [29].

For the future, the advent of ubiquitous monitoring of building performance with smart meters offers a chance to apply calibration and optimisation techniques to the simulation models that have been used in the design and compliance checking of those buildings. This could allow the reconciliation of the often large mismatch between performance in design and performance in practice, and to identify required remedial action to improve performance.

3.4 TRAINING

A series of case studies for estimation techniques for the energy performance characterisation of buildings and building components have been developed during several EU supported research projects. These case studies are freely available.

3.4.1 System Identification Competition

The objective of the system identification competitions is to further develop knowledge of system identification applied to thermal performance assessment in the built environment.

After the success of the first competition [30] in 1994 and the second one [31] in 1996, the organisation has prepared a third challenging one in 2007, involving data from in situ measurements and real experimental set-ups. The previous competitions show that a number of methods and techniques exist and how inventive researchers can be to solve the physical problem of thermal behaviour. The most important conclusion has been that one needs a certain level of skill using system identification techniques, to perform well. The PASLINK network has organised over the last couple of years several workshops and courses to bring the knowledge to the people and to further improve the tools [32]. The implementation now of the Energy Performance of Building Directive [8] requires adequate calculation and modelling tools and this is the main reason that a third competition has been organised.

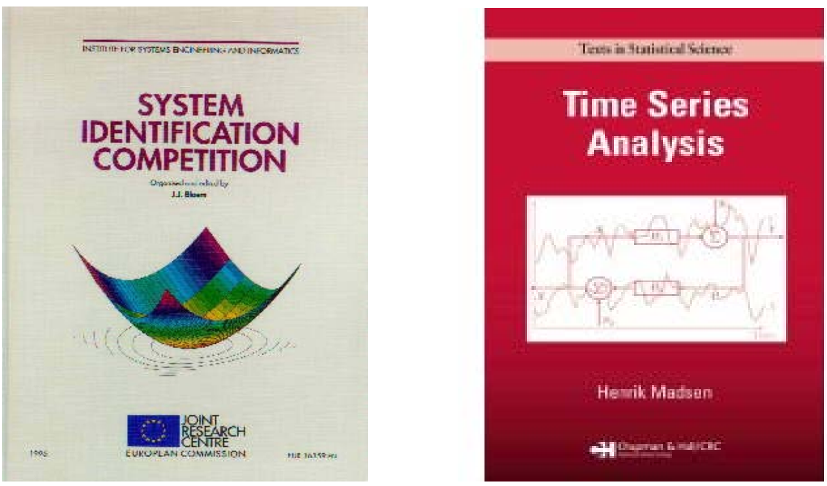

Figure 11. Two examples of available books; Ref [30 and 21]

The application of system identification techniques to the energy performance assessment of buildings and building components requires a high level of knowledge of physical and mathematical processes. Similar problems arise in most observational disciplines, including physics, biology, and economics. As an outcome of the DAME-BC project (funded by DG-RESEARCH) the DYNASTEE network has brought knowledge from different disciplines together to work on this subject.

This new challenge has been organised to help clarify the conflicting claims among many researchers who use and analyse building energy data and to foster contact among these persons and their institutions. The intent is not to declare winners, but rather to set up a format in which rigorous evaluations of techniques can be made. In all cases, however, the goal is to collect and analyse quantitative results in order to understand similarities and differences among the approaches. Moreover participation to this competition will offer material for training and self study.

Research on energy savings in buildings can be divided in to three major areas:

1) building components,

2) test cells and unoccupied buildings in real climate and

3) occupied buildings.

Three competitions were planned along this line, of which the present competition concerned with real data from buildings components will be the third and last one. The present competition is concerned with four different cases for estimation and prediction including real data from a retrofitted wall, an occupied house, an urban area and a solar chimney. Participants are free to submit results from any number of cases. Since all cases deal with experimental data, detailed description is accompanying the data however basic knowledge about the practical energy flows is required.

The data and description for all four cases are available from on www.dynastee.info under the data analysis menu item. The submitted results will be evaluated at regular interval, and presented at appropriate conferences. Because there are natural measures of performance; a rank-ordering will be given and published on the internet. The best contributions will be selected for publication in the SIC III book provided.

3.4.2 BRIEF INTRODUCTION TO THE SIC III CASES

The *first* case is concerned with the monitoring of a wall in a house constructed in the 1990's to assess its thermal performance before and after the installation of cavity-fill insulation. The wall as-built is poorly insulated compared to current standards, with a lightweight concrete block and a cavity providing the insulation. Filling the cavity with insulating material should improve thermal performance, resulting in lower energy consumption and better comfort for the occupants. As a real case study it would be interesting to assess the thermal resistance improvement and the moment of filling the cavity.

The full description and data for analysis can be downloaded from www.dynastee.info

The *second* case concerns an occupied residential house and is a modern (constructed in 1994) two storey single family house with one common wall and the whole envelop insulated (including the roof space). The walls are well insulated and all windows are double glazed. It has been monitored during two heating seasons. In addition the ventilation losses are monitored using PFT techniques.

The *third* case considers the modelling of the heat consumption in a large district heating systems, called VEKS (Vest-Egnens KraftvarmeSelskab). This system actually covers about half of the Copenhagen area. VEKS is a transmission company (established in 1984) supplying surplus heat generated from combined heat and power (CHP) plants to 19 local district heating companies at Western part of Copenhagen. The purpose of this case study is to investigate time series of measured heat production in the VEKS district heating system, and to establish models for predicting the heat consumption one to several hours ahead.

The system considered for the *fourth* case study is a solar chimney constructed and monitored at the LECE (Laboratorio de ensayos Energéticos para Components de la Edificación), from CIEMAT in Tabernas (Almería, Spain). Natural ventilation plays an important role as passive energy saving strategy, regarding cooling of buildings in this climate. Solar chimneys are some of the most useful systems that make use of this strategy. The tests have been carried out in real size and dynamic outdoors weather conditions.

4. THE FUTURE FOR DYNASTEE

2010

Looking towards the future, ten years from today, one may expect that a number of Directives will be put in place. Renewable energies, including passive solar, electrical and thermal technologies, will be visible in the built environment more than 10-20 times than we see today. Being a complex and more dynamic technology, the application of dynamic analysis and simulation techniques is evident. Dedicated energy design and evaluation software tools are needed. An integral energy performance assessment is required and industry will develop innovative building products. An in-situ measurement for the thermal performance of buildings under investigation for renovation becomes a common approach. The "near-to-zero-energy-consuming-building" can be developed and requires dynamic tools for design and operation.

The expertise available in the present DYNASTEE Network can be deployed in particular in the field of dynamic testing, analysis and simulation methods. This is a challenge which the grouping will take by fitting it into the political requirements for building research.

2015

Dynamic mathematical technology is recognised as crucial in optimisation of energy efficiency. Integration of renewable energy technologies in our society is rapidly taking place giving another perspective of the use of available energy resources. The recast of the EPBD, ESD and CPD Directives have taken place and work is ongoing on the update of a 2^{nd} generation of energy standards for calculation methods, certification etc. New buildings consume less energy for space heating while electricity consumption for systems and appliances is increasing.

2020

Ten years from now and a future perspective; in the EU society electric vehicles have become an accepted means of transport in urban areas as well as for long distance. The buildings that are for living and working have become an integral part for distribution and control of energy final consumption. Intelligent metering devices communicate with consumers and utilities and control domestic appliances as well as electric cars.

5. REFERENCES

[1] DIRECTIVE 1989/106/CE. Construction Products Directive (or CPD).

[2] WHITE PAPER; COM (97) 599. Energy for the future: Renewable sources of Energy – White Paper for a Community Strategy and Action Plan.

[3] GREEN PAPER; COM (2000) 769. Towards a European strategy for the security of energy supply.

[4] KYOTO Protocol (1997). http://unfccc.int/resource/docs/convkp/kpeng.pdf

[5] DIRECTIVE 96/57/EC. Energy efficiency requirements for household electric refrigerators, freezers and combinations thereof.

[6] DIRECTIVE 2001/77/EC. Promotion of electricity produced from Renewable Energy Sources in the internal electricity market.

[7] DIRECTIVE 92/75/EC Energy labelling of household washing machines.

[8] DIRECTIVE 2002/91/EC. Energy Performance of Buildings (or EPB).

[9] DIRECTIVE 2003/30/EC. Promotion of the use of biofuels and other renewable fuels for transport.

[10] A. Androutsopoulos, J.J. Bloem, H.A.L. van Dijk, P.H. Baker. Comparison of User Performance when Applying System Identification for Assessment of the Energy Performance of Building Components.

[11] Baker P H and van Dijk H A L, PASLINK and dynamic outdoor testing of building components. Building and Environment, Vol 43 No 2 pp143-151, doi:10.1016/j.buildenv.2006.10.051, Feb 2008.

[12] J.J. Bloem, "Evaluation of a PV integrated building application in a well-controlled outdoor test environment" Reference: Building & Environment 43 (2008) p. 205-216

[13] M.J. Jimenez, H. Madsen, J.J. Bloem, B. Dammann. Estimation of non-linear continuous time models for the heat exchange dynamics of building integrated photovoltaic modules. ENERGY AND BUILDINGS 40; 2008. p. 157-167.

[14] Bloem JJ (Ed.), System identification applied to building performance data. Commission of the European Communities,. EUR 15885. 1994

[15] P.H. Baker. Evaluation of round robin testing using the Paslink test facilities. In Building & Environment. Elsevier 2007.

[16] Kristensen NR, Madsen H, Jørgensen SB. Parameter estimation in stochastic grey-box models. Automatica, 2004; 40: 225-237.

(available from www.imm.dtu.dk/ctsm)

[17] Gutschker O., Logical R Determination (LORD) – Software tool manual, 2003, available from www.dynastee.info

[18] MATLAB – High performance numeric computation and visualization software. Reference guide. The Math Works; Natic; Mass; 1992.

http://www.mathworks.com/products/sysid

[19] Soderstrom T. Theory of System Identification: An introduction and overview. In: Bloem J.J. editor. System identification applied to building performance data. JRC; 1994, p. 3-19. EUR 15885 EN.

[20] Soderstrom T, Stoica P. System Identification. Prentice Hall International: Hemel Hempstead, UK; 1989.

[21] H. Madsen. *Time Series Analysis*. Chapman & Hall ISBN 978 – 1 4200-5967-0

[22] Ljung, L. (1994). *System Identification. Theory for the user.* Prentice Hall. New Jersey.

[23] Norlen, U. (1993). Determining the Thermal Resistance from In-Situ Measurements. In: *Workshop on Application of System Identification in Energy Savings in Buildings* (Edited by Bloem, J.J.), 402-429. Published by the Commission of The European Communities DG XII, Luxembourg.

[24] Baker P.H. In situ U-value measurements in traditional buildings – preliminary results, http://www.historic-scotland.gov.uk/gcu-interim-report-u-value-measurements-traditional-buildings.pdf

[25] Heatflow tiles www.hukseflux.com/heat%20flux/hfp01.pdf

[26] Strachan P and Vandaele L, Outdoor Testing of Building Components: Case Studies, Building and Environment, Vol 43 No 2 pp129-142, doi:10.1016/j.buildenv.2006.10.043, Feb 2008.

[27] Strachan P, Simulation Support for Performance Assessment of Building Components, Building and Environment, Vol 43 No 2 pp228-236, doi:10.1016/j.buildenv.2006.10.051, Feb 2008.

[28] Loutzenhiser P G, Manz H, Felsmann C, Strachan P and Maxwell G M, An Empirical Validation of Modeling Solar Gain through a Glazing Unit with External and Internal Shading Screens, Applied Thermal Engineering, Vol 27, Issues 2-3, February 2007, pp528-538.

[29] Kalyanova O, Heiselberg P, Felsmann C, Poirazis H, Strachan P and Wijsman A, An Empirical Validation of Building Simulation Software for Modelling of Double-Skin Facade (DSF), Proc. Building Simulation '09, Glasgow, pp 1107-1104, July 2009.

[30] Bloem, J. (1996) (ed.). “System Identification Competition”; the book: evaluation, invited and selected papers. EUR 16359 EN ISBN 92-827-6348-X.

[31] System Identification Competitions 1 and 2; description, data and instructions http://www.dynastee.info/sic1_main.php

[32] Vandaele L, Wouters P, Bloem JJ. IQ-TEST: Improving Quality in Outdoor Thermal Testing, Proceedings of the EPIC 2002 AIVC Conference, Lyon, 2002.

[33] N.R. Kristensen, H. Madsen, S.H. Ingwersen: Using stochastic differential equations for PK/PD model development, Journal of Pharmacokinetics and Pharmacodynamics, Vol. 32, pp. 109-141, 2005.

[34] S. Mortensen, H. Aa. Nielsen (2010): Analysis of energy consumption in single family houses, Research Report, Enfor, Denmark (www.enfor.dk).

[35] H. Madsen, J. Holst: Estimation of Continuous-Time Models for the Heat Dynamics of a Building, Energy and Building, Vol. 22, pp. 67-79, 1995.

[36] B. Nielsen, H. Madsen: Identification of a Continuous Time Linear Model of the Heat Dynamics in a Greenhouse, J. Agric. Engng. Res., Vol. 71, pp. 249-256, 1998.

[37] K. Andersen, H. Madsen, L. Hansen: Modelling the heat dynamics of a building using stochastic differential equations, Energy and Buildings, Vol. 31, pp. 13-24, 2000.

[38] M.J. Jimenez, H. Madsen, K.K. Andersen: Identification of the Main Thermal Characteristics of Building Components using MATLAB, Building and Energy, Vol. 43, pp. 170-180, 2008.

[39] M.J. Jimenez, H. Madsen, H. Bloem, B. Dammann: Estimation of Non-linear Continuous Time Models for the Heat Exchange Dynamics of Building Integrated Photovoltaic Modules, Energy and Buildings, Vol. 40, pp. 157-167, 2008.

[40] H. Madsen, K. Sejling, H.T. S\o gaard, O.P. Palsson: On Flow and Supply Temperature Control in District Heating Systems, Heat Recovery Systems and CHP, Vol. 14, No. 6, pp. 613-620, 1994.

[41] O.P. Palsson, H. Madsen, H.T. SÃ¸gaard: Application of Predictive Control in District Heating Systems, Journal of Power and Energy, Vol. 207, pp. 157-163, 1993.

[42] O.P. Palsson, H. Madsen, H.T. SÃ¸gaard: Generalized Predictive Control for Non-Stationary Systems, Automatica, Vol. 30, No. 12, pp. 1991-1997, 1994.

[43] B. Nielsen, H. Madsen: Identification of Transfer Functions for Control of Greenhouse Air Temperature. J. Agric. Engng. Res., Vol. 60, pp. 25-34. 1995.

[44] P. Pinson, T.S. Nielsen, H.Aa. Nielsen, N.K. Poulsen, H. Madsen: Temperature prediction at critical points in district heating systems. European Journal of Operational Research, (in press), 2009.

[45] H. Madsen, T.S. Nielsen, H. Aa. Nielsen: Intelligent Control, News from DBDH, Vol. 3, 2001.

[46] P. Bacher, H. Madsen, H.Aa. Nielsen: Online Short-term Solar Power Forecasting, Solar Energy, 2009.

[47] A. Costa, A. Crespo, J. Navarro, G. Lizcano, H. Madsen, F. Feitosa, A review on the young history of the wind power short-term prediction, Renew. Sustain. Energy Rev., Vol. 12, pp. 1725-1744, 2008.

[48] H. Aa. Nielsen, T.S. Nielsen, H. Madsen: On on-line systems for short-term forecasting for energy systems, Proceedings OR 2002 Conference, p. 265-271, Klagenfurt, Austria, Springer, 2002.

IEE SAVE

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Annex A. SAVE projects

Intelligent Energy – Europe Programme SAVE

SAVE projects

Gordon Sutherland

Timothée Noël

Nathalie Cliquot

Intelligent Energy Europe

ENERGY EFFICIENT BUILDINGS: A KEY ACTION OF THE INTELLIGENT ENERGY – EUROPE PROGRAMME

There are many untapped opportunities to save energy and encourage the use of renewable energy sources in Europe, but market conditions do not always help. The Intelligent Energy - Europe programme is the EU's tool for funding action to improve these conditions and move us towards a more energy intelligent Europe. The SAVE component of the Programme, 'Energy efficiency and rationale use of resources', aims to tap the current large potential for energy savings, in particular in buildings, products and industry. Activities to promote energy efficiency in transport are covered separately under the Programme's STEER component, whilst other parts of the Programme address renewable energies and integrated initiatives.

Energy use in the building sector (residential and commercial) is responsible for about 40% of final energy consumption in the EU, whilst the cost efficient energy savings potential is estimated at 28% by 2020. In fact, we use more energy in buildings than anywhere else. As such, the building sector is key to addressing the challenges of increasing EU energy dependence and growing CO2 emissions, but also provides additional employment and business opportunities and cost-effectively supports local development. The share of buildings in EU wealth in terms of capital -but also social, cultural and historic value and business opportunities- is enormous. Under its key action 'Energy-efficient buildings', the IEE Programme supports actions raising the energy performance of buildings, in particular, but not solely, for the existing stock. It is mainly through environmentally-friendly retrofitting that European citizens can benefit in a short term from improved comfort and less environmental impact from the built environment. If people also change the way they interact with buildings, major savings are there for the picking. Radical changes in the way we design and construct buildings and how we approach urban development will play a leading role in creating a sustainable future for buildings and cities.

Changing today's patterns of energy use is a major challenge both to the professionals who specify, design and construct our homes and workplaces, as well as to the occupants. The projects listed in this section are testament to the spirit of the individual consortia which implemented them, by tackling grass-roots problems and issues within activities of European dimension. Each project has been implemented by a group of organisations from at least three different European countries. To find out more about the outcomes of the projects, their impacts and the organisations and individuals who implemented them, please visit directly the project web-sites as indicated or through the IEE project database (insert link). IEE projects involve a cross-section of people and organisations: municipalities offering vision and leadership and a link to local constituents and the building industry; small to medium-sized enterprises; bodies which promote innovation; and national energy agencies which help shape policy development. To date over 3000 different European organisations have participated in IEE projects, producing a wealth of results for supporting the common energy and climate goals.

The projects listed address all aspects of the building sector and foster energy-efficiency and rational use of energy through various means which include, amongst others, studies, events, training programmes, information campaigns, competitions, voluntary schemes, pilot activities, to name but a few. The topics addressed include:

- Construction techniques and materials, the goal being to promote market penetration of technologies and concepts that take energy performance beyond current legal requirements.

- Training industry professionals, to boost European leadership in integrating architectural design and technology.

- Access to finance, to assist with the implementation of energy efficiency measures in both the private and public sector.

- Effectiveness of regional, national and European policies, building regulations and standards, to provide a fair and level playing field for a mature energy-efficiency market.

New regulations, such as the recast of the Energy Performance of Buildings Directive, reflect the European Union's commitments on climate change and its determination to secure energy supplies for homes and businesses. Together with construction standards, they will ensure our homes and workplaces are safe, comfortable, healthy and non-polluting.

With markets, technology and policy all developing in parallel, there is a need for flexibility, cooperation, networking and the involvement of market actors. Communication with target groups is an essential component in all projects. By communicating their findings on energy efficiency, IEE projects play a vital role in raising awareness about energy savings and renewable energies.

ASIEPI

Assessment and improvement of the EPBD Impact (for new buildings and building renovation)

The ASIEPI project addresses the issue of compliance with European legislation on the energy performance of buildings, the inter-comparison of building energy performance across Europe, plus the following specific technical topics: thermal bridges, summer comfort, airtightness and the use of innovation in buildings. It aims to provide support to both Member States and the European Commission, providing solutions as the project unfolds. Given that many of the project participants are directly involved in the preparation of revised building codes in their own country, the project is expected to have a direct impact from its outset.

http://www.asiepi.eu

AUDITAC

Field benchmarking and Market development for Audit methods in Air Conditioning

Under new EU legislation, governments are obliged to adopt inspection schemes for air-conditioning systems over a certain cooling output. AuditAC investigated and promoted auditing procedures as a fundamental way of achieving real savings, in both CO2 and energy, in air conditioning systems. Part of the work was to produce tools that would help expert auditors, inspectors and energy managers identify the energy saving opportunities and avoid unnecessary waste. The ultimate goal was to get the market to accept the proposed procedures.

http://www.cardiff.ac.uk/archi/research/auditac/publications.html

AVASH

Advanced Ventilation Approaches for Social Housing

The project's first goal was to analyse both thermal and air leakage in a broad range of social housing in Denmark, Ireland and the United Kingdom. After completion, different ventilation upgrade scenarios have been simulated using computer simulation techniques in order to ascertain the best approach for upgrading ventilation systems from a health and energy efficiency point of view. These results are a valuable resource throughout Europe for housing managers, who are becoming aware of the cost and the benefits of upgrades.

http://www.brighton.ac.uk/art/avash/

BESTFACADE

Best Practice for Double Skin Facades

Double-skin façades have become popular over the last 15 years as people seek out more natural interior environments. The double skin can offer a thermal buffer zone, solar preheating of ventilation air, energy savings, as well as acoustic, wind and pollutant protection, and the possibility to open windows and have night cooling. Commercial buildings incorporating such facades can save large amounts of energy. The critical issue is to ensure that the façades are designed appropriately to the local climate and perform well. BESTFACADE aimed to use a range of media to provide the designers with reliable scientific, technical, regulative and financial information on these constructions.

http://www.bestfacade.com

BEWAREE

Energy services reducing the energy consumption of residents by behavioural changes

Households are responsible for 30 % of the total energy consumption in Europe despite of the upgrading of buildings undertaken in order to improve energy performance during the last decades. According to European surveys, most European residents, especially in low-income households, need more information on the efficient use of energy in their houses. The BewareE project aims at stimulating this change of attitude and at enhancing the implementation of 'energy services' in cooperation with housing organizations and companies, drawing on 'good practice examples' from EU and national projects. This project is generating a database of energy services to be disseminated among housing organizations and companies, public and private energy service providers. The beneficiaries should be tenants and residents. Together with several institutional partners, both private and public, best practice examples for energy services are being promoted through actors' workshops, in-house workshops at companies, lectures, publications and a manual.

http://www.izt.de/bewaree

BUDI

Pilot Actions to develop a functioning market for energy performance certificates

BUDI aimed to get energy performance certification of buildings on the move via a regional approach which focused on two key building types: apartment blocks and public buildings. The plan was to roll out pilot actions, information campaigns, tools and advice, training sessions for independent experts, accreditation schemes, as well as to develop regional information and competence centres.

http://www.buildingdirective.org

BUILDING ADVENT

Building Advanced Ventilation Technological examples to demonstrate materialised energy savings for acceptable indoor air quality and thermal comfort in different European climatic regions

The main objective of this project was to support the implementation of low energy ventilation systems by capturing good ventilation practices and widely disseminating them. The main action consisted on telling designers about 18 non-domestic buildings which have low energy ventilation systems. These buildings are located in three different European climates: one with high cooling loads; one with high heating loads; and one with moderate heating and cooling loads. Heating, cooling, electricity loads, CO2 levels and ventilation rates are all monitored, while building occupants are surveyed. These case studies have demonstrated how well these systems work and how to include them in a wider range of building projects.

http://www.buildingadvent.com

BUILDING EQ

Tools and methods for linking EPDB and continuous commissioning

The aim of this project was to strengthen the implementation of new European legislation by linking certification of non-residential buildings with the evaluation of their ongoing energy performance. To this extent, monitoring methodologies and tools have been developed using data gathered from the certification process, so that ongoing performance evaluation can take place (this currently being uncommon). All these materials are tested in twelve demonstration buildings in four countries.

http://www.buildingeq-online.net/

CENSE

Leading the CEN standards on energy performance of buildings to practice. Towards effective support of the EPBD implementation and acceleration in the EU Member States

The European Committee for Standardisation (CEN) contributes to the objectives of the European Union and European Economic Area with voluntary technical standards which promote free trade, the safety of workers and consumers, interoperability of networks, environmental protection, exploitation of research and development programmes, and public procurement. Under mandate from the European Commission, CEN has produced a set of standards in support of the introduction of the energy performance of buildings directive of the European Parliament and the Council. The CENSE project aims to improve the knowledge across the Member States on the role, content and status of these standards and provide guidance on their implementation. Feedback will be collected for the fine tuning of the standards and recommendations are being drafted and put forward.

http://www.iee-cense.eu

CEPH

Certified European Passive House Designer

The project elaborates the first intense training course for Passive House Designer on the European level. This training course will enable the participants – after the passing of an exam – to obtain the Certificate of European passive house designer. The need for such a certification is analysed by all experts who state a rapidly growing interest for passive house design in many European countries which only can be satisfied through experienced and qualified passive house planners. The project invited all stakeholders with experiences in passive house training as well as passive house network hubs from all relevant countries. In close cooperation with other ongoing EU activities on passive house the project therefore will be able to accomplish a highly important step towards the development of broad passive house markets in Europe.

http://www.passivehousedesigner.eu/

CHECK IT OUT!

Check and improve the energy performance of schools and disseminate best practices

Member States have come together to improve energy efficiency in schools and spread best practices. Project partners accelerate this process with Energy Performance Assessments, which form the basis of advice to schools on how to proceed with their energy saving measures. Pupils and teachers are encouraged to get involved through educational programmes on climate change and energy.

http://www.check-it-out.eu

COMMONCENSE

Comfort monitoring for CEN Standard EN15251 linked to EPBD

The European standard EN15251 was recently adopted to define acceptable indoor temperatures and light levels as the basis for energy calculation. The provision of comfort is a key concern for building designers. Mechanical cooling is energy intensive. Naturally ventilated (NV) buildings with fewer energy costs cannot control indoor conditions closely. Formally standards have used comfort models which favour close environmental control so NV buildings have been looked on as second-rate. EN15251 allows NV buildings more freedom for environmental variation in line with the findings of comfort theory. This project seeks to use existing information from field surveys to test the limits set by EN15251 for temperature and lighting and to validate its recommendations using existing data and building simulations. The findings will be widely disseminated among key actors and stakeholders in the countries of the consortium. A website will be initiated with documentation and workshops.

http://www. commoncense.info

COOLROOFS

Promotion of cool roofs in the EU

A cool roof is a roofing system that is characterised by high solar reflectance and high infrared emittance and delivers cooling energy and financial savings, improved thermal comfort conditions, mitigates heat islands and reduces air pollution. The proposed action aims to create and implement an Action Plan to promote cool roofs technology in EU. The specific objectives are: to support policy development by transferring experience and improving understanding of the actual and potential contributions by cool roofs to heating and cooling consumption in the EU; to remove market barriers and simplify the procedures for cool roofs integration in construction and building's stock; to change the behaviour of decision-makers and stakeholders so to improve acceptability of the cool roofs; to disseminate and promote the development of innovative legislation, codes, permits and standards, including application procedures, construction and planning permits concerning cool roofs. The work is being developed in four axes, technical, market, policy and end-users.

http://www.coolroofs-eu.eu/

COOLREGION

Energy efficient Cooling in regions of North and Central Europe

Increasing thermal load, large glass facades and a higher demand for comfort in buildings lead to a higher demand for cooling in the temperate climate zones of the EU. After heating systems, cooling systems in buildings are the installations with the highest share of energy use. In the case of cooling systems, pilot projects to reduce the energy consumption are missing. The project COOLREGION refers to this lack. Based on European and regional expert networks the knowledge about energy efficient cooling has been evaluated and disseminated. In exemplary pilot projects (for new buildings or refurbishment) possibilities to avoid and to reduce the energy use for cooling, or to use efficient cooling systems (possibly with RES), are demonstrated. The discussion of the experiences by regional networks contributes to raise awareness of the subject of "energy efficient cooling". Further guidebooks and a web-based information platform give support to decision makers, house owners, architects, engineers and craftsmen for energy efficient cooling solutions in the future.

http://www.coolregion.info

CYBER DISPLAY / TOWARDS CLASS A

Communicate Your Buildings Energy Rating

The objective of CYBER Display is to show that the overall aim of the EPBD, reducing the consumption of buildings in Europe, can significantly be accelerated if local authorities can stimulate behavioural change by communicating the performances of their buildings to politicians, technicians, building users, different municipal departments and the public. This will be achieved by increasing the visibility and quality of local Communication Campaigns in Europe and analysing the effects they have on actual building performance improvements. Other municipalities will be provided with the information they need to start their own Communication Campaigns and invest in a future with better performing public buildings and, consequently less wastage of public funds. The opportunities for the commercial sector to build on the municipal experience will be investigated by initiating Communication Campaigns in their offices. Cutting edge communication activities will be promoted via an annual award and the overall visibility of all these local campaigns will be provided by Display®, the European Buildings Climate Campaign!

http://www.display-campaign.org

DATAMINE

Collecting data from energy certification to monitor performance indicators for new and existing buildings

This project has been driven by the need for concrete data on potential energy savings and CO2 reductions in the European building stock. Data will in turn help develop tailored, cost-efficient complementary measures to energy performance legislation, such as soft loans and tax incentives. DATAMINE aimed to construct a knowledge base using the information on the energy performance certificates issued when buildings are constructed, sold or rented. The test data comes from buildings in 12 different countries and full allowance is made for the Europe-wide differences in certification schemes, since each country has a scheme tailored to its specific needs, building stock and climate.

http://env.meteo.noa.gr/datamine/

DEEP

Dissemination of Energy Efficiency Measures in the Public Buildings Sector

The DEEP project encouraged and assisted European public authorities to move towards more sustainable building design and renovation, and it promoted the use of green" electricity. To this end simple standards applicable Europe-wide have been developed in consultation with a wide group of stakeholders. For energy performance and the use of sustainable building materials for public construction and renovation works, together with purchasing criteria for green electricity. The project also provided a template for a standard energy efficiency policy to be used by European public authorities, and a range of tools to help implement energy efficiency measures. The project results are disseminated through a wide range of regional and European seminars, workshops and conferences. The developed standards and purchasing criteria are incorporated into Procura+, ICLEI's Sustainable Procurement Campaign (www.procuraplus.org), and through this implemented by a number of European public authorities.

http://www.iclei-europe.org/deep

ECCC

European Citizens Climate Cup

The “European Citizens Climate Cup” (ECCC) is a competition of private households within and between countries. It aims to demonstrate that everybody can save energy significantly and even beat the reduction targets of the European Union and its member states. By competing in a sports-like championship, Energy Saving Accounts (ESA) holders form national teams to fight climate change and to achieve the highest CO2 reduction in the contest. The winner team and additionally the Energy Savers of the Year, the household with the highest CO2 reduction and the most convincing energy saving measures of every partner country/region will be decorated in a glamorous final award ceremony in Brussels. The ECCC campaign will cooperate with media and important multipliers, like e.g. utilities and consumer associations. The ECCC Campaign shall motivate private households to open an ESA (web based energy accounting and advising system for households, SMEs and schools) and to enter consumption and cost data of meter readings and energy bills continuously and to perform energy saving measures and changes in behaviour to improve their energy balance. This project was under negotiation at the time of publication.

http://www.co2online.de

ECOLISH

Energy Exploitation and Performance Contracting for Low Income and Social Housing

There are a number of barriers to promoting energy efficiency in low-income, social housing. These buildings typically use high levels of energy due to poor insulation, poor heating installation efficiency and a lack of financial resources on the part of owners and housing corporations. To help overcome these barriers, this project organised and evaluated pilot projects using Energy Performance Contracting and Energy Exploitation in four European countries.

http://www.ecolish.com

EDUCA RUE

Energy Efficiency Paths in Educational Buildings

Educa-RUE, through a number of interconnected actions, will develop an optimal process to be applied and replicated at local level. The project will develop actions for the qualification of the technicians and certifiers which will have a key role in the implementation of the Directive on local building. Educa-RUE will study possible improvements in the applicative procedures of the Directive, supporting and enhancing specific financial tools and procedural incentives to promote the more efficient use of energy in building

As the project will act upon a range of problem areas such as legislation, certification, education, economic and financial issues, training, information and dissemination, the first direct beneficiaries of the project results will be local policy makers. The involvement of local government players is ensured by the composition of the partnership belonging to 4 EU countries and the attention focused on the issue of energy efficiency at local level. The Local levels will act, where existing, through the collaboration of Local energy agencies, ensuring technical support an eventually training capacity.

http://www.educarue.eu/

EDUCATE

Environmental Design in University Curricula and Architectural Training in Europe

Awareness of climate change and technical requirements arising from new regulations has triggered demands for architects with advanced skills in sustainable design and energy efficiency. This has required that environmental education sits at the core of the architectural curriculum at university and professional level. To meet these challenges, this Action will: -Remove pedagogical barriers to the integration of energy-related design principles within architectural discourse -Define and test a curriculum which bridges sustainability and design studio in architectural education -Develop a Portal on sustainable design and energy efficiency that facilitates such integration in higher education and supports continuing professional development; -Propose homogeneous criteria for accreditation of architectural curricula and professional registration that establish the level of knowledge and skill in sustainable design and energy efficiency expected of graduated architects in Europe -Promote and disseminate environmental know-how and best practice, fostering change of behaviour and expectations towards the integration of sustainable design and energy efficiency in building practices.

http://www.educate-sustainability.eu

EEBD

Development of an interactive vocational Web training tool for the take-off of the buildings DIRECTIVE 2002/91/EC

The partners in the EEBD action aimed to produce a web-based vocational tool to help implement the training requirements for the building certification market arising from new European legislation. Project partners investigated the vocational training needs across the regions of the EU and developed appropriate training material as well as an electronic platform. The resulting web-based tool was based on thorough testing, involving virtual classrooms, to produce a robust product which could act as a central source of training info for engineers.

http://www.eebd.org

EI-EDUCATION

Energy Intelligent Education for Retrofitting of Social Houses

Social housing companies, municipalities and other housing stock owners were targeted by an education programme with the aim of helping them carry out energy-intelligent retrofitting. Renovations can lead to potential energy savings of 30%. The programme used mixed learning techniques adapted to the varying circumstances in participant countries. Teaching tools included an Internet platform, a guidebook and e-learning material.

http://ei-education.aarch.dk

ENERGY TROPHY+

Magnify success: Extension of the European Energy Trophy competition to 18 countries

This project sought to reward companies and public administrations for saving energy in their office buildings by behavioural changes, such as turning off the lights or turning down the heating, etc. A trophy was up for grabs for the biggest savers. The project built on the success of the 2004/2005 pilot competition which involved 38 contenders from six countries. They together came up with annual savings of 3 700 MWh of energy, 1 885 tonnes of CO_2 and €205 000. The expanded competition aimed to reach 18 countries and 350 participants and involved the use of an advanced energy data logging system.

http://www.energytrophy.org

ENERINTOWN

Monitoring and Control of Energy Consumption in Municipal Public Buildings over the Internet

Member States came together to improve energy efficiency in schools and spread best practices. Project partners have accelerated this process with Energy Performance Assessments, which formed the basis of advice to schools on how to proceed with their energy saving measures. Pupils and teachers were encouraged to get involved through educational programmes on climate change and energy.

http://www.enerintown.com

ENFORCE

European Network for the Energy Performance Certification of Buildings

Leading the way to energy-efficient buildings, the ENFORCE project aids the diffusion of energy certification (Energy Performance of Buildings Directive 2002/91/EC). European in scope and nature, it aims to give final consumers independent, qualified, information and assistance on energy certification of their buildings, allowing them to make informed decisions. It tackles obstacles to intelligent patterns of energy use by: - carrying out 6 national studies on the steps and experience in introducing new legislation, plus a European comparative study on replicable best-practice; - creating a trans-national network of trained energy auditors, operating under a common code of conduct, to assist final consumers on energy performance related topics; - operating a call-center for consumers as a first contact point, providing the requested information and access to the network of auditors; - launching an information campaign to promote the call-center and network services, thus qualify the market. ENFORCE includes 7 partners from Italy, Portugal, Spain, Slovenia and Greece working closely with the relevant stakeholders at national and European level.

www.enforce-een.eu

ENPER EXIST

Applying the EPBD to improve the ENergy PErformance Requirements to EXISTing buildings

Better energy efficiency in buildings means looking at both existing buildings and future constructions. By improving our knowledge of existing buildings we can put together a roadmap for better energy performance. This was the goal of ENPER-EXIST, which established a snap-shot of current building stock and assessed which building standards might be applied, what alternative solutions are available, and what would be the impact of the new certification schemes on the market, human capital and national administrations.

http://www.enper-exist.com

ENSLIC BUILDING

Energy Saving through promotion of Life Cycle analysis in Building

This action seeks to achieve energy saving in the construction and operation of buildings by promoting the use of life cycle assessment techniques in design for new buildings and for refurbishment. The project aims to draw on the existing information generated from previous research projects regarding: design for low energy consumption, integrated planning, environmental performance evaluation of buildings, design for sustainability and LCA techniques applied to buildings. The output which will be compiled with the collaboration of key target groups, will be a set of guidelines with a methodology which clarifies different technical options available to users. This will be applied to real buildings by collaborating target groups. The results will be disseminated to a wide target group through multiple channels to highlight LCA's potential for energy saving.

http://www.enslic.eu

EPA-NR

Energy Performance Assessment for Existing Non Residential Buildings

Given Europe's diversity, implementing new European legislation requires flexible tools. The EPA-NR consortium set out to produce and test one such modular tool for existing non-residential buildings, with a view to streamlining implementation of the Directive on the energy performance of buildings. The key target groups were policy makers and the energy consultants who would use the software tool. The software is compatible with the standards on energy performance calculations for buildings, prepared by the European Committee for Standardization (CEN) which draws up voluntary technical specifications to help achieve the Single Market in Europe.

http://www.epa-nr.org

EPEE

European fuel Poverty and Energy Efficiency

'Fuel poverty' is a problem that can be tackled alongside gas emissions by retrofitting old buildings. This project focused on low-income tenants who are victims of fuel poverty because they cannot afford to make improvements. The underlying goal was to identify the best and most appropriate mechanisms for each national context and to make fuel poverty a priority within national and European energy policies. Unless all actors get involved, both energy consumption in the home and greenhouse gas emissions will continue to rise, aggravating fuel poverty further still. Though the phenomenon is not clearly defined across Europe, there is evidence of common trends such as unpaid energy bills, disease and self-disconnecting.

http://www.fuel-poverty.org/

EPI-SOHO

Energy Performance Integration in Social Housing, a strategic approach for portfolio management

The aim of this project was to develop a flexible implementation technique for cost effective, large scale energy performance assessments in social housing existing stock. Moreover, to embed energy assessment data in policy processes such as social housing management and improve collaboration between local authorities, social housing associations and the private sector on sustainable issues.

http://ieea.erba.hu/ieea/

EPI-CREM

Energy Performance Integration in Corporate Public Real Estate Management

Until now, most public building organizations don't pay much attention to energy efficiency in relation to decisions on Real Estate. One of the reasons is a lack of tools to facilitate integrated decision-making, in which energy efficiency is taken into account amongst other aspects. EPI-CREM aims to improve energy efficiency and rational use of energy across public building stock in Europe by embedding energy issues in decision making processes within Corporate Real Estate Management (CREM) at the strategic level, and translating those decisions into tactical and operational levels of building management. This way the decision making process surrounding energy saving measures is embedded in the CREM-process, and is made structural and more cost effective. To reach these goals EPI-CREM provides a strategy and a set of tools enabling building owners and users to make the energy aspect an integral aspect of Corporate Real Estate Management.

http://www.epi-crem.org

EPLABEL

A programme to deliver energy certificates for display in public buildings across Europe within a harmonising framework

EPLabel addressed the requirement of the European Buildings Directive for "Public Buildings" over 1,000 m2 to display an Energy Certificate. The aim was to support Member States planning for and implementing Operational Ratings under the Directive, offering sufficient flexibility to accommodate national diversity whilst seeking increased European harmonisation. The project addressed the following building types: public administration offices, higher education, schools, sports facilities, hospitals and other health facilities, and hotels and restaurants. EPLabel intended to demonstrate a "graduated response" procedure, consistent with CEN Standards, which would allow a progressive introduction of Article 7.3 to suit the knowledge available in each country for each building sector and the level of resources an organisation is able to apply: an easy entry level for cases where detailed information is hard to get or may be less rewarding, a more detailed assessment where the need and scope for improvement is greater.

http://www.eplabel.org/

E-RETROFIT-KIT

Tool-Kit for "Passive House Retrofit"

Social housing companies in 14 countries were given the chance to benefit from a tool kit designed to help them carry out retrofitting in such a way as to considerably reduce primary energy consumption (by up to 120 kWh/m2 a year.) The tool kit includes best practices, “Passivhaus” standards and a methodology. Retrofitting methods include better insulation, air-tightness and balanced ventilation which encompass cooling in southern climes.

http://www.energieinstitut.at/retrofit/

ESAM

Energy Strategic Asset Management in Social Housing Operators in Europe

Social housing managers have thousands of dwellings on their books, many of which require better energy-retrofitting. They need help identifying the energy investments which offer the best return. This project aimed to develop methodologies and information systems supporting energy certification, energy diagnoses and energy-retrofitting strategies.

http://www.esamproject.org

E-TOOL

Energy-toolset for improving the energy performance of existing buildings

The goal of E-TOOL was to collect energy consumption data and develop a simple and practical toolset which could assist in the improvement of the energy performance of existing buildings. The toolset is based on the actual energy consumption of a building, the so called 'operational' rating, as well as benchmarks covering different building categories. The energy savings from recommended measures are calculated and the improvement in energy performance of the building demonstrated by the tool, which has been tested in different climates around Europe.

http://ieea.erba.hu/ieea/

EULEB

European High Quality and Low Energy Architecture

EULEB aimed to help people learn from positive examples which already exist in the building sector. Project participants examined 25 high profile public buildings in the United Kingdom, France, Germany, Italy and Spain, and informed the market on the high quality low energy features they possessed, including design, consumption levels and energy data.

http://www.euleb.info

FACTOR 4

Programme of actions Factor 4 in existing social housing in Europe

This project aimed to produce a cost model for reducing greenhouse gas emissions from social housing by a factor of four by 2050. The projects draw inspiration from the sustainable development world strategy established in 2002. The focus was on managing social buildings and producing recommendations which target all actors. Renewable energy use was also incorporated into this long term vision.

http://www.suden.org/fr/projects-europeens/factor-4/

FINSH

Financial and Support Instruments for Fuel Poverty in Social Housing

The aim of the project FinSH is to develop relevant support schemes to address financial and social barriers to access to energy efficiency retrofitting in social housing. It will contribute to the reduction of fuel poverty and to the increase of energy saving in social housing in Europe. One key of the project is to combine financial, social and energy approaches. The project includes both analysis of financial products to foster energy efficiency retrofitting and development of practical support guidelines to increase the access to these financial products for fuel-poor households and social housing companies. This will aid organisations throughout Europe working with social housing tenants who are at risk of fuel poverty, to encourage them participate to energy efficiency programmes and measures. The project will work closely with banks, energy and social experts and with relevant current EU and national initiatives. The project will be widely disseminated.

http://www.finsh.eu

FRESH

FRESH – Social Housing comprehEnsive Refurbishment through energy Performance contrActing

Lack of adapted funding is a major barrier to the energy retrofitting of social housing in Europe. Funding could be found in Energy Performance Contracts (EPC), in which an Energy Service Company (ESCO) invests in a comprehensive refurbishment (CR - building insulation and renovation of the heating systems), and repays itself through the generated savings. EPCs have not been used until now in social housing because there is no visibility on the business model, although the market is well identified. In the SHERPA project, social housing operators and ESCOs from France, United Kingdom, Italy and Bulgaria propose to address energy performance contracting in social housing aiming at comprehensive refurbishment. The objective is to open the way and demonstrate to Social Housing Operators (SHOs) that EPC can be used for low energy refurbishment on a large scale, thus enabling to reduce by 4 greenhouse gas emissions by 2050 and to reduce energy costs for tenants; it will therefore test EPC in 4 countries and develop generic tools for the broader dissemination of EPC in social housing.

http://www.fresh-project.eu/

GREENBUILING / GREENBUILDINGPLUS

Leveraging the GreenBuilding Programme (GBP) to promote energy-efficiency and renewables in non-residential buildings

Building owners, product suppliers and service providers have been given the opportunity to be recognised as GreenBuilding Partners or Endorsers for their efforts towards implementing ambitious and cost effective energy saving measures in non-residential buildings. In this project, all partners have received technical assistance and public recognition in the form of publications, Internet information, access to a best practices database, advice on cost-effective measures and the right to use the GreenBuilding logo. The GreenBuilding Programme involves voluntary commitments to reduce energy consumption in buildings by 25%. This scheme, set up in 12 European countries, is now being extended within the GreenBuildingPlus project.

http://www.eu-greenbuilding.org

HARMONAC

Harmonizing air-conditioning inspection and audit procedures in the tertiary building sector

HARMONAC will provide key information on the actual energy savings to be achieved from various air-conditioning inspection and maintenance procedures. This information is currently missing from the body of knowledge in this area and is one of the findings from the IEE AUDITAC project on which this project builds. The information will enable EU Member States to make informed decisions about the depth and detail needed for their national air-conditioning inspection procedures based on the extent of its deployment and the types of systems used. This project will also enable economic considerations to be used to weigh up the potential energy and carbon savings to be achieved against the cost to each country's economy of undertaking inspections to varying degrees of detail.

IDEAL EPBD

Improving Dwellings by Enhancing Actions on Labelling of the EPBD

When an existing dwelling changes owner or tenant, the Energy Performance of Buildings Directive (EPBD) requires an energy performance certificate to be issued. This certificate includes a label and/or recommendations of cost-effective energy saving measures. Prior experiences show that even with labels not all cost-effective saving measures are carried out. A risk exists that a large part of the significant energy saving potential in existing dwellings will not be realised under the EPBD in its present form. From 2008 to 2011, the IDEAL EPBD project will analyse consumer behaviour, barriers and supportive policy instruments in 10 different countries. It will provide empirical evidence and monitoring by applying in-depth interviews and electronic questionnaires and will develop policy action plans to change consumer behaviour related to energy labels. The results will be disseminated in the complete EU-27, to optimise the effect of the EPBD.

http://www.ideal-epbd.eu

IDES-EDU

Master and Post Graduate education and training in multidisciplinary teams implementing EPBD and beyond

To achieve implementation of the EPBD and beyond it is necessary to design optimal energy efficient buildings through an integrated multidisciplinary design approach. Currently, architects and engineers don't often work together in such teams. This leads to inefficient solutions and higher costs of construction. IDES-EDU will educate, train and deliver specialists for the building sector, via: 1) Improved curricula and training programs, 2) Exchange between students and professionals, 3) Certification and accreditation of the courses at national level, as well as frameworks for European certification 4) A multimedia teaching portal to make the educational packages available to graduate students and building professionals in Europe at large and, finally, 5) Widespread promotion of the approach. In IDES-EDU, 15 universities across Europe will fulfil this need by developing curricula and training programmes within a European framework. It will be elaborated and implemented in collaboration with accrediting bodies and relevant key actors and stakeholders from the building sector. All EU MS will be addressed in this action by the university exchange programme involving 60 universities. This project was under negotiation at the time of publication.

ILETE

Initiative for Low Energy Training in Europe

This European workgroup is implemented at a Regional level and targets the Buildings Industry through training programmes and communication. Its goal was to bring about awareness of the opportunities and the growing importance for low energy consumption in buildings across Europe, today and for the Europe of tomorrow. The Partner Regions will move very quickly towards a significant reduction in energy consumption in construction and will focus on renovation in which professionals play an essential role in forming public opinion. The objective was therefore to foster desire and know-how among construction industry professionals. To achieve this, the ILETE project followed three priorities: - To set up initial training on low consumption for architects and engineers; - To set up ongoing training on low consumption to reach industry professionals; - To inform the general public and contracting authorities on level A certification.

http://www.ilete.eu

IMMOVALUE

Property valuation, Linking energy efficiency of buildings and property valuation practice

Energy performance certificates will be available in all European countries and provide comparable information on the energy performance of properties. As one of the largest single operating expenses, energy costs are usually an important factor concerning the overall property value. Energy costs therefore deserve great attention from banks, valuers and property owners. Additionally, constantly rising energy prices amplify the need to focus on energy efficiency and a life-cycle perspective of the property in the future. This background given, the project aims at integrating energy efficiency aspects into property valuation standards. In a first step, the project team develops a solid methodology for such a new standard. In a second step, this approach runs through a comprehensive expert reviewing process with direct involvement of the relevant association for property valuation, RICS, the Royal Institute of Chartered Surveyors. In the third step, the newly developed standards for property valuation will be disseminated to the market.

http://www.immovalue.org

IMPACT

Building certification programmes can be more effectively put in place by overcoming barriers such as a lack of information and a lack of expertise, notably auditing skills. To overcome such hurdles and to make a real impact on energy consumption in buildings, every step along the certification process needs to be addressed. IMPACT set about conducting pilot tests in different countries in order to identify best practice, share experiences and produce recommendations for improvements to building certification schemes. These experiences were publicly aired in national and regional workshops and shared with the governmental institutions creating the building certification schemes in every country of the European Union.

http://www.e-impact.org/

IMPLEMENT

If individuals, owner associations and housing associations are unaware of how they can implement energy saving measures then the full impact of building energy certificates may be lost. IMPLEMENT makes use of networks of professionals and information campaigns (on financing mechanisms, turn key solutions and sources of advice). The campaigns are targeted at homeowners and housing associations. The project will demonstrate the measures which need to be implemented to make certification effective and will show other countries how to best proceed in informing the citizens of Europe about the energy consumption in their buildings.

http://www.epbdinaction.eu/

INOFIN

Innovative Financing of Social Housing Refurbishment in Enlarged Europe

This project looked to design financing schemes for refurbishments which were tailored to each country's needs and which involved both new technologies and new building materials. It explored potential links between cross-border initiatives and international finance institutions, helping put together grants, loans, third party financing, and investment funds with the aim of stimulating energy efficiency and use of renewable energy sources. Showcase projects were helping develop local and regional expertise.

http://www.join-inofin.eu

INTELLIGENT METERING

Energy Savings from Intelligent Metering and Behavioural Change

Backed by estimates suggesting that energy savings of up to 30% could be achieved by combining intelligent metering with behavioural change among occupants, the INTELLIGENT METERING partners in the United Kingdom, Austria, Denmark and Germany set themselves the task of improving the energy consumption of some of their public buildings. The consumption of almost 70 buildings was made available on-line in graphic form in order to give occupants an idea of consumption trends. Via training sessions, the building users were shown the impact of their behaviour which was immediately and visibly demonstrated on their computer screens by the intelligent metering system.

http://www.intelmeter.com

INTEND

INTEGRATED ENERGY DESIGN IN PUBLIC BUILDINGS

'Integrated energy design' is a process which focuses on passive energy strategies, low energy measures and indoor climate of buildings, before looking at any mechanical or electrical features. The main objective of this project was to demonstrate that outstanding results regarding energy efficiency, renewable energy sources and indoor climate can be achieved if architects, engineers, building owners and investors adopt together an Integrated Energy Design approach. Guidelines, an Internet database, literature and the study of at least 12 building projects formed part of the work, with the results and practical experiences reported to relevant actors through a variety of events.

http://www.intendesign.com

INTENSE

From Estonia till Croatia: Intelligent Energy Saving Measures for Municipal housing in Central and Eastern European Countries

INTENSE aims at transferring intelligent energy saving measures for municipal housing from “old” EU Member States to “new” Member States and Accession countries in Central and Eastern Europe. The project is implemented in 12 countries by 28 partners representing multiplier organizations, municipalities and project experts. Built on a holistic approach for planning of energy optimized housing, the project comprises an analysis of legal preconditions, experience exchange on best practice examples, development and implementation of training programmes, pilot planning activities at partner municipalities, and public awareness raising. Increased capacities of local authorities will be an investment to the future for influencing new housing development at legislative, technical and planning level as well as guiding consumer behaviour towards efficient energy use. Experiences and lessons learned within the project will be further disseminated across Europe.

http://www.intense-energy.eu

ISEES

Improving the Social Dialogue for Energy Efficient Social Housing

This project focused on consumer choice and its influence on energy demand in social housing. It took the notion of 'social dialogue' and used it to come up with ways to improve energy efficiency and renewable energy use. By involving all actors in the refurbishment process, ISEES assessed typical buildings. It also evaluated the quality of services provided by utilities and district heating companies, identifying any lack of management or service capacity, and sought to address these problems with concrete solutions.

http://ieea.erba.hu/ieea/

KEEPCOOL AND KEEPCOOL II

Transforming the market from "cooling" to "sustainable summer comfort"

The overall goal of the project KeepCool II is to transform the market to achieve good summer comfort conditions with no or limited use of conventional energy and through the use of environmentally non-harmful materials. The project will propose different actions to achieve this goal. For this it is divided in two phases. The first one provides analysis and technical tools to overcome the most important barriers by introducing sustainable summer comfort. The second phase is addressing existing networks and policy makers on national and European level by providing them information materials with good practice examples designed especially for the target groups. It will be accompanied by dissemination campaigns.

http://www.keepcool.info

LCC-DATA

Life-Cycle-Cost in the Planning Process. Constructing Energy Efficient Buildings taking running costs into account

This project focused on Life-Cycle-Cost Analysis (LCC Analysis), a methodology which is used to calculate the cost of a building or a system over its entire life span. It also focused on the need for accessible data throughout the entire construction phase in order to realistically carry out this analysis. The project's goals were therefore to simplify data access and storage and to extend the use of such analysis in construction, thereby improving decision-making when it comes to sustainable buildings. With easily accessible information, building owners would then be able to benchmark their buildings in terms of energy use and operational costs.

http://www.sintef.no/content/page1____17094.aspx

NIRSEPES

New Integrated Renovation Strategy to improve Energy PErformance of Social housing

This project set itself the goal of increasing thermal efficiency by at least 30% by developing an integrated strategy for energy renovation in social housing across the EU. It analysed existing typical buildings in Spain, Greece and Germany, with a view to comparing technological solutions for retrofitting and its cost-effectiveness. Local forums, tailor-made financing schemes, awareness-raising campaigns, education, training, and retrofitting plans were all part of the integrated approach.

http://www.nirsepes.eu

NORTHPASS

Promotion of the Passive House Concept to the North European Building Market

In cold climates it is very difficult to reach the Passive House energy demand defined for Central European countries, 15 kWh/m²,a without substantially increasing the construction costs. The objectives of NorthPass are 1) North European Passive House criteria and concept to raise awareness in the North European countries, 2) Finding solutions to remove market barriers for wide market acceptance of Passive House products and 3) Removing the gap between the demonstration of Passive House concept and broad market penetration of the Passive House concept. The project results in accelerated awareness raising on potential challenges with the market acceptance of North European Passive House, accelerated identification of suitable solutions in order to improve Passive House concepts in the North European housing market and accelerated supporting impact on the implementation of the EU Commissions energy efficiency strategy plan development and on the upcoming update of the Energy Performance of Buildings directive. The scope of the project is in new-erected residential buildings.

http://virtual.vtt.fi/virtual/northpass/about.htm

PASSIVE-ON

Marketable Passive Homes for Winter and Summer Comfort

PASSIVE-ON aimed to build on the success of the Passivhaus concept by spreading the good word –and appropriate practice- towards southern and more moderate climates of Europe. A Passivhaus-compliant home consumes 80% less energy than one built to standard regulations, removing the need for conventional heating systems. The experience gained from building thousands of homes of this type in central Europe was passed on by creating guidelines and software tools for developers. Decision-makers and public bodies also benefited from strategies put together specifically for warmer climates, where the project has shown that it is not always necessary to use advanced technological solutions to build homes of high energy performance in these climatic regimes

http://www.passive-on.org

PASS-NET

ESTABLISHMENT OF A CO-OPERATION NETWORK OF PASSIVE HOUSE PROMOTERS

The project aims at the promotion and diffusion of the passive and very low energy houses and technologies in Europe, including a focus on new member states. Given the huge energy and CO2-saving potential and the low recognition of the passive house standard, the project will offer independent information on financing, construction, and planning matters In some countries there has been a positive uptake of this standard and these experiences need to be transferred to other countries. This will strengthen co-operation and the exchange of know-how between the participating countries (Austria, Belgium, Croatia, Czech Republic, Germany, Romania, Slovakia, Slovenia, Sweden and the U.K.) and will encourage new initiatives Europe-wide. The project activities include promotion and awareness raising as well as training activities for specialists and the dialogue with public authorities. The most important benefit should be an European wide passive house database promoting best practice objects.

http://www.pass-net.net

PEP

Promotion of European Passive Houses

Big savings in home energy consumption are there for the taking. The Passivhaus concept offers a workable, affordable solution for achieving such savings. However, we need to pass on the experience we have gained beyond small groups of experts by targeting a wider community of building professionals. PEP therefore set itself the task of spreading this knowledge throughout Europe using various channels.

http://erg.ucd.ie/pep/index.htm

POWER HOUSE EUROPE

The big green housing and energy exchange

POWER HOUSE EUROPE functions as a catalyst to trigger action. It aims to achieve the maximum potential energy saving in the residential sector by mainstreaming existing know-how required to refurbish and build housing with optimal energy consumption levels. The actual needs of social housing organisations regarding energy efficiency and renewable energy have been identified and analysed, based on a survey of 300+ of them carried out in 2009. Interest in the project is growing at national, European and International levels due to the strategic importance of housing in all climate change strategies. Platforms have been established in all countries as planned and are a welcome forum for exchange for all actors involved.

http://www.powerhouseurope.eu

PU-BENEFS

Regional Market Preparation for Energy Efficiency Services in Public Buildings

The project aimed to develop a suitable management framework for assisting public bodies and especially local authorities to implement energy services including energy efficiency by providing efficient tools to meet the needs of public bodies and facilitating the work of ESCOs. The opening of energy markets and the development of energy services represent a good opportunity for local authorities to include energy efficiency measures in their management, and therefore achieve energy savings. However several barriers such as the lack of information on existing mechanisms needed to be overcome. Study on the specificity of public bodies and feasibility studies for energy services identified the problem and solution for implementing energy services. Tools and elaborated specifications were developed to assist local authorities for their tenders to implement energy services, allowing having the best offer by ESCOs.

http://www.pubenefs.org

REE_TROFIT

Training on Renewable Energy solutions and energy Efficiency in reTROFITting

A major bottleneck for increasing energy performance of existing building stock as foreseen in the EPBD & its recast lies in the shortage of local qualified and/or accredited retrofitting experts, the main reasons being that Building professionals are: a) still not enough aware of the urgency for implementing low-energy retrofitting techniques for energy saving based on EPBD requirements. b) insufficiently trained on the available low-energy techniques and technologies for retrofitting c) not enough prepared to convincingly propose and properly apply available most up-to-date techniques and technologies for retrofitting d) they show limited motivation for (re)qualification programmes unless proper incentives are put in place. The REE_TROFIT project will use in-house know-how and experiences of participants in carrying out vocational courses on innovative eco-building technologies. They will improve the available materials and develop new advanced tools in order to set up and implement a large-scale educational scheme in 6 MS for training more than 450 building professionals and by fostering exchange of knowledge and best practices among stakeholders.

http://www.lucense.it

REQUEST

REnovation though QUality supply chains and EPC STandards

The goal of this project is to increase the uptake of low carbon renovation measures in residential properties. It addresses one of the key barriers to action for property owners, namely easy access to a reliable quality installer or, in the case of major renovation, a range of professionals (i.e. the construction supply chain). An energy performance certificate provides information and recommendations about what can be done in a home. To turn that advice into action, the customer needs to be able to easily commission a “joined up” renovation product, where they can trust the quality of the delivered renovation. Central to this is ensuring different trades and professions can work together effectively and that homeowners or landlords are motivated to invest in renovation. REQUEST facilitates this by providing national and regional agencies across the EU with a set of tried and tested tools and techniques which they can use together in different, but structured, ways to promote: 1) an integrated customer journey that leads from certification to low carbon action and 2) an integrated supply chain with mutual recognition of the roles of the various disciplines involved.

http://www.energysavingtrust.org.uk/

RESHAPE

Retrofitting Social Housing and Active Preparation for EPBD

This project looked at energy performance certification and asked what it could offer social housing. Using results from pilot projects in six countries RESHAPE aimed to help housing managers with certification, to define strategies for retrofitting and to help them get these issues across to tenants, apartment owners and housing cooperatives. The European Directive on the energy performance of buildings and its focus on energy consumption in dwellings are expected to have a big impact on social housing management and the way managers communicate.

http://www.reshape-social-housing.eu

ROSH

Development and marketing of integrated concepts for energy efficient and sustainable retrofitting of social Housing

This project looked at energy efficiency and sustainable retrofitting in social housing in specific regions in six EU countries. It was based on integrated programmes combining information, training and communication. Guidelines on financing schemes were also being drafted, while demonstration projects serve to evaluate practices. The wider aim was to stimulate the market for these solutions, and increase comfort levels and quality of life for tenants.

http://www.rosh-project.eu

SAVE AGE

Strenghthening Energy Efficiency Awareness Among Residential Homes for Elderly People

The SAVE AGE project aims to raise awareness, encourage measures in energy efficiency, monitor and assess energy use in residential homes for elderly people (RCHEP). The main goals are: to identify the existing best practices (technical, behavioural and financial) among 10 Member States, to test them through some concrete pilot-cases, to promote them towards 24,000 residential care homes across Europe and to train 540 managers. Stakeholder involvement and dissemination will be organised through the European association of directors of residential care homes representing more than 1,5 mio residents across Europe. This project was under negotiation at the time of publication.

SAVE@WORK4HOMES

SAVE@Work4Homes - Supporting European Housing Tenants in Optimising Resource Consumption

The project aimed to help tenants improve their energy awareness by encouraging them to monitor consumption and by providing them with information including heating data and data analyses. Notebooks for property managers and a handbook for tenants were planned.

http://save.atwork4homes.eu

SENTRO

Sustainable Energy systems in New buildings- market inTROduction of feasibility studies under the Directive on the Energy Performance of Buildings

The project started with making an inventory on how EU Member States were complying with the requirements of conducting a feasibility study for alternative energy systems for new buildings and which policy they pursued to actively introduce this requirement. Subsequently, in the seven SENTRO countries (Denmark, France, Lithuania, Poland, Slovenia, Sweden and The Netherlands), an inventory was also made of the building practices as a possible barrier of the implementation of alternative energy systems. After this inventory phase, an approach was developed to ensure that assessment of alternative energy systems would become an integral part in the common planning process of new buildings. Supporting tools of the approach (checklist and a handbook) included technical, financial as well as organisational aspects. Core of the project was a field trial in which the developed approach (including the checklist and handbook) was tested in the seven SENTRO countries. Finally, experiences were disseminated through courses and conferences towards the different target groups (e.g. national and international policy makers and key actors in the national building process).

http://www.sentro.eu

SHARE

Social Housing Action to Reduce Energy Consumption

This project aimed to increase the sustainability of energy use, minimise carbon emissions, limit uncomfortable temperatures and reduce fuel bills in social housing. To achieve these goals it raised awareness of economic benefits, developed retrofitting methods that address energy concerns, examined possible changes in behaviour, maximised financial and technical resources, promoted good practices and encouraged the sharing of experiences.

http://www.socialhousingaction.com/

SHELTER

Social Housing organisations and European professionals Linked and acting together for Testing and promoting professionals coordination in Energy Renovations

The social housing sector faces a significant challenge. Housing operators have to implement energy renovations, but have difficulties in implementing them with the professionals on their portfolio. It is observed that without the necessary knowledge: 1) renovation to strict standards can take longer and be twice as expensive as normal, 2) professionals (architects, consultants, engineers, suppliers, installers, builders) don't have enough knowledge of energy aspects and 3) they are not used to working together in a co-ordinated manner. This leads to unnecessary difficulties during the construction, when it is too late to easily make changes and many delivered buildings don't reach the expected energy performance. SHELTER starts from the current situation: the lack of coordination of professionals as the main obstacle to reach high efficiency in buildings and the ineffective use of information and tools available. The integrated design approach is applied, thus changing the way different professions work together along the supply chain. In SHELTER this approach is analysed in the frame of the renovation programmes of social housing operators in 5 countries and applied in practice. This project was under negotiation at the time of publication.

http://www.logirep.fr

SMART-E BUILDINGS

Smart-e buildings - yes we can Enable the building sector to contribute to reaching the 3 x 20 objectives

In its recently adopted Energy & Climate Package, the European Union has set ambitious targets, the 3 x 20 % by 2020. To reach them, the building sector is a key area as it is a big consumer of energy (both electricity & heating) and has a great potential for energy saving measures as well as for energy generation with renewable sources. Only a coordinated, intensive action from all concerned parties will enable Europeans to bring down the energy footprint and to meet the EU's targets. Smart-e buildings contributes to this aim through an industry-led (renewable energy, energy efficiency and building sectors) Europe-wide mobilisation campaign addressed to public authorities at national, regional and local levels, as well as citizens in view of empowering them to act. It will also target and educate national and EU parliamentarians and the media. Smart-e buildings will use the idea of a central interactive webportal linked to a number of social networking sites successfully used during the Obama election campaign. It will allow for volunteering and user group space on the portal, where activists can get organised and translate "yes we can" into the realm of sustainable buildings.

http://www.erec.org

SQUARE

A System for Quality Assurance when Retrofitting existing buildings to Energy efficient buildings

The SQUARE project aims to assure energy efficient retrofitting of social housing with good indoor environment, in a systematic and controlled way. To achieve this, a quality assurance (QA) system for retrofitting and maintenance is adopted in pilot projects in several European countries. This supports decision-making and ensures that suitable energy efficient retrofitting measures are chosen for each case. The QA system will be spread in several European countries by the use in pilot projects and the experiences will be used to improve the QA system and to suggest a future European energy management standard adapted to the building sector. The pilot projects will also act as good examples to inspire social housing owners to carry through energy efficient retrofitting projects. A number of dissemination activities will be carried out in order to spread knowledge and experience to owners, contractors, consultants, national authorities, municipalities, tenants etc. on local, national and international level.

http://www.iee-square.eu

STABLE

Securing The Take-off of Building Energy Certification: Improving Market Attractiveness through Building Owner Involvement

Energy certification boosts the attractiveness of the building market and creates a sustainable future for buildings and their occupants. STABLE grouped national energy agencies, building owners and market professionals to identify customer quality requirements in the field of energy certification, develop recommendations, promote the benefits of certification and organise campaigns and events targeting experts and professionals.

http://ieea.erba.hu.ieea/

SURE FIT

The project was developed to generate savings by combining cutting-edge technology with roof-top retrofitting. Tailor-made guidelines were prepared while small-scale RES installation applications are promoted. SuRE-FIT promoted improvements across Europe in terms of energy performance, financial resources, building areas and refurbishment methods.

http://www.sure-fit.eu/

TABULA

Typology Approach for Building Stock Energy Assessment

TABULA aims to create a harmonised structure for European building typologies. Residential buildings are the focus, but activities extend beyond them. Each national typology will be a set of model residential buildings with characteristic energy related properties. These will each represent a certain construction period of the country and a specific building size. Furthermore, the number of buildings and apartments which they represent, and the overall floor areas, will be identified. The development and utilisation of a webtool, serving as a data source for scenario analyses, will be the other key outcome. The action addresses experts working on scenario analyses, as well as policy makers, at regional, national or EU level. Energy consultants can also use the typologies for initial advice. Efforts are made to expand the typology structure to countries not involved in the project, with the webtool being open for addition of further national typologies by relevant experts.

http://www.building-typology.eu/

TACKOBST

Tackling Obstacles in Social Housing

Better energy performance in social housing can only be achieved through progressive retrofitting of existing buildings. Despite new social housing legislation in several European countries and innovative professional practices among social housing operators, obstacles to efficient energy management remain. The project was led by a consortium of professional associations of social housing operators from four countries, which together developed proposals designed to help key stakeholders overcome these obstacles.

http://www.tackobst.eu

THERMCO

Thermal comfort in buildings with low-energy cooling: Establishing an annex for EPBD-related CEN-standards for buildings with high energy efficiency and good indoor environment

Energy-optimised buildings abandon air-conditioning and employ energy-efficient and sustainable solutions for cooling. As low-energy cooling concepts use environmental energy from the ground, ground water and outdoor air, these buildings cannot necessarily guarantee a certain, specific room temperature. However, energy-optimised buildings with low-energy cooling concepts provide for a good indoor environment considering adaptive thermal comfort criteria. In spite of highly-developed and many successfully realised projects with passive or low-energy cooling in all European climate zones, there is a strong uncertainty among all persons concerned with building design (architects, HVAC engineers and real estate owners) due to conflicting requirements and standards on the European level and also in the member states. The ThermCo project evaluated existing data, summarised experience with low-energy buildings and regulatory and provided a proposal for a new CEN-standard annex on low-energy cooling. A normative design guideline for comfortable low-energy buildings integral to the annex contributed to a consistent quality assessment that would overcome the bottleneck of legal uncertainty

http://www.thermco.org

TRAINENERGY

Continuous, practice-oriented implementation and dissemination of the EPBD 2002 and energy end-use efficiency and energy services 2006 by training craftsmen and trainers in the construction trade

TRAINENERGY prepares and implements a pilot qualification for craftsmen in the building sector. The objective is to contribute to the qualification of the market to make recent European legislation as effective as possible. The project involves: - an on-line training database with institutionalised (nationally approved and validated) training modules - training guides for craftsmen and for trainers, including common European elements and national tailored ones - craftsmen and trainers accredited during the pilot phase The action is accompanied by measures to disseminate its outcomes and to facilitate roll out of the concept through a replicable model.

http://www.trainenergy-iee.eu/english/home.html

TREES

Training for Renovated Energy Efficient Social housing

Currently, existing material focuses mainly on new buildings, despite the fact that existing buildings offer the biggest energy-saving potential. This project aimed to incorporate energy efficiency into further education for architects and social housing managers. Educational material includes techniques, tools and case studies, developed and reviewed by a group which includes teachers themselves. Workshops were held to gather feedback and to prepare for inserting the material into courses.

http://www.cep.ensmp.fr/trees

USE EFFICIENCY

Universities and Students for Energy Efficiency

A common higher educational stream, addressing energy efficiency in university buildings, will be created in this action which is under negotiation. Universities and students are proposed as shining examples for energy efficiency solutions and energy efficient behaviour. Involving universities and market players, it builds on the opportunity to improve energy efficiency in university buildings and to establish training courses for students. Mapping of scenarios for energy performance asset management of university buildings is used as the base for a student training course, during which students can have real work experience implementing energy performance assessment methodologies. Monitoring will be carried out to collect data, upon which solutions to improve energy performance of the university buildings will be based. Students will be the main actors of the project. They will participate in an innovative, practical training experience in tandem with building technicians in team-work activities. An international Summer School is the final step of the project, an opportunity to share information, experiences and cultural habits among students of different countries.

http://www.useefficiency.eu

VENT DISCOURSE

Development of Distance Learning Vocational Training Material for the Promotion of Best Practice Ventilation Energy Performance in Buildings

Modern methods of education can play a vital role in increasing energy-efficiency in new buildings. Vent DisCourse adopted the distance learning method and applied it to ventilation - a core area of the energy performance of buildings. It targeted building professionals in an effort to stimulate the use of best practices in ventilation and addressed non-technological and cultural barriers via pilot training courses and awareness raising.

http://www.ventdiscourse.eu

IEA/ ECBCS

International Energy Agency
Energy Conservation in Buildings and Community Systems Programme

Annex B. IEA/ ECBCS projects

ECBCS

- The IEA Energy Conservation in Building & Community Systems Programme

www.ecbcs.org

Edited by Malcolm Orme

ECBCS Executive Committee
Support Services Unit

EXECUTIVE SUMMARY

About the International Energy Agency

The International Energy Agency (IEA) was established in 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme. A basic aim of the IEA is to foster co-operation among the twenty-eight IEA member countries and to increase energy security through energy conservation, development of alternative energy sources and energy research, development and demonstration (RD&D). The current framework for international energy technology RD&D co-operation was approved by the IEA's Governing Board in 2003.

More information about the energy technology RD&D framework can be found at: www.iea.org/textbase/techno/framework_text.pdf.

This framework provides uncomplicated, common rules for participation in research programmes, known as 'Implementing Agreements', and simplifies international co-operation between national entities, business and industry. Implementing Agreements are legal agreements between countries that wish to pursue a common programme of research in a particular area. In fact, there are now over 40 such programmes. There are numerous advantages to international energy technology RD&D collaboration through the IEA Implementing Agreements, including:

- Reduced cost and avoiding duplication of work
- Greater project scale
- Information sharing and networking
- Linking IEA member countries and non-member countries
- Linking research, industry and policy
- Accelerated development and deployment
- Harmonised technical standards
- Strengthened national RD&D capabilities
- Intellectual property rights protection

In recognition of the significance of energy use in buildings, in 1977 the International Energy Agency established an Implementing Agreement on Energy Conservation in Buildings and Community Systems (ECBCS). The function of ECBCS is to undertake research and provide an international focus for building energy efficiency. Tasks are undertaken through a series of 'Annexes' - so called because they are legally established as annexes to the ECBCS Implementing Agreement. These Annexes are directed at energy saving technologies and activities that support technology application in practice. Results are also used in the formulation of international and national energy conservation policies and standards.

1. ABOUT ECBCS

1.1 GENERAL

The IEA co-ordinates research, development and demonstration in a number of areas related to energy. The mission of one of those areas, the ECBCS - Energy Conservation in Building and Community Systems Programme, is to develop and facilitate the integration of technologies and processes for energy efficiency and conservation into healthy, low emission, and sustainable buildings and communities, through innovation and research.

The research and development strategies of the ECBCS Programme are derived from research drivers, national programmes within IEA countries, and the IEA Future Building Forum Think Tank Workshop, held in March 2007. The R&D strategies represent a collective input of the ECBCS national representatives – the ECBCS Executive Committee - to exploit technological opportunities to save energy in the buildings sector, and to remove technical obstacles to market penetration of new energy conservation technologies. The R&D strategies apply to residential, commercial, office buildings and community systems, and impact the building industry in three focus areas of R&D activities:

- Dissemination
- Decision-making
- Building products and systems

This extensive research output is maintained by a membership of 25 countries. This wide international community includes researchers, from building research institutes and universities, and industry including consultancies, contractors and manufacturers.

Australia	**Austria**
Belgium	**Canada**
P.R. China	**Czech Republic**
Denmark	**Finland**
France	**Germany**
Greece	**Italy**
Japan	**Republic of Korea**
The Netherlands	**New Zealand**
Norway	**Poland**
Portugal	**Spain**
Sweden	**Switzerland**
Turkey	**United Kingdom**
USA	

1.2 OUTREACH AND DISSEMINATION

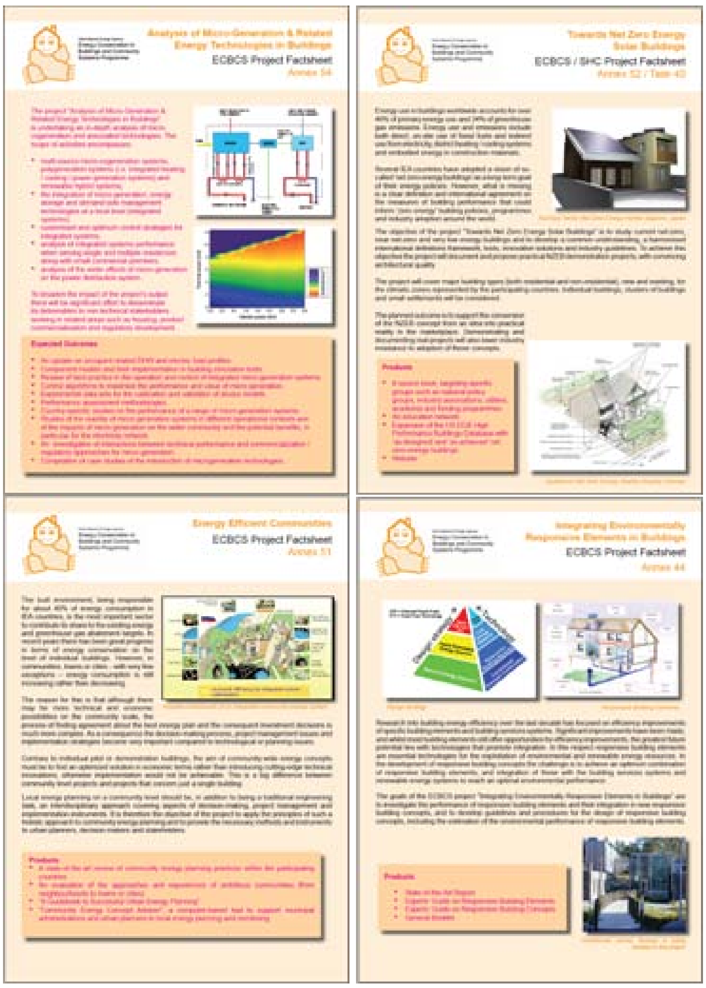
ECBCS is focussed on improving deployment of its project outcomes, including quantifying the impact of the Programme. The ongoing worldwide demand for knowledge about energy conservation in building and communities has been demonstrated with currently over 700 thousand downloads of project reports from the Programme website each year.

Website - The ECBCS website (www.ecbcs.org) is the starting point information for finding out more information about the activities and results of the Programme.

Newsletter - ECBCS News is published twice each year (in June and December). It is intended for a general audience of those active in fields relating to operational energy saving for buildings and community systems.

Annual Report - The Annual Report provides an overview of progress made by the ECBCS Programme, including summaries of new, ongoing and recently completed projects.

Project Factsheets – Summaries of current project are available from www.ecbcs.org in the form of Project Factsheets.



2. ECBCS CO-ORDINATION WITH OTHER IEA BUILDINGS-RELATED IMPLEMENTING AGREEMENTS

The ECBCS Programme co-ordinates its research activities, including Annexes and strategic planning, with all buildings-related Implementing Agreements. This takes place through collaborative projects and through the Buildings Co-ordination Group, constituted by the following IEA research programmes:

- District Heating And Cooling (DHC)
- Demand Side Management (DSM)
- Energy Conservation in Buildings and Community Systems (ECBCS)
- Energy Conservation through Energy Storage (ECES)
- Heat Pumping Technologies (HPT)
- Photovoltaic Power Systems (PVPS)
- Solar Heating and Cooling (SHC)

Proposals for new research projects are discussed in co-ordination with these other programmes to pool expertise and to avoid duplication of research efforts. Co-ordination with SHC is particularly strong and joint meetings are held between the programmes every two years. Both ECBCS and SHC programmes concentrate on buildings and communities.

3. ECBCS PROJECTS

ECBCS carries out research, development and demonstration activities toward near-zero energy and carbon emissions in the built environment. The RD&D activities focus on the integration of energy-efficient and sustainable technologies into healthy buildings and communities.

Past ECBCS projects and activities have produced long-lasting decision-making tools; integrated systems technologies, and seminars / conference proceedings for buildings and communities. ECBCS, in addition to community wide energy systems, covers various types of buildings: residential, commercial and industrial, educational, offices, multi-family and single-family, high and low-rise dwellings.

4. RESEARCH TOPICS

The remit of the ECBCS Programme covers every aspect of energy conservation in buildings and community systems. Community wide energy systems are taking on increasing importance in providing energy services to buildings.

For all building types, there are many issues relating to design, construction and performance in practice that need to be considered. So, ECBCS has carried out many projects in the following areas to provide a common insight:

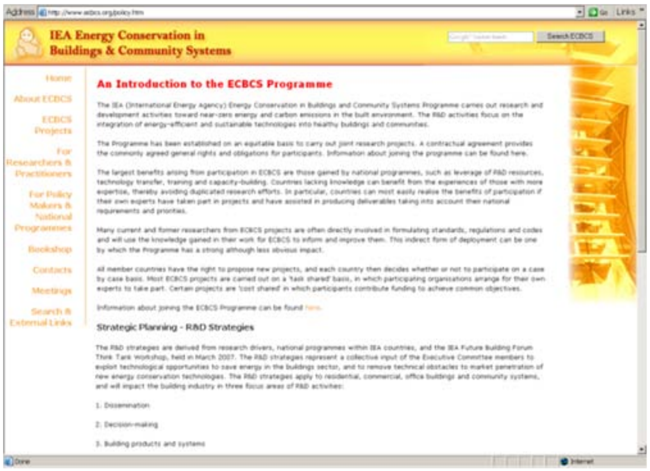
- Integrated system design including renewable energy sources
- Renovation and retrofit
- Construction technologies
- Electric lighting and daylight
- Energy measurement, management & auditing
- Environmental assessment
- Thermal simulation
- Ventilation
- Control of moisture in buildings

For non-residential buildings, ECBCS has carried out several research projects to better understand how energy reduction may be achieved for particular topics:

- Cooling
- Fault detection and commissioning

Sometimes challenges posed by certain building types require special attention. Therefore, ECBCS has undertaken projects on the following end use sectors:

- Government buildings
- Educational buildings
- Office buildings
- Hospitals
- Residential buildings



Project reports and other deliverables are freely available to download from the ECBCS website (www.ecbcs.org) and from the projects' own websites.

Many current and former experts from ECBCS projects are often directly involved in formulating standards, regulations and codes and will use the knowledge gained in their work for ECBCS to inform and improve them. This indirect form of deployment can be one by which the Programme has a strong although less obvious impact. Many national and international standards and regulations relating to energy use in buildings and communities have a technical basis connected with ECBCS research.

Participation in ECBCS projects is decided by an Executive Committee. All member countries have the right to propose new projects, and each country then decides whether or not to participate on a case-by-case basis. Most ECBCS projects are carried out on a 'task shared' basis, in which participating organisations arrange for their own experts to take part. Certain projects are 'cost shared' in which participants contribute funding to achieve common objectives. The AIVC currently operates within ECBCS as a part cost shared, part task shared activity.

At an individual level, the Programme allows researchers and others funded by national programmes and industry to pool their collective expertise to produce high quality project outputs. By taking part in the projects, they create and reinforce their own technical networks, the benefits of which remain long after the particular project has formally ended. This does not happen quickly, but over the course of generally three to five years, these networks of expertise become established as excellent international channels of communication.

Participation in the ECBCS Programme is at the discretion of both the existing member countries and of the national government of a country interested in joining. However, there are usually few barriers to joining, aside from a commitment to actively pursue the goals of the Programme on an equitable basis with the other members.

The largest benefits arising from participation in ECBCS are those gained by national programmes, such as leverage of R&D resources, technology transfer, training and capacity-building. Countries lacking knowledge can benefit from the experiences of those with more expertise, thereby avoiding duplicated research efforts. In particular, countries can most easily realise the benefits of participation if their own experts have taken part in projects and have assisted in producing deliverables taking into account their national requirements and priorities.

5. CURRENT ECBCS PROJECTS

Air Infiltration & Ventilation Centre (Annex 5)

Objective: To be the primary international information centre on research and development in the fields of air infiltration and ventilation, and thus to provide a high quality technical and information forum covering the areas of ventilation and air infiltration in the built environment with respect to efficient energy use, good indoor air quality and thermal comfort. This is described in more detail in an earlier chapter.

Integrating Environmentally Responsive Elements in Buildings (Annex 44)

Objective: Investigate the performance of responsive building elements and their integration in new responsive building concepts, and to develop guidelines and procedures for the design of responsive building concepts, including the estimation of the environmental performance of responsive building elements.

Energy-Efficient Future Electric Lighting for Buildings (Annex 45)

Objective: Identify and accelerate the widespread use of appropriate energy efficient high-quality lighting technologies and their integration with other building systems, making them the preferred choice of lighting designers, owners and users.

Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings (EnERGo) (Annex 46)

Objective: Improve the decision making process for energy retrofitting of government non-residential buildings, e.g. office / administrative buildings, dormitories / barracks, service buildings and production and maintenance facilities. Though the focus is on government buildings, many results can be applied to similar private sector buildings. Collectively, these building types represent a substantial part of the non-residential building stock.

Cost Effective Commissioning of Existing & Low Energy Buildings (Annex 47)

Objective: Enable the effective commissioning of existing and future buildings for improved operating performance. The commissioning techniques developed through this research will help to transition the industry from the intuitive approach that is currently employed in the operation of buildings to a more systematic operation that focuses on achieving significant energy savings.

Heat Pumping & Reversible Air Conditioning (Annex 48)

Objective: Promote the most efficient combinations of heating and cooling techniques in air-conditioned buildings, due to the use of heat recovery and reversible systems. The main goals are to:

- Allow the quick identification of heat pumping potential in existing buildings and to help designers to consider "heat pumping" solutions and to allow for future possibilities
- Improve commissioning and operation of buildings equipped with heat pump systems
- Make available a set of reference case studies and to document the technological possibilities and heat pumping solutions

Low Exergy Systems for High Performance Buildings & Communities (Annex 49)

Objective: From an economic and environmental point of view, high exergy energy sources should mainly be used in industry to allow for the production of high quality products. The Low Exergy (LowEx) approach entails matching the quality levels of exergy supply and demand, in order to streamline the use of high-value energy resources and make best use of low-value energy before it reaches the ambient environment.

Prefabricated Systems for Low Energy Renovation of Residential Buildings (Annex 50)

Objective: Develop and demonstrate innovative whole building renovation concepts for typical apartment buildings, minimising the primary energy use to 30-50 kWh/(m^2·year) for heating, cooling and domestic hot water. The concepts focus on standardized and prefabricated renovation modules for façades and roofs. It is anticipated that they will substantially enhance the building renovation quality and comfort in existing residential buildings.

Energy Efficient Communities (Annex 51)

Objective: Local energy planning on a community level should be, in addition to being a traditional engineering task, an interdisciplinary approach covering aspects of decision-making, project management and implementation instruments; apply the principles of such a holistic approach to community energy planning and to provide the necessary methods and instruments to urban planners, decision makers and stakeholders.

Towards Net Zero Energy Solar Buildings (Annex 52)

Objective: Study current net-zero, near net-zero and very low energy buildings and to develop a common understanding, a harmonised international definitions framework, tools, innovative solutions and industry guidelines. To achieve this objective the project will document and propose practical NZEB demonstration projects, with convincing architectural quality.

Total Energy Use in Buildings: Analysis & Evaluation Methods (Annex 53)

Objective: Enrich our understanding of energy performance of buildings, to broaden our knowledge about determinant factors for total building energy use, and to assess short- and long-term energy measures, policies and technologies.

Technical & Commercialisation Studies for Micro-generation Deployment in Buildings (Annex 54)

Objective: Undertake an expansive analysis of micro-cogeneration and associated technologies. The scope of activities encompasses:

- multi-source micro-cogeneration systems, polygeneration systems (i.e. integrated heating / cooling / power generation systems) and renewable hybrid systems (collectively termed micro-generation);
- integration of micro-generation, energy storage and demand side management technologies at a local level (integrated systems);
- customised and optimum control strategies for integrated systems;
- analysis of integrated systems performance when serving single and multiple residences along with small commercial premises;
- analysis of the wider effects of micro-generation on the power distribution system.

Reliability of Energy Efficient Building Retrofitting - Probability Assessment of Performance & Cost (RAP-RETRO) (Annex 55)

Objective: Develop and provide decision support data and tools for energy retrofitting measures. The tools will be based on probabilistic methodologies for prediction of energy use, life cycle cost and functional performance. The impact of uncertainty on the performance and costs will be considered. Methods based on probability give powerful tools that can provide us with reliable ranges for the outcome. The ultimate outcome of the project will be to develop knowledge and tools that support the use of probability based design strategies in retrofitting of buildings to ensure that the anticipated energy benefits can be realized. These will give reliable information about the true outcome of retrofitting measures regarding energy use, cost and functional performance.

6. ECBCS RESEARCH – SUMMARY OF ALL PROJECTS

Community energy systems
Advanced Local Energy Planning
Energy Efficient Communities I
Energy Efficient Communities II
Local Government Energy Planning
Energy Systems and Design of Communities

Integrated system design including renewables (all building types) Towards Net Zero Energy Solar Buildings Low Exergy Systems for High Performance Buildings and Communities Integrating Environmentally Responsive Elements in Buildings Low Exergy Systems for Heating and Cooling of Buildings
Renovation and retrofit (all building types) Prefabricated Systems for Low Energy Renovation of Residential Buildings Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings Retrofitting of Educational Buildings
Thermal simulation (all building types) Testing and Validation of Building Energy Simulation Tools The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems Bringing Simulation to Application Thermal Modelling Energy Conservation in Residential Buildings Load Energy Determination of Buildings
Cooling (non-residential buildings) Low Energy Cooling Systems
Construction technologies (all building types) Heat Pumping and Reversible Air Conditioning Energy Efficient Electric Lighting for Buildings The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems High Performance Insulation Systems Low Slope Roof Systems Demand Controlled Ventilation Systems BEMS - Evaluation and Emulation Techniques BEMS - User Interfaces and System Integration Windows and Fenestration

Electric lighting and daylighting (all building types)
Energy Efficient Electric Lighting for Buildings
Daylight in Buildings
Energy measurement, management & auditing (all building types)
Total Energy Use in Buildings Analysis & Evaluation Methods
BEMS - Evaluation and Emulation Techniques
BEMS - User Interfaces and System Integration
Energy Auditing
Indicators of Energy Efficiency in Cold Climate Buildings
Environmental assessment (all building types)
Energy-Related Environmental Impact of Buildings
Control of moisture in buildings (all building types)
Whole Building Heat, Air and Moisture Response
Integral Building Envelope Performance Assessment
Heat, Air and Moisture Transfer in Envelopes
Condensation and Energy
Ventilation (all building types)
Air Infiltration and Ventilation Centre
Design of Energy Efficient Hybrid Ventilation
Evaluation and Demonstration of Domestic Ventilation Systems
Energy Efficient Ventilation of Large Enclosures
Multi Zone Air Flow Modelling
Air Flow Patterns within Buildings
Demand Controlled Ventilation Systems

Fault detection and commissioning (non-residential buildings) Cost-Effective Commissioning for Existing and Low Energy Buildings Building Commissioning to Improve Energy Performance Computer-Aided Evaluation of HVAC System Performance Real time HEVAC Simulation
Government buildings Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings **Educational buildings** Retrofitting of Educational Buildings Design of Energy Efficient Hybrid Ventilation Low Energy Cooling Systems Energy Efficiency in Schools Energy Efficiency in Educational Buildings
Residential buildings Prefabricated Systems for Low Energy Renovation of Residential Buildings Solar Sustainable Housing Evaluation and Demonstration of Domestic Ventilation Systems Energy Conservation in Residential Buildings
Office buildings Design of Energy Efficient Hybrid Ventilation Low Energy Cooling Systems
Hospitals Low Energy Cooling Systems Energy Management in Hospitals

7. ECBCS RECENT PUBLICATIONS

Computer-Aided Evaluation of HVAC System Performance

- Technical Synthesis Report: Computer-Aided Evaluation of HVAC System Performance
- Demonstrating Automated Fault Detection and Diagnosis Methods in Real Buildings

Design of Energy Efficient Hybrid Ventilation (HYBVENT)

- Technical Synthesis Report: Control Strategies for Hybrid Ventilation in New and Retrofitted Office Buildings (HybVent)
- Hybrid Ventilation: State of the Art Report
- Principles of Hybrid Ventilation

Retrofitting of Educational Buildings

- Technical Synthesis Report: Retrofitting in Educational Buildings - Energy Concept Adviser for Technical Retrofit Measures
- Case Study Reports
- Energy Concept Adviser
- KULU – a tool for commissioning
- State of the Art Overview: Questionnaire Evaluations
- Overview of Retrofitting Measures
- Calculation Tools for the Energy Concept Adviser
- Energy Audit Procedures

Low Exergy Systems for Heating and Cooling of Buildings (LowEx)

- Technical Synthesis Report: Low Exergy Systems for Heating and Cooling of Buildings
- Heating and Cooling with Focus on Increased Energy Efficiency and Improved Comfort – Guidebook to IEA ECBCS Annex 37 Low Exergy Systems for Heating and Cooling of Buildings
- Guidebook Summary Report
- Introduction to the Concept of Exergy - for a Better Understanding of Low-Temperature-Heating and High-Temperature-Cooling Systems
- Analysis Tool for the Exergy Chain (Excel Tool)

Solar Sustainable Housing

- Sustainable Solar Housing (2 volumes)
- Bioclimatic Housing: Innovative Designs for Warm Climates
- The Environmental Brief: Pathways for Green Design
- Business Opportunities in Sustainable Housing:
- A Marketing Guide Based on Houses in Ten Countries
- Exemplary Sustainable Solar Houses - a set of 40 Brochures

High Performance Insulation Systems

- Vacuum Insulation Panels: Study on VIP Components and Panels for Service Life Prediction of VIP in Building Applications
- Vacuum Insulation in the Building Sector: Systems and Applications
- Vacuum Insulation: Panel Properties and Building Applications - Summary
- High Performance Thermal Insulation Systems - Vacuum Insulated Products (VIP): Proceedings of the International Conference and Workshop
- Building Commissioning to Improve Energy Performance

Commissioning Tools for Improved Energy Performance:

- Final Report
- Toolkit CD

Whole Building Heat, Air and Moisture Response (MOIST-ENG)

- Final Report Volume 1: Modelling Principles and Common Exercises
- Final Report Volume 2: Experimental Analysis of Moisture Buffering
- Final Report Volume 3: Boundary Conditions and Whole Building HAM Analysis
- Final Report Volume 4: Applications: Indoor Environment, Energy, Durability

The Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems

(COGEN-SIM)

- Review of Residential Cogeneration Technologies
- Methodologies for the Performance Assessment of Residential Cogeneration Systems
- Review of Existing Residential Cogeneration Systems

- Performance Assessments and Evaluations
- Residential Cogeneration Systems: A Review of the Current Technologies
- European and Canadian non-HVAC Electric and DHW Load Profiles for Use in Simulating the Performance of Residential Cogeneration Systems
- Specifications for Modelling Fuel Cell and Combustion-Based Residential Cogeneration Devices within Whole-Building Simulation Programs

Testing and Validation of Building Energy Simulation Tools

- In-Depth Diagnostic Cases for Ground Coupled Heat Transfer Related to Slab-on-Grade Construction
- Final Task Management Report - Testing and Validation of Building Energy Simulation Tools
- Empirical Validations of Shading/Daylighting/Load Interactions in Building Energy Simulation Tools
- Double Skin Facades: A Literature Review

Integrating Environmentally Responsive Elements in Buildings

- Responsive Building Elements, Integrated Building Concepts and Environmental Performance Assessment Methods: State of the Art Review

INIVE EEIG

Annex C. About INIVE

International Network for Information
on Ventilation and Energy performance

www.inive.org

About INIVE

1. A GUIDING HAND IN THE HUGE INFORMATION MINEFIELD

Over the past 30 years, there has been a tremendous growth in the volume of available knowledge on indoor climate, energy efficiency and the ventilation of buildings.

It is therefore increasingly important to efficiently handle the available information, to make it accessible in a format suitable for the (various types of) users, to identify major trends and to have intelligent centralisation of information. This kind of work can be done at the level of an individual organisation or country, but there clearly are major synergetic benefits if done in an international and multi-organisational context. This is why INIVE (International Network for Information on Ventilation and Energy performance) was founded in 2001.

2. ABOUT INIVE

INIVE is a registered European Economic Interest Grouping (EEIG), whereby from a legal viewpoint its full members act together as a single organisation and bring together the best available knowledge from its member organisations. The present full members are all leading organisations in the building sector, with expertise in building technology, human sciences and dissemination/publishing of information. They also actively conduct research in this field - the development of new knowledge will always be important for INIVE members.

INIVE has multiple aims, including the collection and efficient storage of relevant information, providing guidance and identifying major trends, developing intelligent systems to provide the world of construction with useful knowledge in the area of energy efficiency, indoor climate and ventilation. Building energy-performance regulations are another major area of interest for the INIVE members, especially the implementation of the European Energy Performance of Buildings Directive.

With respect to the dissemination of information, INIVE EEIG aims for the widest possible distribution of information.

3. INIVE AND THE AIVC

Since its creation in 2001, a major activity of INIVE EEIG has been the Operating Agent for the Air Infiltration and Ventilation Centre (AIVC). AIVC is one of the International Energy Agency's information centres, and is organised under the IEA's Implementing Agreement on Energy Conservation in Buildings and Community Systems (ECBCS). AIVC's main focus is on ventilation, indoor climate, energy in buildings and related building technology & physics. With some 25,000 visitors a month at present, the AIVC website is clearly recognised as a major information point for ventilation related topics.

4. INIVE AND BUILD UP

The European Energy Performance of Buildings Directive (EPBD) is currently the major driving force in Europe for regulatory initiatives regarding minimum energy performance measures in buildings and the energy certification of buildings. Moreover, the approach also receives a lot of attention in other countries. Dissemination of information on the EPBD fits very well in INIVE's mission. During the period from 2006 to 2008, INIVE coordinated the work of the EPBD Buildings Platform on behalf of the European Commission Directorate General for Transport and Energy (DG TREN), with this Platform acting as the official information platform of DG TREN.

Since June 2009, BUILD UP (www.buildup.eu), as the follow-up of the Buildings Platform, has been the EU portal for energy efficiency in buildings. INIVE EEIG has also been selected as lead service provider for this project.

5. INIVE AND THE SAVE ASIEPI PROJECT

The ASIEPI project (01/10/2007 - 31/03/2010) (www.asiepi.eu) was coordinated by INIVE EEIG and deals with the implementation of the EU EPBD directive and analysed the following aspects:

- EPBD requires Member States to define building energy performance requirements... but did the Member States take this opportunity to strengthen their existing legislation?
- Member States are free to define their calculation methods and their requirements... Is it therefore possible to compare requirements across Europe? If yes, are the requirements from one country more severe than those of neighbouring countries?
- EPBD gives a list of aspects to consider in the calculation procedures... Practically - how to effectively handle thermal bridges, stimulate good summer comfort conditions and good building and duct airtightness?
- EPBD should not be a barrier for innovation. Are there legal and technical frameworks to assess the energy performance of new innovative systems not covered by the standard procedures?
- Regulations are only useful if they are respected. How do the Member States organise control and compliance?

In addition to the traditional reports, publications, contributions to workshops and conferences, ASIEPI has also disseminated its result through web events and presentations-on-demand. Web events are on-line workshops that are broadcast on the Internet, with some possibilities of asking questions to the speakers.

6. THE DYNASTEE NETWORK

DYNASTEE stands for: "**DYN**amic **A**nalysis, **S**imulation and **T**esting applied to the **E**nergy and **E**nvironmental performance of buildings". DYNASTEE is an informal grouping of organisations actively involved in the application of tools and methodologies relative to this field. DYNASTEE functions under the auspices of the INIVE EEIG and constitutes a sustainable informal networking mechanism, which is intended for those who are involved in research and applications related to energy performance assessment of buildings.

Over the years, the Grouping of Outdoor Test Centres (formerly PASLINK EEIG), has actively supported activities and initiated European research projects related to the energy performance assessment of buildings. Real experimental set-up for outdoor tesing of building components provided high quality data series for estimation of thermal characteristic parameters.

The objective of DYNASTEE is to provide a multidisciplinary environment for a cohesive approach to the research work related to the energy performance assessment of buildings in relation to the Energy Performance for Buildings Directive (EPBD).

Belgian Building Research Institute (BBRI)
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The Belgian Building Research Institute is a private research institute founded in 1960 at the instigation of the National Federation of Belgian Building Contractors in application of the so-called "De Groote" Federal decree-law of 1947. Specifically, this decree-law, named after the post-war Belgian Minister of Economic Affairs, aimed at promoting applied research in industry in order to improve its competitiveness. At the time, it represented an innovative approach to promoting technology development in a rather traditional sector. In application of this law, the statutory contributing members of the BBRI are the more than 80,000 Belgian construction companies (general contractors, carpenters, glaziers, plumbers, roofers, floorers, plasterers, painters, etc.), most of which are small or medium-sized enterprises. According to its statutes, BBRI has the following three main missions:

- to perform scientific and technical research for the benefit of its members
- to provide technical information, assistance and consultancy to its members
- to contribute in general to innovation and development in the construction sector, in particular by performing contractual research at the request of the industry and the authorities.

To fulfil its mission, the BBRI pools the expertise of some 230 highly skilled and motivated staff members with widely varying educational backgrounds: this enables it to set up multidisciplinary teams as required by the problem at hand.

Research at the BBRI is concentrated on practical work yielding results in the short term which can be applied readily by the members. The field of research activities is quite broad, and in fact touches upon all essential requirements for building work, i.e. mechanical resistance and stability, health and environment, safety in use, acoustics, energy economy and heat retention. Expertise is grouped in different research departments, divisions and laboratories covering aspects such as structural design, soil mechanics, execution techniques, construction materials, façade technology, environmental issues, renovation, recycling, technical equipment, automation, building physics, lighting, heating, internal climate, building chemistry and information and communication technologies. Research programmes at the BBRI are in general initiated and monitored by technical committees bringing together all the relevant stakeholders, i.e. contractors, material producers, authorities, designers, architects, consultants, universities, etc. Where necessary, research alliances are set up nationally and internationally with universities and other research centres. Besides the statutory membership fees, incomings are generated amongst others by research projects funded by the European Commission, the Federal Ministry, and the Communities and Regions (Flanders, Wallonia and Brussels). Results are published in technical guidance notes which are considered as high quality reference documents for Belgian construction practice.

Collaboration and networking is key in the present open approach to innovation. The BBRI is therefore a member of numerous European networks. In particular, it was a founding member and currently runs the executive secretariats of the European Network of Building Research Institutes – ENBRI (*http://www.enbri.org*) and the European Council for Construction Research, Development and Innovation – ECCREDI (*http://www.eccredi.org*). The ENBRI network provides full coverage of topics for construction and the built environment and continuously updates international knowledge and experience for the construction sector. The European organisations participating in ECCREDI in fact represent the principal interests within construction: contractors, engineering, consultants, architects and designers, product and material producers, social housing providers and research bodies. Through its participation in this network, BBRI seeks to help build "a sustainable and knowledge-based European construction sector, which is competitive, innovative and market-driven and meets users' needs and those of society by providing the best living and working conditions for all people".

The BBRI is currently involved in quite a number of European projects, including the following:

PERFECTION - Performance indicators for health, comfort and safety of the indoor environment *www.ca-perfection.eu*

CLEAR-UP – Clean buildings along with resource efficiency enhancement using appropriate materials and technology *www.clear-up.eu*

EU CHIC – European Cultural Heritage Identity card

ASIEPI – Assessment and improvement of the EPBD impact for new buildings and building renovation *www.asiepi.eu*

BUILD UP - EPBD Buildings Platform phase two www.buildup.eu

Mobi3Con - Developing Mobile 3D Data Collection, Processing and Dissemination Solution for Construction SME-s *http://mobi3con.eii.ee*

SuPerBuildings - Sustainability and performance assessment and benchmarking of buildings *http://cic.vtt.fi/superbuildings*

Information and technology transfer is a core activity of the BBRI. Over 450 conferences, seminars, workshops and training sessions on specific topics are organised each year. Winter courses allow practitioners to invest in permanent professional education. Problem-solving advice and technical assistance to building contractors are provided by a dedicated team of specialists who deal with over 40,000 technical queries each year and are on standby to deliver their expert view by phone/fax or during on-site visits and in dedicated reports. As well as being much appreciated by members, this service is also an effective means of pinpointing research needs.

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CETIAT is a French research, testing and training centre in fluid mechanics, aerodynamics, heat sciences and acoustics. Its activity is as an independent testing and study centre (8 M€/year), performing tests, calibrations of measuring devices, performance certification, calculations, technology watch, studies, audits, training, … for its members and various customers from all industrial sectors.

CETIAT also operates a cooperative research programme (4 M€/year) for its 340 industrial members and sponsors, covering themes such as energy conservation, integration of renewable energy sources, indoor environmental quality, innovative systems, environmental issues, reliability and quality of installed systems, metrology and quality of measurements. Results are distributed through reports, workshops, technology watch bulletins, a dedicated website and a 3-days annual conference. CETIAT is a key actor in several European and standardisation groups within CEN and ISO. It also contributes to the discussions between industry and public authorities or certification bodies for the implementation/revision of regulations and certification schemes.

Founded in 1960, CETIAT has the legal status of "Centre Technique Industriel". With a staff of 135 persons (mainly engineers and technicians), located in the immediate vicinity of Lyon, CETIAT operates about 2000 contracts per year.

CETIAT industrial members are 340 manufacturers of systems for heating, ventilation, air handling, air conditioning, air filtration, dust removal, air drying, air humidifying, intended to be used in buildings, industrial process or transport vehicles.
CETIAT is ISO 9001 certified for its activities as a whole, while CETIAT laboratories (50 test and calibration rigs) are ISO 17025 accredited for most of their activities.

CETIAT skills applied to buildings, industry and transport vehicles cover various aspects of air handling: ventilation systems, ductwork, fans, air diffusers, indoor air quality, air filtration, air cleaning, energy performance, heat recovery, integration of renewable, acoustics, fan noise, silencers, comfort of occupants, coupling of ventilation systems with heating systems, domestic hot water systems, heat pumps, …
CETIAT has also developed a recognised expertise about testing methods, standards, regulations, certification schemes, calculation / simulation, training, technology watch.
CETIAT skills in metrology relate in particular to accurate measurement of air velocity, air flow rate, air humidity, pressure, temperature and the assessment of measuring uncertainties.

Recent or ongoing interesting projects operated by CETIAT about ventilation cover important topics such as:

Indoor air quality, air filtration, air pollutants removal:

- Air quality issues at the outlet of earth-to-air heat exchangers
- Indoor air quality in very low energy buildings
- Testing method for air cleaners
- Efficient hoods for welding fumes in industrial premises

Energy efficient ventilation systems:

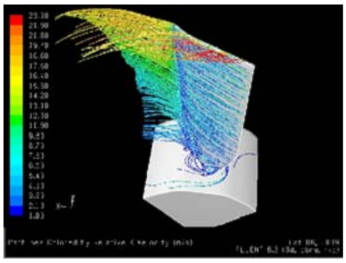
- Ventilation systems in the French regulation
- Assessment method for sensors in demand-controlled ventilation systems
- Energy labelling of air filters
- Heat recovery techniques at the exhaust of industrial warm air dryers
- Energy efficient hoods for commercial kitchens

Improvement of ventilation systems operation:

- On site measurement of air flow rates
- Improvement of training sessions for ventilation systems installers

Acoustics:

- Methodology to predict noise of fans



Some key publications to which CETIAT contributed are:

- Trends in the French building ventilation market and drivers for change (www.aivc.org/Publications/Vips/vip19.htm)
- Air filtration in HVAC systems (http://www.rehva.eu/?page=bookstore)
- Aerodynamic noise of fans
- Flow generated noise in ventilation systems
- Air quality in ventilation installations
- Demand-controlled ventilation

(www.cetiat.fr/gb - *Publications)*

INIVE membership brings to CETIAT an efficient way to cooperate with partners having similar skills at an international level. INIVE also offers to CETIAT an appropriate place to build up and operate common fruitful projects concerning the ventilation and energy performance of buildings.

International Centre for Numerical Methods in Engineering (CIMNE)
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The International Centre for Numerical Methods in Engineering is an autonomous research centre dedicated to promoting and fostering advances in the development and application of numerical methods and computational techniques. In 2001 CIMNE created the Building Energy and Environment Group (BEE-Group. *www.cimne.com*). The main objectives of the BEE-Group have been focused in the development of energy modelling methods and decision for the support tools that enable the penetration of advanced energy efficiency management strategies into the building sector. More specifically, the fields of expertise of the BEE-Group are the following:

- Development of numerical methodologies for the analysis of the energy performance of PV/T systems and PV ventilated façades.
- Development of advanced energy services for municipalities and building managers.
- Detailed analysis of the ventilation in the urban environment and around large PV or wind installations.
- Technical post graduate courses in ST hot water systems, solar cooling installations, energy efficiency in buildings and building physics.

CIMNE is one of the first autonomous research and development centers created by the Generalitat de Catalunya and the Universitat Politècnica de Catalunya (UPC) in 1987 under the auspices of the UNESCO. In the last twenty years CIMNE has promoted training and research activities and technology transfer demonstrated by milestones such as: 440 courses and seminars; the publication of 125 books, 15 educational software programs, and more than 910 R+D international projects.

Representative projects for the last five years can be grouped within the following categories:

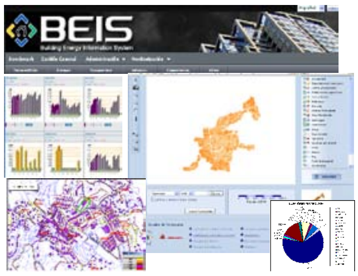
1. Applied research for the energy retrofitting of buildings and neighborhoods
   - Revisión y actualització de los Criterios de construcción de nuevos edificios para centros docentes públicos.
   - Desarrollo de un sistema de diagnosis energética del municipio de Cerdanyola del Vallès, y seguimiento del impacto energético en los edificios residenciales y terciarios de la realización del Plan Urbanístico del Centre Direccional.
   - Casa Kyoto: Energy monitoring and Analysis of the Kyoto's home.
   - ITL 2: Analysis and monitoring of PCiTAL green house buildings.
   - Diagnosis Energética y Socio Económica del Barrio de Can Jofresa.
2. Introduction of RES and RUE and application of ICT technologies

– eSESH- Saving Energy in Social Housing with ICT.
– SIGE.-Sistema Integral de gestión energética y seguridad eléctrica.
– NATVENT-Caracterizacion de sistemas de ventilacion natural en las fachadas de los edificios, para su inclusion en el codigo tecnico de la edificacion.
– PVFAVENT -Diseño y Optimización de Fachadas Fotovoltaicas Ventiladas
– Directrices Energéticas Integrales en Edificios de Oficinas Transparentes (TOBEE).
– TRE- TEST REFERENCE ENVIRONMENT (TRE
– MEDISCO-Mediterranean food and agro Industry applications of Solar Cooling technologies.

3. Applied research for numerical simulation of ventilation in large regions

– EST- European Solar Telescope (EST).
– ATMOST: Atmospheric transport models and massive parallelism, applications to volcanic ash clouds and dispersion of pollutants at an urban micro-scale

In 2005, BEE-Group signed a collaboration agreement with Gasso Auditores (*www.gassorsm.com*) for the development and commercialisation of an advance energy management service oriented to municipalities. This service is called Municipal Information Energy System (SIE) (*www.cimne.com/sie*). SIE is an energy management service aiming at auditing, controlling and following-up energy consumption in public buildings and public lighting systems at municipal level. Up to 2009, SIE has been installed in **over 300 municipalities, and 1600 public buildings**.



Key publications of BEE-Group are:

– X. Cipriano, J. Carbonell, J. Cipriano. *Monitoring and modelling energy efficiency of municipal public buildings: Case study in Catalonia region.* Int. J. of Sustainable Energy. Vol 28. p.p. 3-18. Taylor and Francis. (March 2009).
– R. Codina, J. Baiges, D. Pérez, M. Collados. *A numerical strategy to compute optical parameters in turbulent flow. Application to telescopes Computers and Fluids.* Computers and Fluids. Elsevier B.V. (Accepted July 2009)
– Martí Herrero J; Heras Celemin MR. *Dynamic physical model for a solar chimney*. Solar energy. Vol 5. pp 612- 622. (May 2007).
– J. Cipriano, C. Lodi, D. Chemisana, G. Houzeaux, O. PerpiñánT. *Development and characterization of semitransparent double skin PV facades*. EUROSUN 2008. 1st Int. Conf. on Solar Heating, Cooling and Buildings – Lisbon, 2008.
– X. Cipriano, J, Jimenez, C. Zinggerling, D. Pérez. *Applications of the Geographical Information Systems for the Municipal Energy Management*. Intergraph Review (2005).
– R. Codina, J. Baiges, D. Pérez, M. Collados. *Fluid Mechanics and Optics: the Effect of Turbulence in the Observation of the Universe*, IACM, 2007.
– J. Martí (2007). *Transfer of low-cost plastic biodigester technology at household level in Bolivia*. Livestock Research for Rural Development, Vol 19 pp1-1

The main aim of the CIMNE Bee-Group in becoming an associated member of INIVE concerns the interchange of knowledge among the INIVE members in the fields of building ventilation and energy efficiency. Furthermore, INIVE represents an international discussion forum and an ideal research frame where we can share our projects and experiences.

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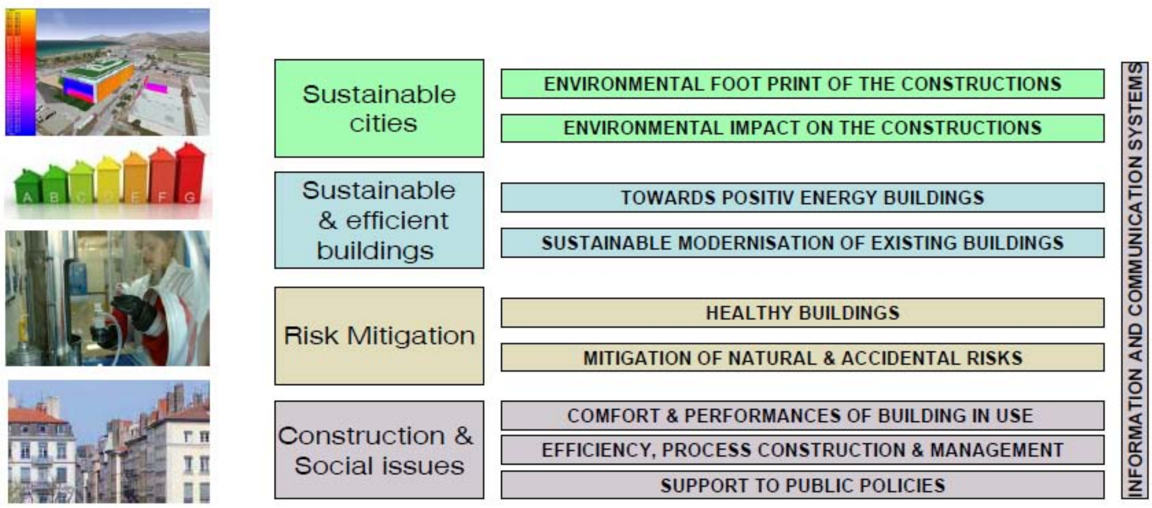
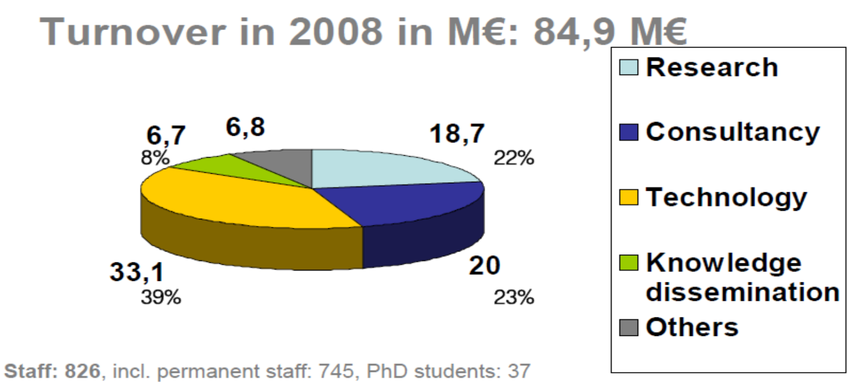
http://www.cstb.fr/

In its quest to improve well-being and safety in buildings, CSTB practises four complementary trades: research, advanced engineering, quality assessment and the dissemination of knowledge. In combination with its fields of expertise, these allow CSTB to adopt a global approach to buildings, which includes their urban environment, services and new information and communication technologies.

CSTB is composed of eight departments which deal with four major themes:



CSTB collaborates with contracting authorities, architects, research offices, manufacturers and builders, and helps the French public authorities to define technical regulations and ensure the quality of buildings. CSTB is a state-owned industrial and commercial corporative, placed under the administrative supervision of the French Ministry of Housing. It is one of Europe's leading research and evaluation centres.



The complementary skills of its experts allow it to deal with the most complex construction problems from a multidisciplinary standpoint.

At the international level, CSTB has asserted its international vocation ever since it was founded, and is involved in many scientific and technical partnerships. However, with the creation of the EU's Construction Products Directive (89/106/EEC) and its application via European technical approvals, European standards and CE labelling, CSTB's European vocation has taken on a far more important dimension.

With its involvement in European codification and research programs, CSTB is well-placed to help manufacturers deal with the European single market and support their export projects.

Outside the European Union, CSTB carries out activities in five main geographic areas:

- Asia: China, Japan
- South Korea
- North America: USA, Canada, Mexico,
- South America: Brazil, Argentina, Chile
- Mediterranean: Morocco, Algeria, Tunisia, Lebanon, etc.

Ecole Nationale Travaux Public de l'État (ENTPE)
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"Ecole Nationale des Travaux Publics de l'Etat" (ENTPE) is an institute of the Ministry of Public Works training engineers in urban development and civil engineering for government departments or local communities as well as public organisations or private companies.

"Laboratoire Sciences de l'Habitat" (LASH) - Building Sciences Laboratory - is one of the six research laboratories of ENTPE and is associated -with "Département Génie Civil et Bâtiment" DGCB (Department of Civil Engineering and Building) and with the "Centre National de la Recherche Scientifique" - National Scientific Research Centre (URA 1652).

LASH-DGCB is made up of thirty researchers. In addition, each year, more than twenty students prepare a Master's degree and / or their Diploma at the laboratory.

LASH-DGCB is specialised in indoor climate issues (thermal behaviour of buildings, ventilation, acoustics, lighting). LASH has a large experience in the field of building physics and is specialised in the energy efficiency of buildings and building management system, and has experience and knowledge in simulation, analysis and energy management systems. Past and present actions of LASH on energy efficiency of buildings will provide the activities of INIVE with advanced experience. LASH carries out research programmes with scientific or financial support of different partners or private companies.

The laboratory contributed to several projects in the framework of European programmes (ENERGY, JOULE, SAVE, ALTENER, COMETT) e.g. recent projects:

- PASCOOL, JOULE.
- OFFICE, JOULE.
- SCATS, JOULE.
- GENESYS, JOULE (coordinator).
- AIOLOS, SAVE.
- SIG-BIO, ALTENER (coordinator).
- MEDIABEMS, SAVE (coordinator).
- DUCT, SAVE (coordinator).
- EcPRO, SAVE (coordinator).
- HELP, SAVE (coordinator).
- Best Façade, Save.
- Vent Dis course, Save.

International actions on related topics include:

- IEA, annex 35: Hybrid Ventilation in New and Retrofitted Office and Educational Building (subtask A, control strategies, leader)
- IEA, annex 36: REDUCE, retrofitting in Educational Buildings.
- IEA task 46: EnerGo, retrofitting in public buildings.

LASH is responsible for all educational activities dealing with building physics, relevant to the topics of activities of INIVE. The results of research and application activities are thus broadly disseminated through educational as well as training courses. Moreover, LASH assumed responsibility for the organisation of EPIC International Conferences in 1994, in 1998, in 2002 and 2006 with INIVE (supported by DG XII, CNRS and several other national or international bodies) on Energy Performance and Indoor Climate in Buildings, which met 300 participants, coming from more than 35 countries.

Relevant National actions in France include:

- Groupe de Pilotage de la Qualité des Ambiances (a group of expert working on indoor climate issues) partly financed by the Ministry of Public Works.
- Projet de Nouvelle Réglementation Thermique (new thermal building code project) that stresses on energy and indoor climate issues.
- Research works on ventilation and indoor air quality in dwellings, schools and offices for the Ministry of Energy and Ecology.
- Contribution to the European Concerted Action of EPBD for Ministry of Energy and Ecology.

Fraunhofer Institute for Building Physics (Fraunhofer IBP)
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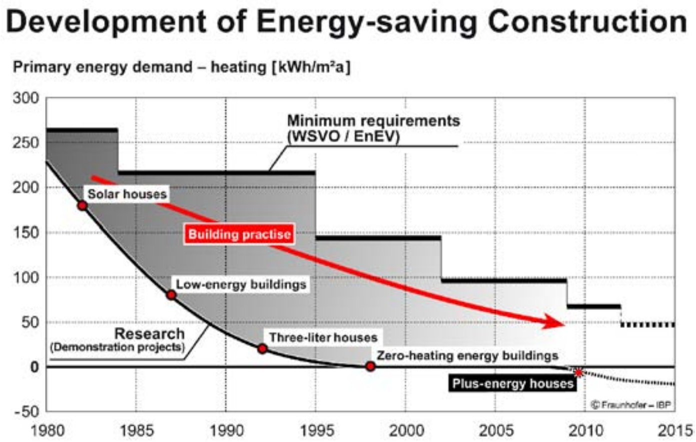
Fraunhofer research activities are application- and results-oriented. The organisation pursues the implementation of innovative research findings in industrial and social applications. Its work is based on a dynamic balance between applied basic research and innovative development projects. The Fraunhofer Institute of Building Physics is one of over 50 research institutes of the Fraunhofer-Gesellschaft and deals with research, development, testing, demonstration and consulting in the fields of building physics, including indoor climate and preservation of building structures. The Department of Heat Technology focuses on energy conservation strategies such as energy-efficient building components and building service systems including renewable technologies.

The non-profit research institution, founded in 1949, is recognized as an organisation guaranteed by the Federal Republic of Germany. As it stands today, the Fraunhofer-Gesellschaft has attained a size (more than 10000 employees, turnover more than 1 billion Euro/year) and influence that makes it an undisputedly vital element in Germany's industrial and scientific landscape. The turnover of the Institute for Building Physics in 2008 was 17.3 million Euro, generated by 136 regular employees.

Hans Erhorn,
Department leader

The Department of Heat Technology is doing research and development in the field of energy-efficient buildings and community systems. Our scientists design, supervise and assess low-energy buildings, low-entropy buildings, 3-liter-houses, zero-heating energy houses and surplus energy houses and entire housing estates. They prepare energy-efficient renovation concepts for existing buildings and implement these into practical construction solutions. The working groups develop and investigate façade, heating, ventilation, solar, hybrid, storage, low-entropy and energy supply systems, designed for practical use in buildings.

Moreover, the department calculates total energy balances, including the life cycle analysis of buildings and heat supply systems, and analyses and assesses energy saving potentials.



Milestones of high performance demonstration buildings developed and evaluated by the Fraunhofer IBP in comparison with the German minimum requirements.

A focus is also on air flow and on the temperature performance of buildings in summer. Our scientists compute and measure lighting and the daylighting supply in buildings and are engaged in the assessment of mould growth. The department of Heat Technology develops and maintains computer-aided planning tools and information systems, in addition to integrated national and international demonstration and standardisation projects, as well as guideline panels.

The Department participated and still participates in leading positions in the following indicative projects:

- Concerted Action project (*www.epbd-ca.org*)
- Buildings Platform and BUILD UP (*www.buildup.eu*)
- IEA ECBCS Annexes 46, 36 and 51 (*www.annex46.org*, *www.annex36.com*, *www.annex51.org*)
- Various German national research initiatives: EnEff:Stadt, EnEff:Schule, EnSan
- German standardisation panel on energy performance of buildings DIN V 18599

The main activities of the department focus on:

- Consultancy on energy efficiency in buildings, summer performance, ventilation strategies for high performance buildings
- Development of software tools and guidelines for assessing the energy performance of buildings incl. the most used calculation core for DIN V 18599
- Blower-door tests, tracer gas tests, thermography

Some key publications to which the department contributed are:

[1] The Energy Concept Adviser—A tool to improve energy efficiency in educational buildings. (*http://www.sciencedirect.com*)

[2] Airtightness requirements for high performance buildings. (*http://www.asiepi.eu/wp-5-airtightness/related-papers.html*)

[3] Executive summary report on the interim conclusions of the Concerted Action supporting transposition and implementation of the Directive 2002/91/EC. (*http://www.epbd-ca.org/Medias/Pdf/CA_Summary%20report_Feb2010.pdf*)

Fraunhofer IBP is a founding member of INIVE and has joined this network of excellence for the exchange of information on red-hot research outcomes and for working together with other leading organisations in high-level international projects and supporting activities.

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Group of Building Environmental Research

Physics Department - University of Athens

The Group of Building Environmental Research (GRBES), operates under the frame of the Section of Applied Physics, Department of Physics of the University of Athens. It carries out specific research and development programs in the fields of environmental quality of the built environment and environmental materials. In parallel, it offers education and training to under- and post-graduate students, and prepares educational material and books on the field of energy and environment. The Group was established after 1991. It employs 19 researchers and carries out specific research under contracts from National and International Institutions.

The Group works on the following research topics within the corresponding laboratories:

- Design and Development of Intelligent Environmental Materials
- Energy Performance of Buildings
- Solar Energy Systems and Techniques
- Energy Efficient Technologies
- Indoor Environmental Quality
- IT Technologies applied to Buildings
- Urban Environmental Quality
- Energy and Environmental Rating

The Laboratory of Energy audits and energy efficient design of buildings, specialises in energy and environmental assessments of the built environment and studies to improve the energy and environmental performance of buildings. It has all the necessary equipment to support experimental and theoretical studies integrated in a modern mobile energy bus (infrared cameras, luminance cameras, tracer gas, equipment to measure in situ U values, thermal and visual comfort, all climatic parameters etc.). The Group has carried out more than one thousand energy audits and studies aiming to improve the energy efficiency of buildings in Greece and elsewhere. In parallel, the lab has developed materials that present thermochromic properties for the outdoor environment and materials that have extremely high reflectivity and appropriate emmissivity using nanotechnology procedures and tools. Experimental facilities involve advanced spectrophotometers and other sophisticated equipment to carry out ageing tests and measure the emissivity of materials.

The Laboratory of Ventilation and Indoor Air Quality involves all the necessary equipment to carry out specific ventilation and indoor air quality measurements. It combines multiple and single tracer gas equipment with an air chromatographer, an advanced indoor pollutants measurement equipment, air flow visualisation equipment, and equipment to measure the air speed and flow in indoor and outdoor environments. The lab has extensive experience in natural ventilation experiments. In parallel, the Group is equipped with a blower door facility to perform research and development work related to air infiltration and transfer of pollutants between the ambient and indoor environment and a modern GCMS facility for the qualitative and quantitative analysis of indoor pollutants.

The Group has coordinated the following International Research and development programs:
PASCOOL - Passive Cooling of Buildings.

OFFICE - Passive Retrofitting of Office Buildings to Improve Their Energy Performance and Indoor Environment.

AIOLOS - Preparation of Scientific Material on Natural Ventilation of Buildings.

URBANCOOL - Study of Efficient Cooling Techniques for the Urban Environment.

FENESTRATION - Study of Advanced Window Systems

EUROCLASS - Preparation of the European Experimental and Theoretical Methodology for the Energy Rating of Buildings.

RESET - Use of Renewable Energies for Urban Renewal.

INTERSET - Use of Energy Efficient Technologies for Urban Renewal.

Combined Use of Satellite and Ground Data for the study of the thermal environment of urban areas: methodologies and mitigation strategies. Scientific and Technological Cooperation between NKUA and Lawrence Berkeley Lab, US.

COOLROOFS - European Project on the Use of Reflective Materials in Buildings.

The most recent publications by the Group include, among many others:

- Thermal Analysis & Design of Solar Buildings, James & James Science Publishers, 2002
- Solar Thermal Technologies for Buildings – The State of the Art, James & James Science Publishers, 2003
- Ventilation of Buildings, The State of the Art, James & James Science Publishers, 2007
- Energy Rating of Residential Buildings, James & James Science Publishers, 2004
- Cooling the City, Editions des Ecoles des Mines, Paris, 2004
- Natural Ventilation in the Urban Environment, James and James Science Publishers, London, 2005
- Advances in Solar Energy, American Society of Solar Energy, 2005
- Environmental Design of Urban Buildings, James & James Science Publishers, 2005
- Advances in Passive Cooling, James & James Science Publishers, 2006
- Air Quality: New Research, NOVA Publishers, NY, 2008
- Buildings, Energy and the Environment, University Studio Press, Thessaloniki, 2008

The scientific work carried out by NKUA fits in perfectly with the objectives of INIVE. INIVE membership facilitates efficient collaboration and information exchange among its members, while at the same time bringing complementarity to existing knowledge and skills. NKUA is a very active partner and participates in most of the activities of INIVE.

end-use Efficiency Research Group (eERG), (a research unit of the Energy Department (Dipartimento di Energia) – Politecnico di Milano)

Via Lambruschini, 4, IT- 20156, Milan, Italy, Tel. + +39 02 2399 3870

Email: *info@eerg.it*, **Website** *http://www.eerg.polimi.it*

Within the Energy Department of Politecnico di Milano, the end use Efficiency Research Group (eERG) is dedicated to research, technology transfer and teaching about the efficient use of energy in buildings. In particular, this includes the fields of: low energy buildings; passive cooling techniques - night ventilation, ground coupling, etc -; efficient lighting and daylighting; technical and economic analyses of energy-using products; and evaluation and certification of energy savings in the context of liberalised energy markets.

The Politecnico di Milano (PoliMi) is a state university with curricula both in Engineering and Architecture. The nine schools are dedicated to education, while the 16 departments are dedicated to research. The Dipartimento di Energia is involved in research in three sectors: electric power generation, transmission and distribution; energy technologies in transport; thermal engineering and efficient final energy use. The end-use Efficiency Research Group, active since 1996, comprises seven researchers and has carried out about 2,5 million Euros in external research contracts in the period 2000-2010.

Past and ongoing work of eERG includes: research on advanced glazing, shading, and ground exchangers for heating and cooling, using experimental test facilities and computer simulation; building simulations to identify retrofit savings potential, with special focus on passive summer comfort; energy analyses to support the integrated design of advanced low energy buildings; large in-field measurement campaigns to assess comfort levels in buildings (ASHRAE Class I measurements and subjective surveys in commercial buildings).

Fig 1: Comfort measurement and surveys in an Italian office building

eERG has promoted and coordinated an IEE project on the adaptation of the PassivHaus concept for Mediterranean climates (*www.passive-on.org*). This work has proposed a new performance-oriented standard definition for PassivHuas (PH), adapted to warmer climates, including an upper limit to the energy need for cooling and a more explicit definition of summer comfort. eERG performed simulations to find models of buildings able to meet the new PH standard in archetype warm Italian climates and to support the design of real buildings, some of which have been extensively monitored and analysed. Current work is focused on further improvements, and the realization and monitoring of zero energy houses in Mediterranean climates, in conjunction with IEA SHC task 40 - ECBCS annex 52, as well.

Teaching activities include "Thermodynamics” and ”Building Physics”, for Building Engineering students at the Politecnico di Milano, and Vice Direction of the 12-month post-graduate Master’s Course in Renewable Energy, Decentralised Generation and Energy Efficiency (www.ridef.polimi.it).

Ongoing and recent projects include: GreenBuilding, promoting energy efficiency and renewables in non residential buildings (IEE 2005-2006 and 2007-2010); Commoncense, Comfort Monitoring (IEE 2007-2010);

Fig 2: The Italian school winner of one of the EU GreenBuilding awards, 2010

KeepCool 2 (IEE 2007-2010) and KeepCool (2004-2006), promoting sustainable summer comfort in the service building sector; Thermco, thermal comfort in low energy buildings (IEE 2007-2009); and El-Tertiary (IEE 2005-2007) and Remodece (IEE 2003-2005), monitoring electricity consumption in the tertiary and domestic sector. eERG has promoted and coordinated various projects, e.g **Passive-on** (see above), EuroWhiteCert (on energy efficiency policy and saving certificates (IEE 2005-2007)), DSM pilot actions and the removal of DSM disincentives from price regulation (IEE 1998-1999).

A selection of eERG publications

Pagliano, L., Zangheri P., “Comfort models and cooling of buildings in the Mediterranean zone”, to be published in ABER – Advances in Building Energy Research 2010, Volume 4, p. 1-34, http://www.earthscan.co.uk/JournalsHome/ABER/tabid/1503/Default.aspx

“The PassivHaus Standard in European warm climates: design guidelines for comfortable low energy homes; Part 3: comfort, climate and passive strategies”, www.passive-on-org

A. Dama, T. Kuhn, L. Pagliano, “Modelling the solar factor of glazing combined with indoor Venetian blinds”, in Proceedings of PLEA, Geneva, September 2006, www.plea2006.org .

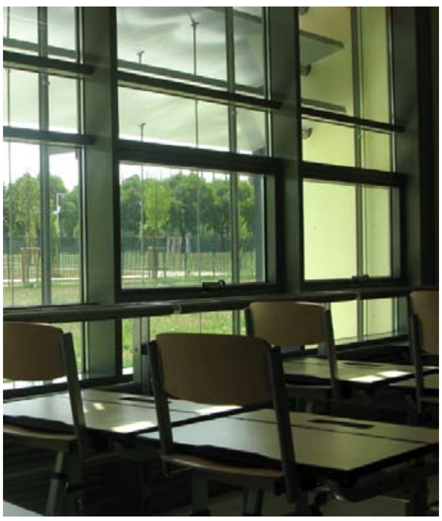

Figure 2. Solar protection and daylighting control in a school that also features night ventilation and ground coupling, in Emilia, Italy

L. Pagliano, S. Carlucci, T. Toppi, P. Zangheri, “Combining high-end architecture and low energy: energy analysis to support the design of a large office building within the Greenbuildingplus project.” In Proceedings of IEECB’08, Frankfurt, http://re.jrc.ec.europa.eu/energyefficiency/html/Proceedings_IEECB2008.htm.

Angelotti A., L. Pagliano, G. Solaini “Summer cooling by earth-to-water heat exchangers: experimental results and optimisation by dynamic simulation” in Proceedings of “EuroSun 2004, pp. 2-678 – 2-686, Freiburg, Germany, 2004.

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Visitors' address: Forskningsveien 3b, Oslo
Tel. +47 22 965 555
E-mail: *Peter.Schild@sintef.no*
Homepage: *www.byggforsk.no*

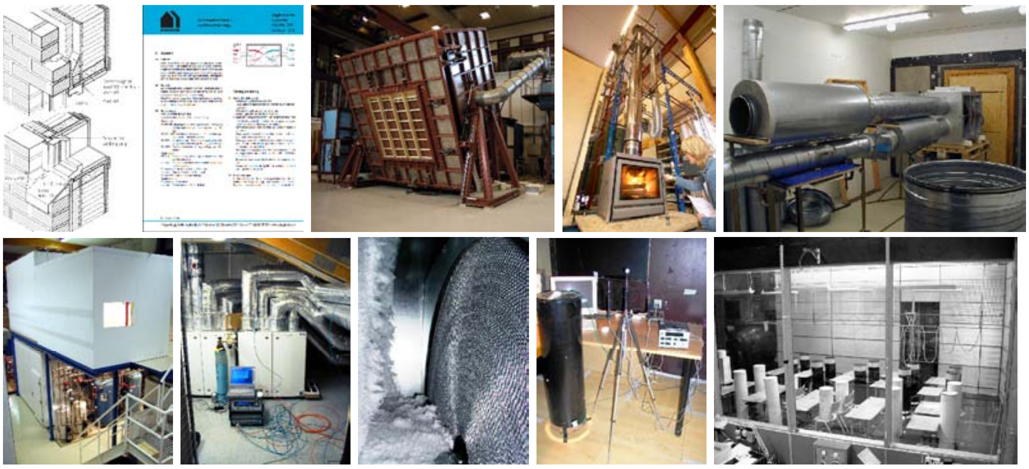

Oslo: Headquarters


Trondheim, NTNU campus

'SINTEF Building and Infrastructure' is the third largest building research institute in Europe. Through contract research, we solve challenges linked to the entire construction process. The institute offers specialist expertise in technical fields ranging from architecture and building physics to the management, operation and the maintenance of buildings, water supply, and other forms of infrastructure. An important aim for us is to contribute to sustainable development in this sector. Close dialogue with the industry gives us a deep understanding of our clients' needs.
SINTEF Building and Infrastructure is the leading disseminator of research-based knowledge in Norway. By means of our knowledge systems, publishing house and the SINTEF Certification system, we have established a unique knowledge dissemination platform (*bks.byggforsk.no*) which serves the greater part of the construction sector, with 5000 subscribers. Another key service we provide is laboratory facilities at both our offices, in Oslo and Trondheim. The Trondheim office is closely associated with the Norwegian University of Science & Technology (NTNU).

Employees: 265 (of which approx 48 are doctorates)
Turnover: € 34 mill.
Sources of finance: 39.6% from industry & commerce, 19% from Norwegian Research Council, 13.6% from international contracts, 9.9% from public sector

SINTEF Building and Infrastructure is an independent foundation. It was established in 2006 following a merger between the SINTEF Foundation and the Norwegian Building Research Institute, both organisations over 50 years old at the time. The SINTEF Group as a whole has over 2100 employees, and is the largest independent research organisation in Scandinavia. SINTEF Building and Infrastructure has specialists on indoor climate issues (thermal, ventilation, acoustics, building services) and building physics (thermal, moisture, airtightness, energy simulation). Research is conducted in the laboratory, in the field, and more theoretical work. A major strength of SINTEF is its in-house publisher and the web-based subscription service for guides (*bks.byggforsk.no*).



SINTEF has a large portfolio of national projects related to ventilation and indoor air quality, the largest of which is the new research centre *Zero Emission Buildings (ZEB), www.zeb.no* with a budget of €1.8 mill. per year over 8 years (2009-2016).

Previous and present EC co-funded projects:

- FP5: *RESHYVENT (Residential hybrid ventilation)*
- FP6: *BRITA-in-Pubs (Bringing Retrofit Innovation to Application in Public Bldgs)*
- FP6: *ECO-City (Joint ECO–City developments in Scandinavia and Spain)*
- IEE SAVE: *ASIEPI (Assessment and Improvement of the Impact of EPBD)*
- IEE SAVE: *ENSLIC (Energy Saving through Promotion of Life Cycle Analysis)*
- FP7 ICT: *IntUBE (Intelligent Use of Buildings' Energy Information)*
- FP7 ENV: *SUSREF (Sustainable refurbishment of facades and external walls)*
- IEE II: *NorthPass (Passive houses in Nordic Countries)*

Previous and present IEA collaborative projects (*www.iea-shc.org* / *www.ecbcs.org*):

- ECBCS Annex 5: *Air Infiltration & Ventilation Centre (AIVC), www.aivc.org*
- ECBCS Annex 35: *Control Strategies for Hybrid Ventilation (HybVent)*
- ECBCS Annex 36: *Retrofitting in Educational Buildings - Concept Adviser*
- ECBCS Annex 37: *Low Exergy Systems for Heating and Cooling (Low-Ex)*
- SHC Task 28/ECBCS 38: *Sustainable Solar Housing*
- ECBCS Annex 41: *Whole Building Heat, Air and Moisture Response*
- ECBCS Annex 42: *FC+COGEN-SIM*
- SHC Task 37: *Advanced Housing Renovation by Solar and Conservation*
- SHC Task 40/ECBCS Annex 52: *Toward Net Zero Energy Solar Buildings*

The main reason for SINTEF's membership is INIVE's role as operating agent for AIVC, which SINTEF is actively involved with. Membership of INIVE gives additional rights related to free national dissemination of AIVC publications.
Secondly, the INIVE is a very useful and active network whose members all have a common interest in developing and collaborative energy-related EU projects.

The Netherlands Organisation for Applied Scientific Research (TNO)
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Innovation with impact is what TNO stands for. We develop knowledge to be applied in real life. To create new products and concepts that make life enjoyable and valuable and help companies to innovate. To find creative answers to the questions posed by society. We work for a variety of customers: governments, the SME sector, large companies, service-providers and non-governmental organisations. We engage in co-development and open innovation in order to create new knowledge and know-how for better products and provide clear recommendations on policy and processes. As 'knowledge brokers', we advise our customers. Moreover, we help our customers find the optimum solutions that are geared precisely to the questions they have.

In everything we do, impact is the key word. Our product and process innovations and recommendations are only valuable if our customers can use them to boost their competitiveness. If they enable the government to create more effective policy. And if they really help people and organisations.

The Netherlands Organisation for Applied Scientific Research (TNO - Nederlandse Organisatie voor toegepast-natuurwetenschappelijk onderzoek) is a non-profit research organisation. Established in 1932, TNO's public mission has been laid down in a special law: to support industry and society in general in transforming knowledge into products and processes of economic and societal value. In 2005, the TNO's turnover was €501 million, comprising €196 million of government funding and €305 million of market turnover (40% from foreign contracts).

Close relationships with universities are essential for TNO, which is why its main research facilities are situated close to the Dutch universities. About fifty of our top scientists have a part-time professorship at one of these universities. Several hundred young scientists are doing their graduate or PhD work within TNO.

The Department of Energy Comfort and Indoor Environment has a key position in the field of the built environment with respect to research, testing and development, carrying out national and international R&D. It integrates the knowledge fields of building physics, physical aspects of the indoor environment, solar energy, light, and HVAC systems.

The department is a leading expert in the development of energy performance standards for new buildings as well as the development of approaches and standards for improving the energy performance of the existing building stock. At international level TNO is closely involved in ISO and the European standards developed by CEN to help the European Member States implement the Energy Performance of Buildings Directive (EPBD). It is active in the development technology of energy-efficient building components, sustainable energy components, building and installation components.

Representative projects of the Department in relation to the field of activities of INIVE are:

- IEE tenders (European Commission, Intelligent Energy Europe) “Service contract BUILDUP (within INIVE consortium)” and “Service contract OJEU 205-S 123, EPBD Buildings Platform (2006-2008)” (within INIVE consortium);
- CENSE project, “Leading the CEN Standards on Energy performance of buildings to practice. Towards effective support of the EPBD implementation and acceleration in the EU Member States” EIE/07/069/SI2.466698 (2007-2010);
- ASIEPI project, “Assessment and Improvement of the EPBD Impact (for new buildings and building renovation)” EIE/07/169/SI2.466278 (2007-2010);
- Development of demand-driven hybrid ventilation methods, control and products, such as RESHYVENT;
- Cost Effective: the main focus of this project is to convert façades of existing high-rise buildings into multifunctional, energy-gaining components including ventilation with heat recovery.

Key activities of the Department are research, development and the assessment of sustainable energy and HVAC components and systems, the assessment and improvement of indoor air quality in buildings and the development of methods to assess energy use in buildings during the use phase.

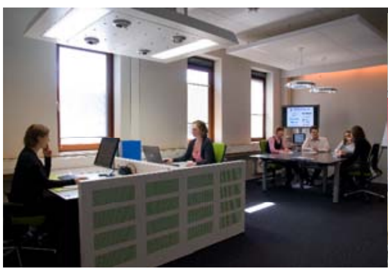
Some indicative key publications of the Department of Energy Comfort and Indoor Environment are:

Diffuse ceiling ventilation, a new concept for healthy and productive classrooms, http://www.buildup.eu/publications/2713

Comparing energy performance requirements levels: method and cross section overview, http://www.buildup.eu/publications/8755

First draft set of recommendations: Towards a second generation of CEN standards related to the Energy Performance of Buildings Directive (EPBD), http://www.buildup.eu/publications/8166

TNO is a member of INIVE because of its network of professionals, exchanging the latest developments and research results between experts and working together on exciting international projects.



Grupo Termotecnia – Universidad de Sevilla (TMT-US)

Energy Sustainability in Buildings

Escuela Técnica Superior de Ingenieros

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Email: ***salvarez@us.es***, ***jlmolina@us.es, jms@us.es;*****Website** ***http://tmt.us.es***

Grupo de Termotecnia is a research team within the frame of the School of Engineering at the University of Seville. It was established in 1979, with the main objective of researching and promoting the rational use of energy, with emphasis on the building sector.

Most of its research activities are managed through the Andalusian Association for Research & Industrial Cooperation, AICIA, a private, non-profit organisation established in 1982 in the Engineering School at the University of Seville. AICIA is a Technological Centre conducting research activities in most of the Engineering Areas. Its turnover was 15 million € in 2009. Some 300 researchers are active in AICIA.

Grupo de Termotecnia's research covers both the thermal performance of the building envelope and the building technical systems. Integration of renewable energy sources and environmental heat sinks (passive heating and cooling) are priorities. Natural ventilation, innovative systems, indoor air quality and the impact of the urban environment on the thermal performance of buildings have also been fields of extensive research. A significant number of PhD dissertations have been developed in all of these areas.

Research activities have been funded through many regional, national and more than 45 European projects. Some of these are mentioned here due to their relationship to INIVE's scope of activities:

- In the general field of energy and buildings: PASSYS II, PASCOOL, EUROCLASS, INTERSET, WIS, REVIS, SOLAR CONTROL, SOLVENT, WINDAT, REASURE, PASSIVE-ON, RETROFIT-KIT, ASIEPI.
- In the area of ventilation: COMIS, AIOLOS, VENT-THERMIE.
- In the area of indoor air quality: EDBIAPS, MATHIS, AIRLESS, ENVIE.
- In urban climate and microclimate:- Climatic control of outdoor spaces at EXPO´92, POLIS, POLISII, URBACOOL, GREENCODE
- In the field of natural cooling techniques: ALTENER-SINK, ROOFSOL I and II, PDEC I and II, PHDC.

A significant set of national projects have been related to the support and development of the scientific basis and final user documents and tools for the transposition of the EPBD (Energy Performance of Buildings Directive) in Spain.

Among the activities undertaken in this topic since 1999, to mention a few:

- Building thermal regulations for minimum requirements in buildings;
- Performance scale for energy certification for new and existing buildings;
- National calculation tools for verification of minimum requirements (LIDER) and for

energy certification of buildings (CALENER);

- Approved document for accreditation of alternative detailed and simplified procedures and programmes; ;
- Technical frame for the inclusion of innovative systems and additional capabilities in the national calculation tools.

At present, Grupo de Termotecnia is deeply involved in the updating of the minimum requirements (foreseen for 2011) and the preparation of the EPBD Recast implementation. Team members are participating, as Spanish representatives, in all the editions of the Concerted Action for EPBD.

Grupo de Termotecnia is taking part in national projects in cooperation with private building industry companies, building practitioners, the energy sector, architecture and engineering consultancies interested in research, development and innovation focused on low energy buildings.

The latest related contributions in scientific publications include:

- Revision of the Trombe wall Calculation Method proposed by EN-ISO 13790. Ruíz A., Álvarez S., Sanz, J.A.; Energy and Buildings, 42 (2010), pp. 763-773
- Climatic Zoning and its Application to Spanish Building Energy Performance Regulations. Sánchez de la Flor FJ, Álvarez S., Molina J.L., González R. Energy and Buildings (2008)
- Flow Pattern Effects on Night Cooling Ventilation. Lissen J.M.S., Fernández J.A.S., Sánchez de la Flor F.J., Álvarez S. and Pardo A.R. Intl. J. of Ventilation 6,1 (2007), 21-30
- Energy efficient buildings in Mediterranean countries. The role of the energy performance regulations and certification. S. Álvarez. RHEVA Journal, 44, Issue I (2007)
- A new methodology towards determining building performance under modified outdoor conditions. F.J. Sánchez de la Flor, J.M. Salmerón and S. Álvarez. Building and Environment 41 (2006), 1231-1238

The Grupo de Termotecnia joined INIVE due to an interest in a deeper collaboration with other members that have been developing their activities in the same fields. INIVE is a network of excellence that has promoted a number of key actions in the context of building ventilation and energy. The participants have contributed significantly to progress in the rational use of energy in buildings, which closely agrees with Grupo de Termotecnia's main objective.

ABOUT INIVE EEIG

INIVE EEIG (International Network for Information on Ventilation and Energy Performance) was created in 2001 as a so-called European Economic Interest Grouping. The main reason for founding INIVE was to set up a worldwide acting network of excellence in knowledge gathering and dissemination. At present, INIVE has 7 full members and 4 associated members and there is interest in joining among other organisations. (www.inive.org)

The original reason for creating INIVE was the availability of a strong entity able to act as the Operating Agent for the IEA' Air Infiltration and Ventilation Centre (AIVC). AIVC is the IEA Information Centre that deals with the topic of energy efficient ventilation and air tightness of buildings. Since 2001, INIVE has been the Operating Agent for the AIVC (www.aivc.org).

Energy efficient ventilation while maintaining a good indoor climate is an area of high priority where good information management is important. Another major area where targeted information is crucial is the implementation of national energy policies and, more broadly, energy efficiency in buildings. As a service provider to the European Commission and the European Agency for Competitiveness and Innovation, INIVE EEIG has been coordinating the European Buildings Platform since 2006 and, since 2009, BUILD UP, which is THE European portal on Energy Efficiency (www.buildup.eu).

INIVE aims to stimulate and contribute to the creation of new knowledge in key areas of ventilation and energy efficiency. In the ASIEPI project (www.asiepi.eu), which finished in March 2010 and was coordinated by INIVE, several critical areas related to energy-efficiency policies were analysed, with a whole range of new findings as a result.

INIVE also wants to facilitate structured collaborations, which go beyond the duration of single projects. The best example of such collaboration is the DYNASTEE-PASLINK network (www.dynastee.info), which is the leading network of use and development of system identification techniques and related applications. The DYNASTEE-PASLINK network is a part of the INIVE Activities.

Dissemination of high quality information is a key activity for INIVE. This is done through a range of instruments, whereby of course the website is very important. But also conferences, workshops and (more and more) Internet seminars play an important role. This book highlights some of the major outcomes of INIVE related projects during its first 10 years of existence.

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