DYNASTEE
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Foreword

If you are involved in energy performance analysis of buildings, systems and components, then DYNASTEE is the platform for information exchange on dynamic methods for testing, simulation and analysis . Training such as in the summer school reported hereunder, is one means of knowledge transfer. Test methods and data sets can help you in validating your modelling work. See the results of the twinhouses tests as developed in Annex 58 on p. 2-3. And more test facilities for energy performance analysis are described on p.4.

DYNASTEE organised a successful workshop in Brussels, on 11th April 2018, on 'Building energy performance assessment and quality assurance based on in-situ measurements'. It showed interesting interactions between researchers of Annex 71, CEN standard developers and other stakeholders from the building sector. The presentations are available on http://dynastee.info

And for the latest news on DYNASTEE, see the new Twitter account @DNSTEE. Enjoy!

Luk Vandaele, DYNASTEE - INIVE

Building insulation (9 points for improvement)

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Newsletter Editors

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Outcome of the Summer School in Almeria - September 2018

Outcome of the 7th Summer School on "Dynamic methods for whole building energy assessment" organised by the INIVE-DYNASTEE and PSA-CIEMAT in collaboration with CIESOL (Joint Centre University of Almeria-CIEMAT dedicated to research in Solar Energy and its applications), in Almería, Spain. The focus has been more on pragmatic application of developed dynamic calculation techniques to support the analysis of building energy data that is of high importance and can give potentially high value information to utilities and end-users. The focus this time has been on increased complexity and variability, and several approaches have been applied to benchmark data.

Eighteen participants from all over Europe participated in the week-long Summer School. Six lecturers presented in 12 sessions the theory, while roughly half of the available time was devoted to practical work on the data made available by the DYNASTEE network. All participants were asked to hand-in before the start some homework, making it possible for the lecturers to adjust their presentations. Most of the problems encountered have been on the dynamic contents of the in-situ measured data and how to convert that in mathematical models. It is known that wind and solar radiation are the most prominent sources of variability when it concerns the assessment of building thermal characteristics. The students were asked to use LORD, CTSM-R and other software to study high quality data produced from a small test-box at PSA that simulated a miniature version of a one-zone building. The presentations by six lecturers dealt with physical processes and sources of uncertainty in measured data as well theoretical background on statistical techniques and how to apply them with CTSM-R to real data. All lecturers were available for instant advice during exercise time.

The software used during the week has been diverse, ranging from EXCEL, Matlab, R-environment, to CTSM-R and LORD. Software, data and presentations were made available on a USB-stick.

In the middle of the week a visit to the *Plataforma Solar de Almeria* took place followed by a cultural intermezzo to the famous *Alcazaba de Almeria* that appears in many well-known movies. The evening was concluded with a social dinner near the beach.

A follow-up Summer School has been discussed which may take place in June 2019 again in Spain. Follow our organisational progress on the DYNASTEE web-site, www.dynastee.info.


Almeria 2018 Summar School participants

Announcement of a whole model empirical validation dataset on a full-scale building including building service equipment and synthetic users

Matthias Kersken (Fraunhofer Institute for Building Physics IBP), Paul Strachan (University of Strathclyde)

Building Energy Simulation (BES) tools are commonly checked using an inter-program validation suite such as BESTEST. Although difficult to conduct, empirical validation is another important part of any validation methodology, because it in principle provides a "truth" model. A large-scale study for validating building energy simulation programs against measured data was undertaken within IEA EBC Annex 58 "Reliable building energy performance characterization based on full scale dynamic measurements". The experimental data were gathered in two experiments conducted at the Fraunhofer IBP test site at Holzkirchen in Germany [1]. There was a high level of engagement from modellers (over 20 sets of modelling predictions; 16 organisations; 12 different programs, both research and commercial), with the developed experimental specification being implemented and thoroughly tested. The experimental data sets ([2], [3]) and their documentation [4] is publicly available, with a significant number of downloads (currently 60 and 36 for Experiment 1 and 2 respectively). This validation study proved valuable to many participants, for assessing the accuracy of the tested program, or for identifying flaws in the programs' models or modelling techniques, or for general simulation training purposes. The validation scenario data set of Annex 58 based on the Twin Houses of the Fraunhofer IBP at Holzkirchen (see Figure 1) was full scale, multizone and under real weather conditions but otherwise the experimental design was consciously kept simple to focus on the validation of the basic models like thermal transfer through walls, internal and solar gains and ventilation.

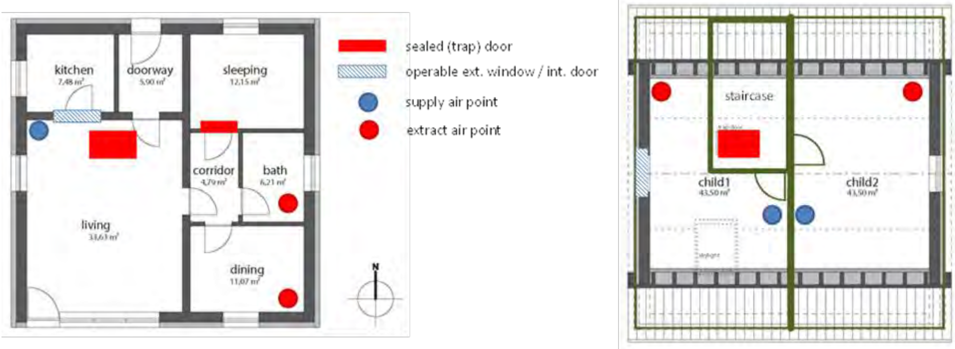

Figure 2: Floor plans of the twin houses including mechanical ventilation and operable openings

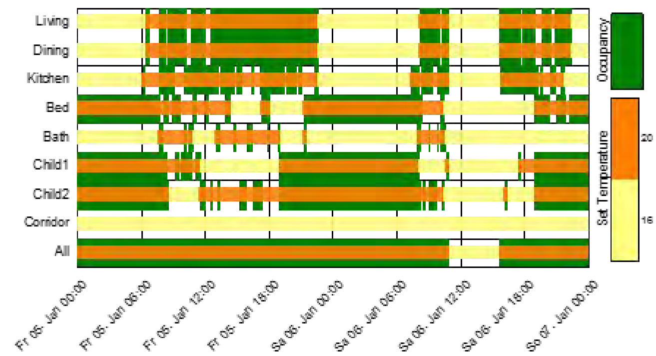

Figure 3: Typical roomwise occupancy and set temperature profiles for the twin houses

Within IEA EBC Annex 71 a more complex BES model validation scenario will be created in winter 18/19. Unlike the previous Annex 58 experiment, the attic with its two children's rooms and staircase will be part of this experiment as can be seen in the floor plans in Figure 2. In the upcoming validation experiment the two identical Twin Houses will be "occupied" by synthetic users. The users' roomwise presence in the individual rooms is determined by a statistical occu-pancy model based on time use survey data [5], [6]. They will change the heating's set points, emit heat and moisture and operate external windows and internal doors. Figure 3 shows a typical roomwise occupancy and set temperature profile. During the main experiment the identical thermal and energetic character of the two Twin Houses will be used to investigate the modelling quality of different heating systems: electric convectors with minimal thermal mass as used in in Annex 58, and an underfloor heating system with an air source heat pump. In an extended experiment both Twin Houses will be heated with electrical convectors, which can be modelled reliably. The difference between both houses in this extended experiment is the addition of internal moisture loads in one of the houses, injected through the supply air, to allow for the validation of BES-tools moisture models.

Figure 1: Twin Houses of the Fraunhofer Institute for Building Physics IBP

During the process of the experimental design, simulations of the intended experiment are used to perform a sensitivity analysis to determine the significant influences on the measured results. This allows adaptation of the experimental design either by changing the experiment's schedules (e.g. duration of experi-mental phases, magnitude of internal heat sources) or by adding suitable instrumentation to better record the significant influences.

The preliminary experimental design consists of 7 different phases. An initialization (phase 1) to equalize the measurement's start conditions in both houses is followed by a coheating (2) test to serve as a baseline for further evaluations (within Annex 71). Afterwards the 1st user phase (3) starts. Here all rooms follow an identical set temperature and only the internal heat gains are active while the operable windows and door remain in a fixed position.

In the 2nd user phase (4) the user behaviour is more complex. From the occupancy roomwise set temperatures are varied. Also the external windows and external doors are operated, controlled by the Twin House's measurement and control system.

A subsequent second (re-)initialization phase (5) is required when the underfloor heating is changed to electrical convectors in both Twin Houses. The 3rd (humid) user phase (6) corresponds to the 2nd user phase's boundary condition but includes moisture gains in one house and open trap doors between ground floors and the attics creating a more complex air flow scenario. Except for the open trap door the dry building's scenario is identical to the 2nd user phase (electric convectors in the 2nd and 3rd user phase). To achieve this comparability between the 2nd and 3rd user phase the moisture sources will be injected into the house that was heated by the underfloor heating in the main experiment.

The last part of the experiment is a free floating phase (7) with no heating but internal heat and moisture gains. During this phase, the rooms' indoor climate will be predicted instead of the heating demand. Between the 6th and 7th phase a separate Annex 71 experiment focused on Model Predictive Control (MPC) may be scheduled in the humid building.

After the measurements, to perform the validation exercise itself a group of modelling teams will be invited to recreate the experiment in simulation, using simulation programs of their choosing. The validation methodology will be a two phase blind validation, as used in Annex 58 [4] and similar to other previous IEA validation studies.

These steps are as follows:

1. Blind validation (Phase 1). Modellers predict heating energy and indoor climate using the experimental specification, measured climate data and operational schedules but without knowledge of the measured heating energy consumptions and indoor climate. At this stage there are usually additional questions regarding the experimental details – these questions and answers are distributed to all modelling teams. Modelling teams submit modelling reports with details of the programs used and assumptions made.

2. First stage analysis. This compares predictions against experimental data for indoor climate and heat fluxes. Inevitably at this stage, differences are due to a mix of user and modelling error (and potentially measurement uncertainties).

3. Re-modelling (Phase 2). The measured data is disseminated. Modelling teams are encouraged to investigate differences between measurements and predictions and resubmit predictions and updated reports. Only changes which correct user modelling errors or alter a modelling assumption (with documented rationale) are allowed. It is important to ensure that model input parameters are not simply tuned to improve agreement with measurement. This step separates the modelling from the user error by eliminating the user errors.

4. Final analysis and archiving of high quality data sets. The improved predictions are compared against the measurements to identify remaining flaws. The intention is that the resulting specification and datasets will be useful for developers of new programs and those improving modelling algorithms.

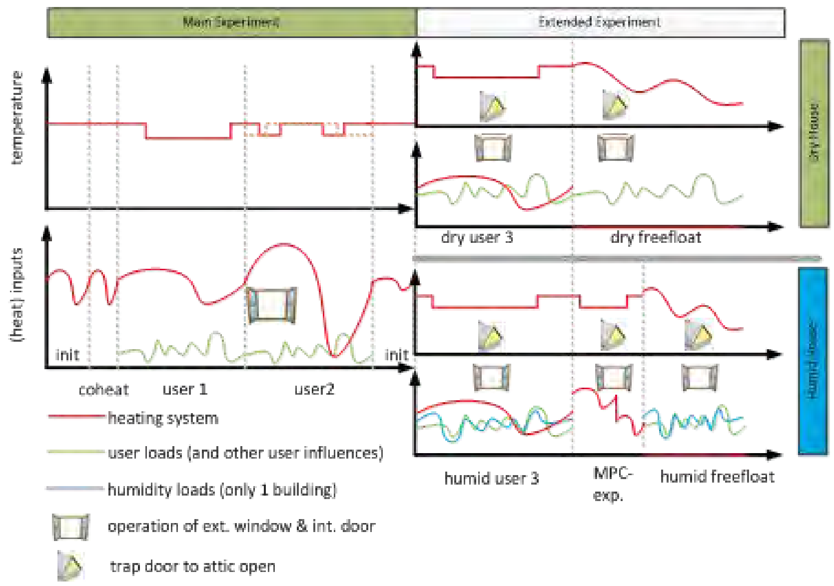

Figure 4: Preliminary experimental schedule

As soon as the main experiment has been conducted successfully the detailed specifications and the measured climate data will be released to the modelling teams in early spring 2019.

The participation of modelling teams is very welcome and open to everybody experienced in BES modelling, especially to developers of BES tools! Those interested are encouraged to contact the authors of this article.

When the validation exercise is completed the resulting datasets still can be used for validation and also for training and teaching purposes. In addition to the empirical validation research, the datasets collected will also be used by other subtasks within Annex 71 for developing methods to extract performance characteristics such as overall heat loss coefficients and for training low order statistical models.

References:

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[2] IEA EBC Annex 58 - BES Model Validation Data. https://pure.strath.ac.uk/portal/en/datasets/twin-houses-empirical-dataset-experiment-1%288a86bbbb-7be8-4a87-be76-0372985ea228%29.html. Checked 14.08.2018

[3] BES Model Validation Data - Experiment 2. https://pure.strath.ac.uk/portal/en/datasets/twin-houses-empirical-validation-dataset-experiment-2(94559779-e781-4318-8842-80a2b1201668).html. Checked 14.08.2018

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A matched pair of test houses with synthetic occupants to investigate summertime overheating in dwellings

Ben M. Roberts, David Allinson and Kevin J. Lomas (Building Energy Research Group), School of Architecture, Building and Civil Engineering, Loughborough University, UK)

Summertime overheating is increasingly prevalent in both new and existing UK homes. High internal temperatures cause health problems, thermal discomfort, and disrupt sleep. Loughborough University's matched pair of test houses (Figure 1) have been used to test if occupants can improve thermal comfort during the summer. In particular, can different window, internal door and blind opening strategies reduce summertime overheating without the need for air conditioning?

The test houses are a pair of real houses, built in 1939 in an architectural style common with the era and dominant amongst UK homes built in the interwar period. The houses are of the same construction, have been maintained in the same way and modified in ways to ensure similarity (see Dynastee Newsletter Issue 2016/7). Side-by-side testing using a matched pair of houses allows direct comparison of indoor conditions under the same weather.

Synthetic occupancy devices in the houses enable precise behaviours to be performed at specific times. This includes: actuators to open windows and doors; motorised rails to open curtains and blinds; and heat emitters to mimic gains from people, lights and appliances. Windows can be opened on a timer or set to react to indoor air temperature thresholds and room occupancy levels.

The houses are fully instrumented with sensors to measure internal air temperatures, operative temperatures, air velocity and include multi-room tracer gas detection to monitor air change rates. For more information on the current research projects, please see the papers listed below and feel free to contact the authors.

References:

Roberts, B.M., Allinson, D. and Lomas, K.J. (accepted for publication). A matched pair of test houses with synthetic occupants to investigate summertime overheating in dwellings. SDAR* Journal of Sustainable Design & Applied Research.

Roberts, B.M., Allinson, D. and Lomas, K.J. (2018). Overheating in dwellings: a matched pair of test houses with synthetic occupants. CIBSE Technical Symposium, 12-13 April 2018, London, UK.

Roberts, B.M., Allinson, D., Lomas, K.J. and Porritt, S.M. (2017). The effect of refurbishment and trickle vents on airtightness: the case of a 1930s semi-detached house. 38th AIVC Conference, 13-14 September, Nottingham, UK.

Figure 1: Loughborough University's matched pair of test houses with windows open

Smart Meter Laboratory in Joule House

The Smart Meter lab is a newly-established Research and Development facility of the Applied Buildings and Energy Research Group (ABERG) of the University of Salford. The Smart Meter lab is located in Joule House where the prominent physicist James Prescott Joule lived.

The Smart Meter lab focuses on the Research and Development of integrated systems where data acquired from the Smart Meters as well as from other smart home devices is utilised in order to provide energy-saving and cost-saving solutions for the consumer. This integrated approach incorporates, amongst others, communication between the Smart Meter lab server with the cloud servers of the Smart Meters as well as with the servers of the other smart devices. Subsequently, Artificial Intelligence and Machine Learning algorithms are developed in order to utilise the acquired data. These algorithms provide tips and solutions in relation to decision-making for energy saving.

In terms of hardware and software infrastructure, the Smart Meter lab has been equipped with the latest models of Smart Meters from all major brands, Smart speakers, Smart Home appliances such as fridge/freezer, washing machine, robot vacuum cleaner etc., a PV system, Battery storage devices, Air Source Heat Pump and other devices as well as with the latest software for Smart Meter simulation and for Data Analysis and Machine Learning.

The Smart Meter lab is organised in three rooms, namely the Kitchen and the Living room, where the Smart Home Appliances and the other smart devices are located, as well as the Monitoring & Control room where the Smart Electricity and Gas Meters are installed and the energy usage is monitored. A photo of the Smart Electricity meters of Joule House's Monitoring and Control room is in Figure 1.

Figure 1: Smart Electricity Meters in Joule House