SUMMER SCHOOL 2012
18-22 June
Dynamic Calculation Methods for Building Energy Assessment

Deadline for submission is 15 May 2012.

Organisers/Lecturer: DYNASTEE – Hans Bloem (EC-JRC, Ispra), María José Jiménez (CIEMAT, Spain), Henrik Madsen (DTU, Lyngby, Denmark), Paul Strachan (Strathclyde University, Glasgow, UK)

Objective.

Today more and more data related to building and building components originates from outdoor testing, time-varying and dynamic conditions, or just from real life use of buildings, etc. The main purpose of this summer school is to consider methods for using such time series data to obtain valuable information about the energy performance of the building or the building component. Many of the dynamic methods can be seen as techniques which bridge the gap between physical and statistical modelling. During the summer course hints on software will be given and some software tools will be used. Specifically the focus will be on how to extract essential performance parameters for buildings using these models and techniques.

It will be shown how for instance the U-value of a quite simple wall can be estimated in dynamic conditions using different models and estimation techniques. It will also be shown that dynamic analysis methods linked to appropriate models can give rather detailed information about the various components of a building, and in general it will be become clear that more advanced models can provide more detailed information about the building or the component.

PhD students might be interested to know that this Summer School is valid for 5 ECTS (2.5 ECTS for attending the Summer School and 2.5 for the additional work).

Programme (contains 5 parts; for details of the programme, see below):

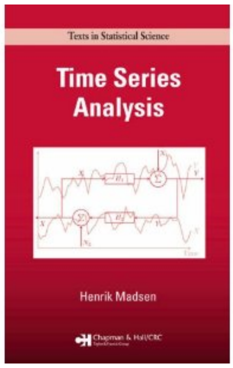
1. Homework (the participants will have to arrive a bit prepared).
2. Building Physics and hints on experimental setup.
3. Theory about models (ARMA methods, State-Space, etc.), modelling using time-series, validation and on some tools.
4. How to obtain results like the physical characteristics, etc.
5. Modelling of a double skin PV ventilated facade as advanced example.

The cost for the week-long Summer School is 250 Euro. This covers:

- Handout of lecture notes and relevant papers
- Lunch (during lecture period)
- Coffee etc. (at breaks during lecture period)
- As a break event an excursion to Kronborg is planned. (Kronborg is known by many also as "Elsinore," the setting of William Shakespeare's famous tragedy Hamlet).

For further information on the content of the course, please contact:
Hans Bloem hans.bloem@jrc.ec.europa.eu,
Maria Jose Jimenez mjose.jimenez@psa.es,
Henrik Madsen hm@imm.dtu.dk

For further information on practical issues like accommodation and logistics, potential participants could contact Janne Kofod Lassen jkl@imm.dtu.dk.
Note that the Summer School requires a minimum of 12 participants.
The deadline for submission is, 15 May 2012.



Programme

1. Homework for participants.

Some homework will be given to the participants in order to a get a minimum homogeneous starting level with the objective of optimising the usefulness of lectures. As homework some reading material will be recommended. Participants will be asked to solve as homework a proposed common exercise and report step by step, the analysis and validation carried out as clear and illustrative as possible. These reports will be submitted to the organisers. In the first sessions different applied approaches will be presented by the participants who can also raise questions to the lecturers.

2. Building Physics and hints on experimental setup.

This lecture will provide the necessary background information on building physics to support the development of mathematical models for energy performance assessment. This includes basic knowledge of thermo dynamic processes, in particular heat transfer and the impact of solar radiation. Topics like thermal conduction, convection and radiation will be presented as well as thermal mass. Using data-series for analysis the students will be introduced to the complexity of the physical process and how to translate the available information in mathematical models, e.g. the importance of model simplification of building physics represented by measured signals. Also the issue of standardisation will be presented, e.g. laboratory testing of building products and in-situ measurements for building energy performance assessment.

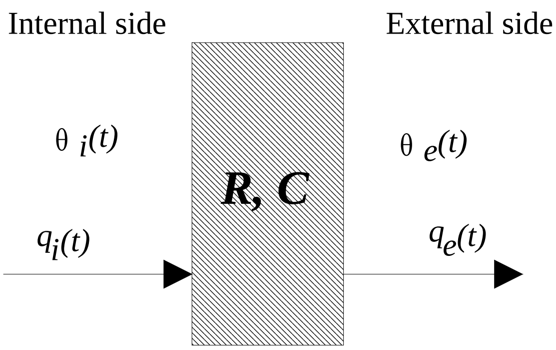


Figure 1. Notation for wall components

Figure 2. Building wall under construction

3. Models and model building

Linear input-output models. Topics such as, identification, formulation, estimation, and validation are presented. Furthermore, impulse response models, transfer function models, frequency domain models, ARMAX and Box-Jenkins models and how to use these techniques to estimate values like the UA-value, gA-value and time constants of a building or a component. Software tools.

State-space models. Topics such as, identification, formulation, estimation, validation and Kalman Filter techniques are presented. In addition, lumped parameter models, RC-models, Grey-box models, and combining information from data with prior information from physics. How to use these techniques to estimate detailed physical quantities like the heat capacitance, window areas, solar aperture, effect from wind speed, nonlinear heat transfer, non-stationary heat transfer.

Simulation, Prediction and Control. A short introduction to the use of the previously considered models for those purposes. The difference between simulation and prediction will be discussed as well as uncertainty in simulations and predictions. As an example the optimal control of heat pumps will be presented.

4. How to obtain results using different models and methods.

The presented analysis and validation approaches will be step by step illustrated using a very simple and well documented case study.

The U value of a well-known quite simple opaque wall will be estimated using different analysis approaches. The simplicity of this component allows the application of a wide variety of analysis approaches with different degree of complexity, capabilities and accuracy. This simplicity also allows isolate and highlight the effects of the different analysed aspects, from the effects of other assumptions about the test component and its boundaries that could be necessary if more complex case study were considered.

The different approaches will be presented “bottom to top”, starting from the simples and, gradually increasing complexity highlighting and discussing the main features added by each level by the corresponding modelling approach. The following approaches will be considered: average and pseudo-dynamic methods, transfer function models (using the Ident Toolbox of MATLAB or the statistical package R) and continuous-time state space models (using CTSM).

5. Modelling of a double skin PV ventilated facade as advanced example.
In this part the potential of the tools presented along the course to model building systems will be demonstrated. The modelling of a double skin PV ventilated façade is presented as advanced example using non-linear models. All the complementary aspects of its analysis will be detailed described.

It will be highlighted that once enough skills in using tools are achieved, they must be combined with physical knowledge and understanding of the physical system, to pick all relevant influences and simplify them when necessary to find optimum models. The implementation of the different physical assumptions in different continuous-time state space models is step by step presented. The performance of each considered model is analysed and discussed.

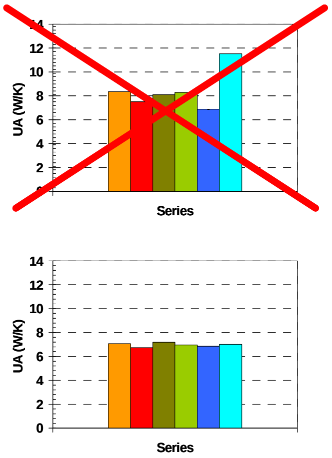


Figure 3. Example. UA values estimates for a given component. Top: using models based in non appropriate physical assumptions leading to absurd results. Bottom: models based in correct assumptions leading to very consistent parameter estimates.

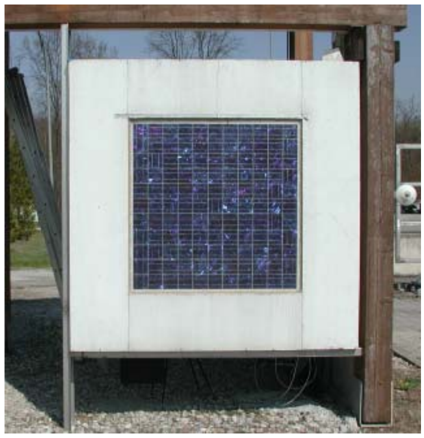


Figure 4: Double skin PV ventilated facade prototype for electrical and thermal energy assessment.

For PhD students
In order to receive 5 ECTS credits on PhD level, the students must:
1) Hand in the solution to a preparing exercise before the Summer School starts. This exercise will be theoretical and will use simulated data
2) Follow the Summer School.
3) Hand in a report for relevant exercise after the Summer School. In this exercise some real life data from a building will be used for identifying the dynamical performance.

Venue
Technical University of Denmark (DTU), DTU Informatics, Building 305, Room 053, Asmussens Alle, DK-2800 Lyngby, Denmark.

Social Event
There will a bus excursion to Kronborg Castle (all included)
Kronborg Castle in Elsinore, at the seaward approach to The Sound Øresund, is one of northern Europe's most important Renaissance castles. Known all over the world from Shakespeare's *Hamlet*, it is also the most famous castle in Denmark.

How to register to the Summer School?

Registration for the Summer School 18-22 June, 2012, on "*Dynamic calculation methods for building energy assessment*" is simple and can be performed by filling out this page, e-mail it and pay the costs. Note that the deadline for submission is not later than **15 May 2012**. The sooner, the better since a first in rule will be applied.

Step 1:
Please fill in this data, and mail them to jkl@imm.dtu.dk:

Name:

Address:

Phone No.:

e-mail:

Your academic status: (e.g. Ph.D. Student, Professor, etc.)

Step 2:
Transfer before the deadline, 250,00 EURO to:
Project No. 15920 "**YOUR NAME**"(your name is IMPORTANT)

Bank account: Danske Bank, Nytorv Erhvervsafdeling, Frederiksberggade 1,
Reg. No. 4180,
Account No. 4263972007
Swift/BIC: DABADKKK
Iban: DK5730004263972007

It is very important that you state your name in the bank transfer reference. Please give notice by mail to jkl@imm.dtu.dk – Janne Kofod Lassen will confirm your registration upon receipt of your transfer.