Technology Collaboration Programme
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IEA Technology Collaboration Programme

International Energy Agency

Technology Collaboration Programme on

Energy Storage (ES TCP)

Storage for renewables and flexibility through standardized use of building mass

Questionnaire: SIMULATION

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Contact:

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Dear madam or sir,

thank you for taking the time to fill out this questionnaire! In order to provide a good overview of available **simulation tools** / simulation **models** dealing with **thermally activated building components**, we require your knowledge and expertise. Please use this opportunity to make your work known or provide useful information for other interested parties about tools or models you use or have experience with.

If you give us your personal information, we can keep in touch and maybe consider you as a co-author in possible publications or reports.

Personal Information *(optional)*	
Name: *(Family name, given name)*:	Peter Nageler
E-Mail:	peter.nageler@equa.ch
Contact	☒ I am available for follow-up questions

Company / Institution	
Name:	
Country:	
Type:	☐ University / Education ☐ Research Institution ☐ Company using simulation software ☒ Company developing simulation software

Please give feedback on categories of simulation software you are developing and / or using.

We distinguish between two different categories of mathematical models, depending on their intended usage: ***Detailed* simulation models** should reproduce measurements as precisely as possible and are intended for planning, e.g., in construction. ***Prediction* models** have reduced complexity and can be used for very fast simulations or even within optimization problems, e.g., in control tasks, to predict how changes in the operation influence the temperature and comfort of residents.

Please provide information on one or both of the simulation types, depending on your professional experience.

Note that your responses will be made available to the task participants and may be used in the preparation of official reports that will be made publicly available.

Please send the questionnaire to daniel.muschick@best-research.eu once you have filled it out.
Thank you!

Detailed Simulation Models

Detailed simulation models are used to calculate the behaviour of systems in reality (temperature propagation, heat bridges, constructive stability, humidity, dew points, …) as precisely as possible. They may also be used to test control strategies, which may depend on simplified prediction models, before implementing them. The parametrization of the models is done by specifying physical and geometric properties, i.e., It is not necessary to have real measurement data to setup a simulation.

The focus is on simulation algorithms and tools either with a special focus on activated building components or which at least can handle them well.

Detailed simulation models are typically part of a software package (TRNSYS, Modelica) or are a dedicated software tool themselves (IDA ICE, …). If your input is more about the method than the tool, please feel free to add information in the "Additional information" field.

If you have experience / information on multiple tools, please feel free to copy the table.

Detailed Simulation Tool / Model		
Name:	IDA ICE	
Homepage:	https://equa.se/de	
Relationship to you:	☒ I / my company are developing this software ☐ I / my company are using this software on a daily basis ☐ I / my company are using this software sporadically ☐ Other:	
License:	☐ Not publicly available; developed in-house, e.g., in research projects ☒ Commercial license ☐ Free software ☐ Open source ☐ Other:	
Type:	☒ Stand-alone software ☐ Library / Plugin for: ☐ Other:	
Co-Simulation Interfaces:	☐ None ☐ FMI / FMU ☒ Custom (e.g., call to DLL) ☐ Other:	
Consideration of TABS:	☒ Ceiling ☒ Floor ☒ Wall ☒ Other: roof	☒ Concrete ☒ Brick ☒ Wood ☒ Other materials:

Method to consider TABS[1]:	☐ Ordinary differential equations (ODE) ☐ Partial differential equations (PDE) ☐ Finite Element Method (FEM) ☒ Other: according to Koschenz and Lehmann
Scope:	☒ Component ☒ Room ☒ Building ☒ City (quarter) ☐ Other:
Main application:	*IDA ICE can be used to accurately model the building, its systems, and controllers – ensuring the lowest possible energy consumption and the best possible occupant comfort.*
Integration of control:	☐ None (e.g., steady state calculations only) ☒ Controllers defined in model ☒ External control possible with co-simulation interface ☐ Other:
USP: *(unique selling point)*	https://www.youtube.com/watch?v=1zmVZy6_rWU
Alternatives:	*See attachment*
Publications on method:	*See attachment*
Publications on applications:	https://www.youtube.com/@EQUAsimulation
Additional Information:	-

Open Challenges for Detailed Simulation Models
The input dialog will probably be adapted. At the moment the TABS is modelled with a depth below the surface and a given thermal resistance. This will change to a layer of the surface construction. The model remains the same.

[1] How are thermally activated building components represented in the simulation? If, for example, the entire slab is considered as one block (1D model), this would correspond to an ODE. If piping space can be considered, it could be either PDE or FEM

Prediction Models

Prediction models are simplified models that focus on the input/output relationship of thermal zones or buildings, i.e., how different operating strategies will affect the temperature and comfort experienced by the residents. They are directly used as models in optimization problems or for quick evaluations of scenarios. They are often resistor/capacitor (RC) equivalent models of a certain order, (linear) state-space models or data-driven models based on Machine Learning / Artificial Intelligence.

Here, the focus is less on the tool / software, and more on the **method**.

Specifically, the problem of **parametrization** (based on measurements or derived from more detailed models), and the **mathematical complexity** (linear, mixed integer, non-linear) – and thus the ease of integration into optimization problems – are of interest here.

Prediction Model	
Name:	*(if applicable)*
Homepage:	*(if applicable)*
Relationship to you:	☐ I / my company are developing this model ☐ I / my company are using this model on a daily basis ☐ I / my company are using this model sporadically ☐ Other:
License:	☐ Not publicly available; developed in-house, e.g., in research projects ☐ Commercial license ☐ Free software ☐ Open source
Type:	☐ Mathematical model only ☐ Stand-alone software ☐ Library / Plugin for: ☐ Other:
Method / Complexity:	☐ State space / Ordinary Differential Equation (nonlinear) ☐ State space / Ordinary Differential Equation (linear), e.g., RC model ☐ Neural network ☐ Other:
Scope:	☐ Individual room temperature ☐ Multiple rooms / entire building ☐ Multiple buildings ☐ Other:
Main application:	*Please describe the typical use-case when working with this simulation model as envisaged / used by you.*

Usage[2]:	☐ Simulation studies ☐ Real-world implementation and control ☐ Other:
Consideration of comfort[3]:	☐ Indoor air temperature ☐ Surface temperatures ☐ Air draft ☐ Humidity ☐ Other:
USP: *(unique selling point)*	*What makes this method better/different from other models*
Alternatives:	*If you know about similar solutions, please denote them here.* *Ideally, copy this table and fill it out for the alternative as well.*
Thermally activated components:	☐ Implicitly considered (depending on parametrization) ☐ Explicitly considered ☐ Other:
Phenomena considered:	☒ Ambient temperature ☒ Solar irradiation ☐ Internal gains (preconfigured) ☐ Internal gains (automatically detected) ☐ Shading ☐ Air ventilation ☐ Interaction (heat / air exchange) between the rooms ☐ Interaction with the energy hub (heat flows, feed temperature, …) ☐ Other:

[2] How has the model/the method been used / what is it intended for?
Simulation studies can give an indication, e.g., on the benefits of using TABS or intelligent controllers. The models they use for control/optimization, however, need not represent a real building, but perhaps only a simplified version of a more detailed model used for validation of the controller. The parametrization and estimation of internal gains etc. are, therefore, possibly simpler.
Real-world implementation and control, on the other hand, requires either a robust control algorithm or a very good match between the model parameters and reality.

[3] Good control algorithms should not only consider temperature, but also other comfort parameters.

Parametrization[4]:	☐ Manual ☐ Derived from detailed simulation model: *please indicate possible sources / file formats* ☐ Derived from archetypes ☐ Automatic via historic measurements (controlled operation) ☐ Automatic via historic measurements (specific experiments) ☐ Automatic parameter update (online)
Publications on method:	*E.g., own publications on the methodology; review papers*
Publications on applications:	*E.g., simulation or optimization studies performed with this tool/method*
Additional Information:	*Please provide any information you consider of interest, e.g., provide details only asked of simplified simulation models*

Open Challenges for Prediction Models
Please indicate open challenges for simplified simulation models and tools, esp. regarding the correct representation and integration of thermally activated components.

Thank you for completing the questionnaire! Kindly send back the filled-out form to daniel.muschick@best-research.eu.

[4] Every model depends on its parameters. Please indicate how they are determined in this model/method.
Manual: The user has to choose the parameters by hand, e.g. by running multiple simulations and adjusting the parameters.
Derived from detailed simulation model: A detailed (building) simulation model is used to parametrize a more simplified model. Example: BRCM Toolbox of ETH Zurich.
Derived from archetypes: The parameters are chosen from a set of pre-defined parameters. This is more suitable for performing simulation studies, but probably not enough for the control of an actual building.
Automatic via historic measurements: The parameters are estimated from historic measurements, e.g., using a least-squares based algorithm or any data-driven method. "*Controlled operation*" means that the algorithm can cope with measurements taken in an already controlled environment, meaning that the room temperatures stay close to the setpoints and little information on the effect of heating/cooling is available. "*Specific experiments*" means that special heat-up / cooldown experiments need to be performed in order to obtain trustworthy parameter estimates.
Automatic parameter update: The parameters are not only estimated once, but continuously adapted based on new measurements. This requires methods ensuring that the parameters do not take on meaningless values.