Dynamic Sensitivity Analysis of Building Energy Simulation of Residential Quarters

Name: Manuel Lindauer  
E-Mail: manuel.lindauer@tum.de  
Supervisor: Prof. Dr.-Ing. Dipl.-Phys. Klaus Peter Sedlbauer  
Chair of Building Physics  
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Motivation
Refurbishment measures have to be developed and applied individually for every single building due to the variety of possible measures. In the past, stationary calculations or simulation tools for single buildings were applied to identify the best solution. In the future, the energy supply of buildings will have an increasing interdependency between the heating and the electric grid due to the usage of e.g. heat pumps, and also between different buildings due to quarter-wide energy supply systems like CHP-systems or district heating grids. The sensitivities in a simulation of multiple buildings have to be identified in order to give recommendations on the most important information to be gathered in the future.

Progress
A tool, which is able to import building geometries from GIS files enriched with data about the age of the buildings, the usage, the heating system and additional information was developed in MATLAB®. After procession of the data, simulation models in EnergyPlus are parametrized by the data. The simulation models can interact via FMI to exchange information, e.g. on local energy generation and demand side management options. The results are reimported into MATLAB® and processed for sensitivity analysis and uncertainty calculation.

A building block in the city of Nuremberg is used as a test case (cf. fig. 1).
Sensitivity Analysis

The elementary effects method by Morris [1], modified by Campolongo et al [2], is used for assessing the parameter sensitivities of the model. This method is computationally cheap and calculates qualitative importance measures of the parameters.

The importance measures are calculated in a dynamic way, i.e. for every single hour of a year. This enables us to get a detailed insight on the changing sensitivities in different times of the year. In order to keep evaluation simple, a moving mean is used on the result data before the sensitivities are calculated. This results in an increased error because short term variations are neglected.

In addition, a sensitivity analysis using functional transformed result data, e.g. by principal component analysis, is introduced. This considers also short term fluctuations, but more effort has to be put into identifying the effect described by the base functions of the functional transformation.

Additionally the effects of dynamic input parameters, e.g. the time of a night setback of the heating system and its duration, can be assessed. For this the idea of the Impulse Parametric Sensitivity Analyse [3] was transferred to the field of building simulation.

Outlook

The next steps will be further detailing of simulation models and application of the methodology in a real world project. Hereby recommendations for data acquisition to improve the modeling will be created.

References