Dynamic sensitivity analysis for energy simulation of residential districts

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Renewable decentralized energy supply of buildings will become more and more important in the future. Due to the fluctuation of the renewable energy sources the focus of energy demand and supply calculations will switch for both electric and heating systems from cumulative monthly or annual energy demand and averaged thermal comfort indices to a detailed hourly examination. Models of existing buildings, especially when looking at a whole district, have to cover a huge range of possible refurbishment measures and the effects of these measures have to be considered in a detailed examination in order to create the best solution. Data sources for parameters of existing buildings are limited in Germany. Therefore information on these parameters has to be collected in order to create realistic projections. Which information should be acquired with the highest priority is a yet unsolved research question and the answer can change with the district under consideration. Also different target functions like overall energy demand, necessary peak power, thermal comfort or self-sufficiency for electricity have to be considered. Therefore screening methods for identifying the most important parameters of such models have to be utilized. In this work an approach for using the elementary effects sensitivity analysis method in connection with time series output to assess the effects of different building refurbishment measures is presented. This methodology was developed in the course of the author's dissertation and parts of it were already respectively will be presented in [1], [2] and [3]. Here the achievable results using the different screening methods on the model EmMi-transient will be presented.

The district energy model EmMi-transient, which uses GIS data, building typology information and addition statistical information to create transient building simulation models in EnergyPlus, is used as case study for the screening method. The models of the single buildings can be coupled [4] using the Functional Mockup Interface to analyze the effect of district measures like a district heating system or local electricity production and demand side management to increase the percentage of self-used energy. Here a district of the city of Nuremberg with 25 residential buildings, 183 units, 10426 m² heated area is used as case study.

For calculating sensitivity indices the elementary effects method [5] with the modifications by [6] is used. For scalar target values and constant parameters the elementary effects can be used without modification. For time series target functions two approaches will be presented: a sequential approach (figure 1), in which sensitivities are calculated for every hour of a year, resulting in a huge effort for evaluating and recognizing the arising effects. The second approach uses functional transformation with principal component analysis to transform the time series results into a new coordinate system (figure 2) and then calculate the sensitivity indices for the coefficients of the functional transformation. With this method most effort has to be put into analyzing the meaning of the principal components, but once this is done the evaluation of sensitivities is straight forward.

In addition the applicability of an adapted version of the impulse parametric sensitivity analyses method [7] used in computational biology was evaluated. Using this method, parameter changes during the simulation time can be assessed. This is especially important for building simulation as most of the time user behavior and other dynamics are modelled by

fixed schedules, but the influence of the fixed times in these schedules were never evaluated.

The results which can be achieved using these sensitivity analysis methods will be compared and recommendations for the usability in connection with district energy models will be given. In the future the methodology will be utilized with data of other existing districts to derive recommendations on required data acquisition. Then reliable models considering possible refurbishment scenarios can be created.

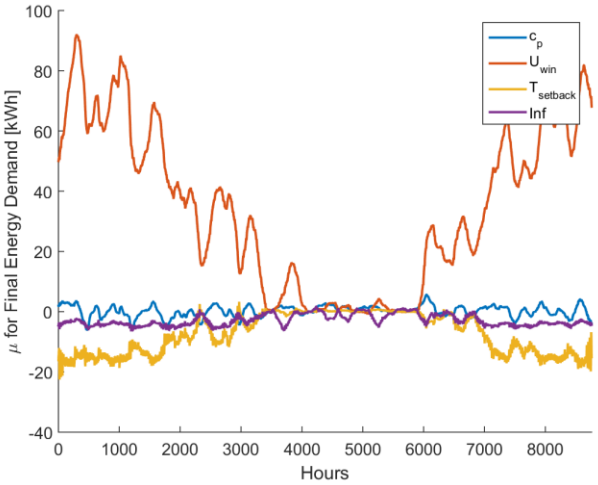

Figure 1: Moving mean of elementary effects sensitivity index μ using sequential evaluation for parameters heat capacity of walls, U-value of windows, setback temperature of heating system, infiltration rate with target final energy demand for heating

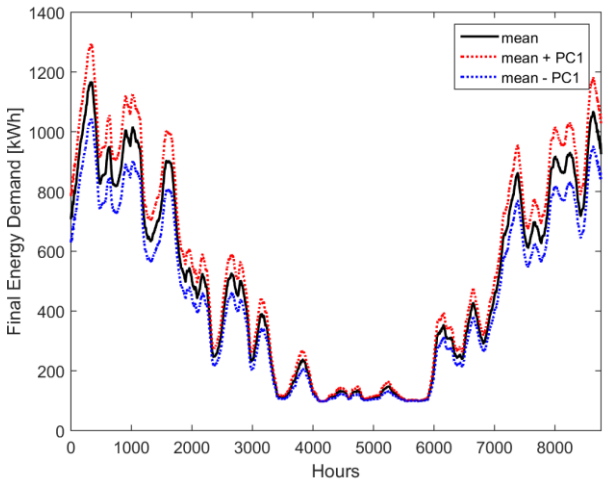

Figure 2: Moving mean of final energy demand for heating plus/minus the first principal component

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