FastHVAC - A library for fast composition and simulation of building energy systems

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The dynamic simulation of building energy systems, including heating, ventilation and air conditioning (HVAC) technologies, is gaining importance in recent years. Today, the simulation of building energy systems has broadened to analyze entire city districts [1]. This is especially important when considering the interconnection of buildings, which can be in terms of district heating networks or the electrical grid. In this field, measures like Demand Side Management [1] are meant to become more important in the future. The simulative analysis of these (large) energy systems with implemented thermal storages as well as heat generators, e.g. heat pumps and combined heat and power plants, requires the calculation of large equation systems and might lead to unreasonable computational effort.

Further, the simulation of (especially closed) hydraulic circuits, whose models are based on the package Modelica.Fluid of the Modelica Standard Library shows considerable difficulties. In particular, the steady-state initialization of these systems can be a critical issue [2]. Especially in cases where the thermal investigation of energy systems is focused, it requires additional expenditure without benefit. Further, the computational effort can be a critical factor, depending on the size of the observed system. The number of initialization variables can grow very fast [3]. In case of a city district analysis, this becomes a very critical issue, as the building energy systems should probably be parameterized automatically with little manual input.

This paper describes the implementation of a Modelica library that is designed to enable fast composition and simulation of building HVAC systems. The library is based on an approach which is focusing the thermal behavior of the components, while reducing the information about the hydraulic circuit to the mass flow rate. This approach limits the applicability of the library, but decreases the computational effort as well as the time to set up a model. Particularly, it is suitable for applications such as rapid prototyping of innovative energy systems and the development of advanced control systems for heat generators.

As stated in the case study, the simulation speed can be increased noticeably following the new approach. Nevertheless, the results are almost identical to more complex approaches, with coefficients of determination of approximately 1 for individual components as well as on system level. The modelling principle can be transferred to additional components.

References

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