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Open-Source toolchain to support building energy systems from digital planning to optimal operation

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Buildings and their energy systems contribute to 16 % of global greenhouse emissions. These emissions may be reduced during planning and operation. However, most buildings are unique: In terms of architecture, used protocols, energy carriers, etc. Thus, deployment of optimal planning and operation does not scale as well as, e.g. the automotive industry. Therefore, both digital planning and cloud based optimal operation is scarce in practice. However, research proves the potential of software-based solutions. To increase the share of optimal, software-based solutions in practice, reducing the upfront cost of development by publishing research findings as open-source software is vital.

Thus, at the Institute for Energy Efficient Buildings and Indoor Climate, we provide the expertise from various research theses and publicly funded projects in the form of open-source tools. In this work, we present our open-source tool chain from digital planning to optimal operation of building energy systems. Using digital Building Information Models (BIM) data, we generate detailed Modelica simulation models using our Python library bim2sim. Missing data is enriched with typical information provided by TEASER. The models use our open-source model libraries BESMod and AixLib, as well as detailed heat pump models generated by our Python library VCLibPy. To automate, analyze, and optimize the planning stage of building envelope and energy system, ebcpy interfaces with Modelica Simulation tools for fast and parallelized simulations. Once the optimal design is found and build, measurements and simulation may be compared. If measurements deviate from simulation, AixCaliBuHA enables an automated calibration of unknown parameters. The validated models are then used to optimize operation. Herein, the python libraries Agentlib and its plugins (Agentlib-MPC, Agentlib-FIWARE) allow decentralized, cloud-based deployment of model predictive controllers, communicating over an IoT platform, e.g. FIWARE, interfaced by our python library FiliP. Be it with physics based or data-driven, the detailed simulation models generated during design help to develop an efficient and reliant Model Predictive Control.

This rich and diverse stack of tools are continuously developed by researchers with different level of expertise. To ensure a high code quality and integrity of results, we employ cloud-based Continuous Integration pipelines for unit testing, code quality, documentation, releases, creating Jupyter notebooks, and pull-request management to guide new developers. Future work will focus on improving usability and providing frontends to support application in both research and practice.

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