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HiSim: House Infrastructure Simulation

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Summary

High volatility and low availability of renewables are the major hurdles in combating climate change. Strategies based on Demand Side Management (DSM), e.g., peak clipping and load shifting, combined with technologies to improve renewables flexibilities, e.g., storage and Power-to-X, are possible solutions, that can be addressed at the consumer household level. The Python package `HiSim` developed in Forschungszentrum J"{u}lich integrates these technologies and strategies in one interface for simulation and analysis of the scope of viable scenarios.

Modern households and their residents employ a variety of devices to suffice the basic needs. Given the house structure and the family behavior, the overall usage of these devices during a certain period of time yields electricity consumption and thermal demand profiles. With support of Load Profile Generator (Pflugradt, 2016) and model 5R1C (ISO, 2008-03) equipped with dataset of European housing sector, the Python package `HiSim` provides means to determine electricity, heating and cooling demands for many house and family configurations down to a 1 min resolution.

As alternative to fossil fuel based appliances, `HiSim` uses a variety of components such as photovoltaic systems, batteries, electric vehicles, EV chargers and heat pumps. Photovoltaic system and batteries are responsible to generate and storage electricity respectively, while electric vehicles and heat pumps substitute conventional fossil fuel based vehicles and appliances. Photovoltaic systems implementation is supported the pvlib library (Holmgren et al., 2018), while the other components are based on commercial technical data from current market devices.

Acknowledgements

A statement of need

Simulation and analysis of home demand side management strategies require either commercial software (Carrasco & Hunfeld (2010)) and a combination of a plethora of tools (Pflugradt (2016)), that can be only compatible through manually merging. The `HiSim` library uses a pipeline for more better flexibility, packing up these tools and current appliances:

- Popular photovoltaic Python library pvlib (Holmgren et al., 2018), to simulate PV system electricity generation (https://doi.org/10.5281/zenodo.5366883)
- European building stock database by EPISCOPE/TABULA (Loga et al., 2016), covering the most common houses from multiple European countries.
- Thermal Building 5R1C (Jayathissa et al., 2017)(ISO, 2008-03) to calculate household heating and cooling demands for an entire year.

- Load Profile Generator (Pflugradt, 2016), behavior simulator that generates electricity and warm water load profiles.
- Database for appliances:
  - Heat pumps
  - Batteries
  - EV chargers
  - Washing machines
  - Thermal Energy Storages
  - Dishwashers
  - Electric Vehicles

The devices, load profiles and controllers are structured as components. The connection among the components are based on compatibility and desired control over their functionality. These components are ordered and connected to form a setup function. The setup defined by user is passed to the`HiSim`framework, which links all the inputs and outputs of the components as shown in the figure below (Tjaden et al., 2021).

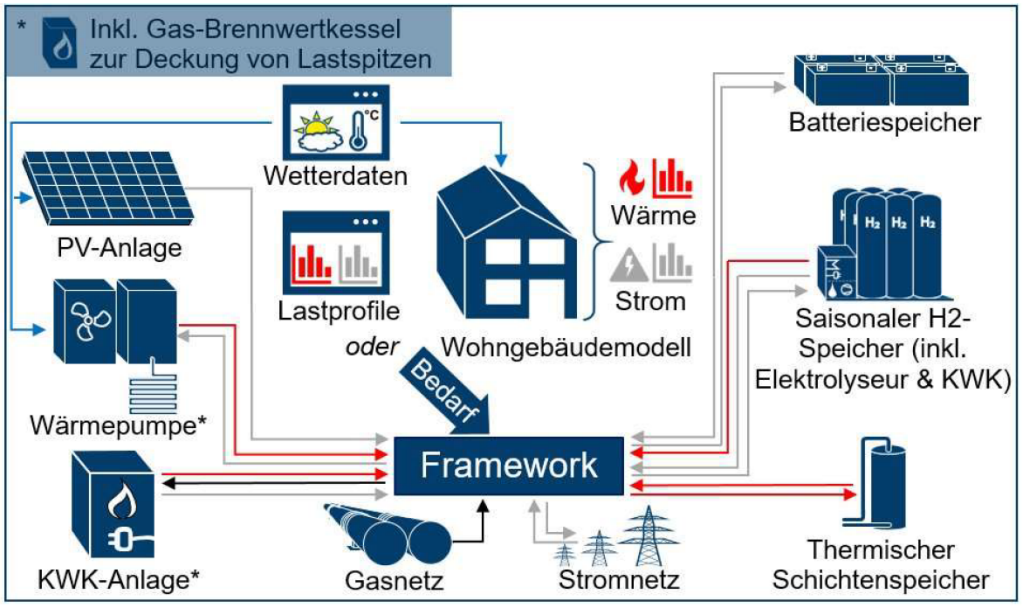

Figure 1: Framework

After connecting and testing all the links, the`HiSim`framework performs all the time steps simulations for the user defined timeline. The postprocessing automatically outputs carpet, sankey, line plots and generate a final report of the simulation run.

Target audience

The scientific community involved in household energy management and building optimization can find here a great tool to investigate different configurations for a transition to low carbon emission households.

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