MULTI-OBJECTIVE OPTIMIZATION OF URBAN ENERGY SYSTEMS CONSIDERING HIGH SHARES OF RENEWABLE ENERGY GENERATION

Andreas Fleischhacker, Energy Economics Group, Vienna University of Technology
Gusshausstrasse 25-29/E370-3, 1040 Vienna, Austria
Phone: +43-(0)1-58801-370361
Email: fleischhacker@eeg.tuwien.ac.at
Georg Lettner, lettner@eeg.tuwien.ac.at

Overview

The major challenges in the development of cities and municipalities in terms of sustainability and a low-carbon society addresses the sensible integration of existing buildings and infrastructures. The Austrian government founded project “SC_Mikroquartiere”[1] shows the possibilities of the city planning on a district level towards a low carbon city with a high quality of living and good resilience taking into account existing and planned buildings, infrastructure and utilization. The central element of this project is the modeling of urban structures on micro-district level.

This approach allows us to

- formulate and present of viable district/neighborhood models on a high-resolution spatial scale,
- developing practical district-specific assessment criteria / indicators for post-compression and high-quality energetic solutions, which refer to buildings and indicators
- the examination of the practicability of high-quality planning solutions on the basis of real micro-district.

The overall objective is the identification of neighborhood solutions and the adaptation of these proposals to 2 city districts, as well as the identification of synergies.

Methods

Within this project an optimization model “*urbs_HERO*”[1] consisting of multiple energy-hubs was developed. Energy hubs are a simplification of an urban (i.e. it is an abstraction of a spatial area). An energy hub is characterized by a production capacity, energy consumption and storage capacity. Different energy hubs are connected by grids. Mathematically, energy hubs are formulated by a multidimensional linear system. These predefined energy sources are grid conducted energy sources (e.g. electrical, natural gas and heat grid) as well as stationary energy sources (e.g. coal or biomass). This concept allows us to investige multiple levels of aggregation, starting from analyzing optimum energy distribution systems on building level up to district level. Figure 1 shows the various levels of aggregation.

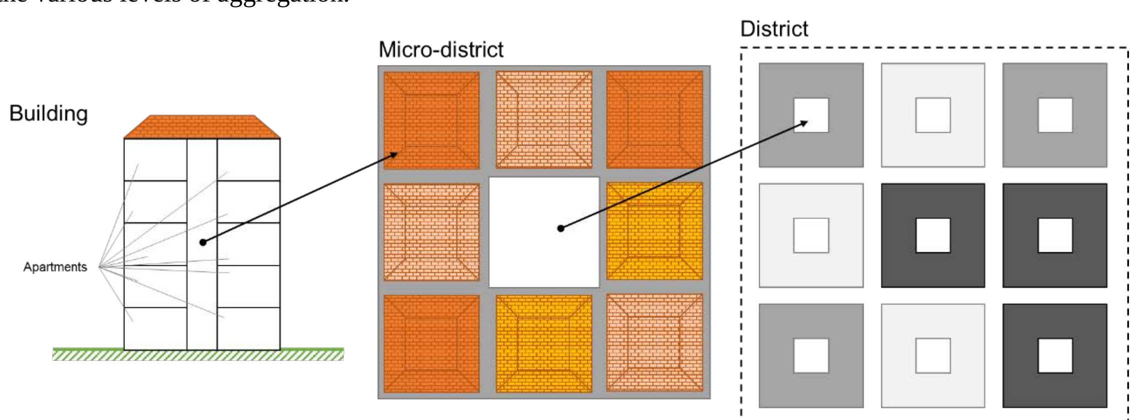

Figure 1: Visualization aggregating three levels of aggregation (from and building to micro-district to district level)

The objective of this optimization model does not only addresses minimal costs rather multi-objectives allows an combined analysis of multiple objectives. The following objectives were considered in this work:

1. ***Minimum total costs***: minimizing total costs, i.e. investment, maintenance and operating costs. This objective function is used to illustrate the maximum cost-effectiveness.
2. ***Minimum emissions***: minimization of emissions, emissions incurred in the production of technologies are not considered.

[1] Based on an open-source python/pyomo[2] optimization model “*urbs*”[3]

3. ***Minimal grid supply / Maximum energy autarky***: This target function increases the level of local self-generation. With this objective, investments in local energy generation technologies are to be strengthened.

Results and Conclusions

The expected results of the investigated cases shall indicate optimal investment strategies differentiated by technology, energy carrier, supply/demand pattern, and others. It also determines the optimal technology portfolio and optimal investment trajectory as well as the optimal dispatch of existing and new plants and storage technologies over the predefined planning horizon. Energy prices are used, among others, as sensitivity parameters.

References

[1] https://nachhaltigwirtschaften.at/de/sdz/projekte/sc-mikroquartiere.php, visited April 1st 2017.

[2] Hart, William E., Jean-Paul Watson, and David L. Woodruff. "Pyomo: modeling and solving mathematical programs in Python." Mathematical Programming Computation 3, no. 3 (2011): 219-260.

[3] https://github.com/tum-ens/urbs/blob/master/doc/overview.rst, visited April 1st 2017.