15. Symposium Energieinnovation, 14. bis 16. Februar 2018, Technische Universität Graz, www.EnInnov.TUGraz.at
ISBN 978-3-85125-585-0 DOI 10.3217/978-3-85125-584-3

PARETO OPTIMIZATION OF A LOCAL URBAN ENERGY SYSTEM CONSIDERING COSTS AND EMISSIONS

Andreas FLEISCHHACKER[1], Georg LETTNER[1]

Introduction

The significant challenges in the development of cities and municipalities regarding sustainability and a low-carbon society address 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 excellent resilience taking into account existing and planned buildings, infrastructure and utilization. The central element of this project is the modeling of urban areas on a city block level. This approach allows us to formulate and present of viable district/neighborhood models on a high-resolution spatial scale. (Figure 1 shows one city area).

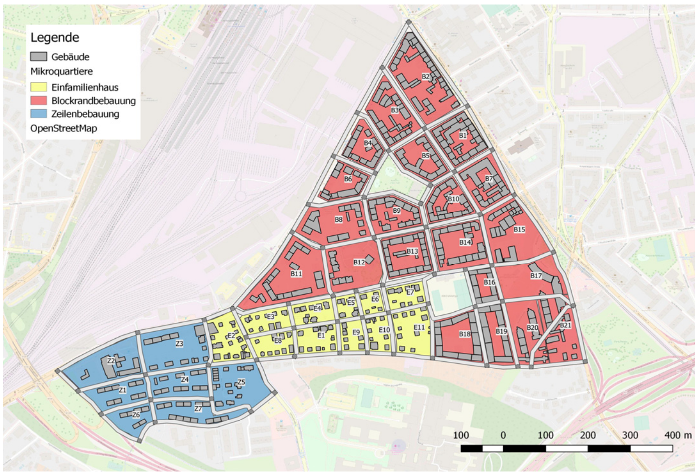

Figure 1: Investigated city area, including the block assignment (three types) in Linz (Austria)

Methods

Within this project, we developed an optimization model "urbs_HERO" (Based on two open-source python open source optimization model "*urbs*" [3] and "*rivus*" [4]) consisting of multiple energy-hubs. Energy hubs are a simplification of an urban (i.e., it is an abstraction of a spatial area). We characterize an energy hub with a production capacity, energy consumption, and storage capacity. Energy grids, such as electrical, district heating and gas grids connect the energy hubs. 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 investigate multiple levels of aggregation, starting from analyzing optimum energy distribution systems on building level up to district level.

The objective of this optimization model does not only address minimal costs rather ϵ-constrained multi-objective optimization allows us to conduct a combined analysis of multiple objectives:

(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 operation related emission. We are not considering underlying emissions, as incurred by the production of technology.

Results and Conclusions

Figure 2 shows both, the Pareto Front and the corresponding quantities of electricity, heat, cooling, and emissions necessary to cover the load. The results show that a very high share of photovoltaic is essential to reduce emissions. Heat pumps may be an essential technology for the integration of renewable generation. On the other hand, grid enforcement measures are necessary, as shown in Figure 3. We will discuss advantages and disadvantages of the electrification in our work.

[1] Vienna University of Technology, Institute of Energy Systems and Electrical Drives / Energy Economics Group, Gußhausstraße 25-29 / E370-3, 1040 Vienna, {fleischhacker|lettner}@eeg.tuwien.ac.at, www.eeg.tuwien.ac.at

ISBN 978-3-85125-585-0 DOI 10.3217/978-3-85125-584-3

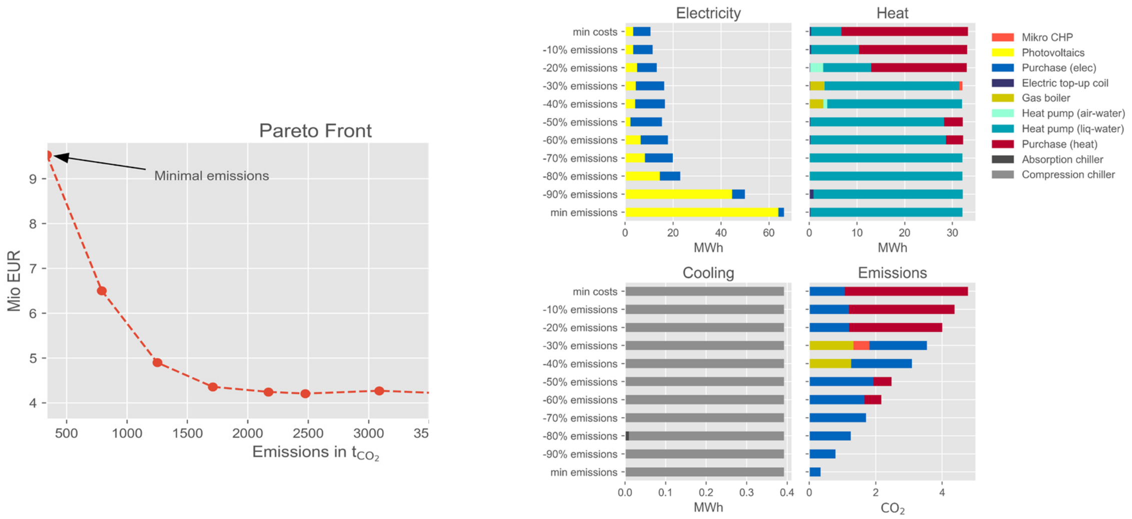

Figure 2: Pareto Front (left) and the corresponding quantities of electricity, heat, cooling, and emissions (right). The composition (e.g. photovoltaic or heat pumps) is shown as well.

Figure 3: Electricity distribution grid capacity in the "minimum cost" scenario (left) and "minimum emissions" scenario (right)

Acknowledgements

This project has received funding from the Austrian Federal Ministry of Transport, Innovation, and Technology (BMVIT) research and technology program "Stadt der Zukunft." On behalf of BMVIT, it is handled by the Austrian Research Promotion Agency together with Austria Wirtschaftsservice GmbH and the Austrian Society for Environment and Technology ÖGUT.

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] Johannes Dorfner, "Open Source Modelling and Optimisation of Energy Infrastructure at Urban Scale", Munich, 2016.

[4] Johannes Dorfner, https://github.com/ojdo/urbs/, visited Dez. 1st 2017.

[5] Johannes Dorfner, https://github.com/tum-ens/rivus/, visited Dez. 1st 2017.