Obsolescence of the gas distribution grid in urban areas: An open-source modeling approach for the gas face-out in local neighborhoods

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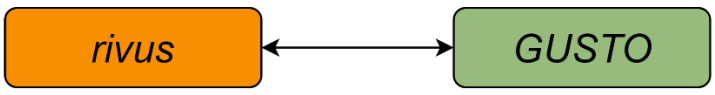
Overview

Decarbonization pathways and the accompanying sustainable energy transformation mean a fundamental change in the provision of energy services. In particular, this applies to the heat supply, which has so far been substantially dependent on fossil fuels, such as natural gas. The main objective of this work is to find the optimal local energy supply for a small urban neighborhood under a targeted local gas phase-out of the district from the gas distribution network. The investigation includes the distribution network infrastructure of several energy carriers (e.g., electricity, gas, and district heating/cooling) and their trade-offs. This provides valuable insights into needed trajectories to a sustainable energy supply. Equally important in the analysis is the expected increase in the cooling demand and identification of its impact on the distribution network grid. The method applied to answer the main research question is a linkage between two open-source models, namely, *rivus* and *GUSTO*. In this work, different scenarios are carried out, which consider relevant scientific literature on the development and future role of natural gas in the heat supply, providing further insights, especially on the local level of energy system planning. Among others, the following scenarios are analyzed: (i) high electrification of the urban neighborhood including the provision of the heat and cooling demand, (ii) connection to a district heating and cooling network, (iii) connection to a significantly enhanced district heating network, which enables both, the provision of heat and cooling services using the same infrastructure, and (iv) a very limited heat supply via synthetic gas. The contribution of this work has high relevance especially due to findings of previous works. As stated in [1], the profitability of the natural gas supply significantly depends on the number of users/customers. Thus, the gas phase-out of local neighborhoods can be seen as a trigger for feedback-loop effects that promotes an extensive replacement of natural gas and speed up the sustainable transformation of the energy system.

Methods

This work uses the two open-source models *rivus*[1] and *GUSTO* [2], which both enable the optimization for distribution networks. However, the strengths of the models lie in the individual high resolution of the spatial or temporal resolution (see Figure 1). Hence, in the first step, *rivus* models the optimal distribution network for multiple energy carriers in the small urban district taking into account technical and economic parameters. In a second step, GUSTO is used to optimize der energy technology dispatch with a high temporal resolution considering different (local) objective functions (e.g., profit maximization, boosting local self-reliance, minimizing greenhouse gas emissions, etc.). Both open-source models are implemented in *Python*, using the *Pyomo* package. The case study analyzed is a small urban district in the vicinity of the Vienna University of Economics and Business, so-called Viertel2, and the surrounding area. The boundaries of the area were chosen to achieve high diversity in terms of generation capacity units, energy demand profiles, building structure and efficiency, as well as the availability of multiple energy carrier infrastructures. Note that the contribution of this work serves as an analytical and methodological extension of the previous work of the author (see [3]). The latter work has so far neglected a high-resolution spatial analysis of urban neighborhoods.



	rivus	GUSTO
Resolution strengths	High spatial	High temporal
Optimization	Distribution network infrastructure (multiple energy carriers)	Local energy technology capacities and dispatch
Objective function	Minimizing total costs	Different objective functions (e.g., costs, self-reliance)

Figure 1 Description of the open-source models rivus and GUSTO

[1] See https://github.com/tum-ens/rivus.

Results and Conclusions

The expected results of the case study are to identify the optimal distribution network of the different energy carriers in the urban neighborhood over the predefined planning horizon. In particular, these take into account a local gas phase-out and thus a sustainable future provision of energy service in the neighborhood. See, for example, Figure 2, which already shows preliminary results in the high electrification scenario (i) and highlights selected electricity distribution network capacities and their expansion in the small area. Besides, the results of this work show with a high temporal resolution the impact of different operation strategies of local energy technologies within the neighborhood and their implications on the distribution network in particular. Furthermore, different sensitivity analyses (e.g., electricity and CO2 prices, etc.) are carried out.

Figure 2 Distribution network capacitiy expansion within the urban neighborhood

References

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