TECHNO-ECONOMIC ANALYSIS OF USING SEWAGE WATER FOR DECENTRALIZED HEAT GENERATION IN LARGE DISTRICT HEATING NETWORKS

Daniel SCHWABENEDER[1], Georg LETTNER[1]

Motivation

The current heat supply, supply quality and robustness of district heating systems is guaranteed by the versatility and ease-of-use of fossil fuels. To maintain the same supply standard in a future sustainable, fully decarbonized district heating system, increased flexibility for the overall system and smart interactions of all its components is required. Moreover, district heating networks are highly suitable for measures to provide flexibility to the electricity system, using sector-coupling technologies like heat pumps.

This work presents a use case of the flagship project ThermaFLEX [1]. Project partner WIEN ENERGIE plans to use a compression heat pump to extract heat from wastewater in a sewer and feed it continuously into the district heating network. A techno-economic analysis of the heat pump investment and optimal operation on the day-ahead spot market and the automatic Frequency Restoration Reserve (aFRR) balancing market is conducted to answer the questions if a storage and heat pump investment is economically feasible and to identify the optimal sizing of these components.

Methods

The basic concept of the analyzed use case is illustrated in Figure 1. The sewage water is redirected through a storage to a heat exchanger. The heat pump is operated with electricity to provide heat from the heat exchanger to the district heating grid.

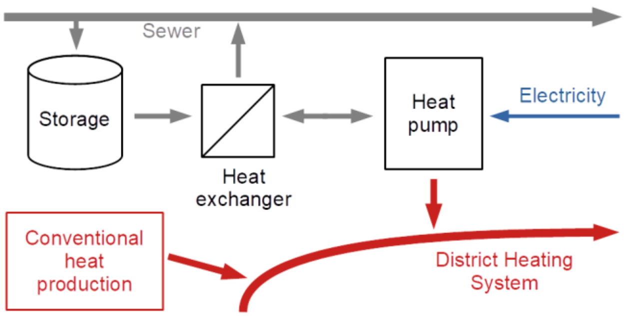

Figure 1: Basic concept of the heat recovery from wastewater with a compression heat pump.

To simulate the optimal operation of the heat pump and to identify the optimal sizing of the storage and the heat pump, a mixed integer linear program, minimizing annual heat production cost, is formulated and solved. In a first step, electricity purchase from the day-ahead spot market is considered exclusively. In a second step the provision of flexibility to the electricity system by participating in the aFRR balancing market is investigated, in addition. The optimization models are implemented in Julia [2] using the JuMP [3] toolbox and solved with the Gurobi Solver [4].

Results and Conclusion

First results indicate, that the heat pump investment is barely economically feasible. The wastewater storage, in contrast, provides no economic benefit for the district heating system operation. However, it is required for technical reasons to filter and clean the wastewater before it enters the heat exchanger. The analysis of the heat pump's operation on the balancing market is still work in progress. A further increase of economic benefits compared to day-ahead spot market optimization is expected.

[1] Energy Economics Group / TU Wien, Gußhausstraße 25-29/E370-3, +43-(0)1-58801-370375, {schwabeneder, lettner}@eeg.tuwien.ac.at, www.eeg.tuwien.ac.at

References

[1] Forschungsinitiative Green Energy Lab, "Green Energy Lab ThermaFLEX," 2019. [Online]. Available: https://www.greenenergylab.at/projekt/thermaflex/. [Accessed 28 11 2019].

[2] J. Bezanson, A. Edelman, S. Karpinski and V. B. Shah, "Julia: A Fresh Approach to Numerical Computing," SIAM Review: 59, p. 65–98, 2017.

[3] Dunning, J. Huchette and M. Lubin, "JuMP: A Modeling Language for Mathematical Optimization," SIAM Review: 59, pp. 295-320, 2017.

[4] Gurobi Optimization, LLC, Gurobi Optimizer Reference Manual, 2019.