Excess Heat as a Sustainable Energy Source for District Heating: A Multi-Stakeholder Perspective

[Muhammad Bilal Siddique, Technical University of Denmark(DTU), +45 2222 4306, bsikh@dtu.dk] [Nikita Padmadas, Technical University of Denmark(DTU), s222487@dtu.dk]
[Per Sieverts Nielsen, Technical University of Denmark(DTU), pernn@dtu.dk]

Overview:

Recently, excess heat has been under focus as it can meet the heat and coooling demand of Europe [1]. Excess heat (EH) is also referred to as waste heat. As the names suggest, it is a byproduct of some industrial process that is not utilized but instead escapes from the system, mainly into the environment. This excess heat can reduce primary energy consumption, reducing overall CO2 emissions [2].

One benefit of district heating (DH) is the easy integration of excess heat. The potential sources of EH also increase with reducing the DH supply temperature [3]. DH in Denmark has contributed to making the Danish energy sector among the most efficient in the world [4]. Presently, high energy prices have renewed focus on DH [5]. The DH sector relies heavily on CHP, where excess heat from cogeneration is taken out in the heating network. However, other sources of excess heat have also been successfully integrated into the DH network, like excess heat from the waste treatment plant, excess heat from sewage water, data center excess heat, etc.

Despite the many benefits of EH integration in DH, some barriers remain. The DH network is often considered closed, with DH operator having their own generation assets. EH integration requires opening up the DH network to the third party of EH suppliers [6]. While technically it is possible to integrate the excess heat into the DH network, there is a lack of understanding of the impact of EH integration to DH on the business model of different actors involved, primarily DH operator, EH supplier, & DH consumers.

Therefore, a better understanding of the potential benefits and risks of EH integration in DH can help strengthen cooperation among different stakeholders. Our paper focuses on the integration of EH in the DH network from multiple stakeholders' perspective. We use a comprehensive modeling framework that matches excess heating (or cooling) to desired demand.

Methods:

Modeling Framework:

We use a modeling framework developed under Horizon 2020 project EMB3Rs [7]. The EMB3Rs platform is open source and easy to use due to its drag-and-drop interface. The platform matches excess heating or cooling with demand and is aimed as a one-stop shop for the feasibility analysis of excess heat/cool utilization.

The platform has different modules, each performing a crucial function. These modules characterize sinks and sources (Core Functionalities module), find the shortest route for the heating network (Geographical Information System), invest in least-cost technologies to meet demand (Techno-economic optimization), simulate different markets to get a price for the heat (Market module), and calculates the financial profitability of the whole project (Business model module). Thus, the EMB3Rs platform can consider the perspective of multiple stakeholders. More information on these modules can be find here [8].

We use the EMB3Rs platform for our study due to its comprehensive modeling framework. The EMB3Rs modeling framework provides all the necessary optimization and simulations under one platform.

Case Study:

We model the case of Regstrup town in Denmark. Regstrup is a small rural town with a population of 2,000 inhabitants. The town mostly consists of single-family houses with individual heating systems, mostly consisting of gas boilers. The town doesn't have any prior DH network. The total annual heat demand of the town is approximately 23 GWh.

The town has two industrial units that produce excess heat. The first source (Super Frost) of excess heat is cold storage for food products, where the cooling compressor produces excess heat. The second source (Schoeller Plast) is the manufacturer of transport boxes and other plastic-based packaging. They also require cooling with a total cooling capacity of 730 kW, which can be replaced by a heat pump. We model this case in the EMB3Rs platform and compare different options for excess heat utilization.

Results:

As most of the houses in the case study are heated with natural gas boilers, we consider a conventional DH network with a forward temperature of 90 degrees and a return temperature of 45 degrees. This ensures that the heating system installed in houses does not have to be completely replaced.

The simulation results indicate that only one source (Super Frost) is suitable for integration in DH. A further investment in natural gas recovery boiler of 3 MW is made as a backup. The total payback period is 11 years, with the highest cost coming from piping network installation (18 million euros). The total length of install DH grid is 27 km and the average price of heat in this case is 0.06 EUR/kWh.

The payback period of this project is only 2 year if we exclude the network cost, which are often funded by the government. The levelized cost of heat (LCOH) for most of the sinks (except for two) is under 80 eur/MWh, which is the cheapest among all individual heating technologies according to the IEA database.

Conclusion:

Excess heat provides an important opportunity to decarbonize the heat supply in a sustainable manner. The modelling framework discussed in this paper provide a comprehensive overview from the perspective of different stakeholders, which is crucial for most of the excess heat project.

Our results indicate that EH from cold storage is a feasible option for DH in Regstrup. The network cost is the most significant cost component, which might require an active engagement from the local municipality. Ultimately, we see that EH utilization lead to a reduction in local natural gas consumption and EH in DH is a cheaper option than the alternative individual heating technologies.

References

[1] Turns A. Recapturing excess heat could power most of Europe, say experts. Guard 2023. https://www.theguardian.com/environment/2023/feb/23/recapturing-excess-heat-could-power-most-of-europe-say-experts (accessed April 1, 2023).

[2] Broberg Viklund S, Johansson MT. Technologies for utilization of industrial excess heat: Potentials for energy recovery and CO2 emission reduction. Energy Convers Manag 2014;77:369–79. https://doi.org/10.1016/j.enconman.2013.09.052.

[3] Sandvall A, Hagberg M, Lygnerud K. Modelling of urban excess heat use in district heating systems. Energy Strateg Rev 2021;33:100594. https://doi.org/10.1016/j.esr.2020.100594.

[4] Danish Energy Agency. Regulation and planning of district heating in Denmark. 2016.

[5] Heating price analysis: District heating is still price robust. Press Release DBDH 2023. https://dbdh.dk/heating-price-analysis-district-heating-is-still-price-robust/ (accessed April 1, 2023).

[6] Bürger V, Steinbach J, Kranzl L, Müller A. Third party access to district heating systems - Challenges for the practical implementation. Energy Policy 2019;132:881–92. https://doi.org/10.1016/j.enpol.2019.06.050.

[7] EU Horizon 2020. EMB3Rs n.d. https://www.emb3rs.eu/ (accessed April 1, 2023).

[8] EMBERs. MEB3Rs Platform. EU Horiz 2020 n.d. https://www.emb3rs.eu/platform/ (accessed April 1, 2023).