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District heating cost modelling

Introduction

The district heating (DH) cost modelling assessment addresses the long-term energy planning of DHs, considering the evolution of systems towards greater efficiency, lower distribution temperatures, greater shares of renewable energy and the incorporation of distributed renewables in the context of an increase of nearly zero energy efficient buildings (NZEBs).

Heat production costs

The assessment is performed based on the large DHs already in operation within RELaTED (Tartu & Belgrade). A cost model is constructed, where operation costs are defined for each heat production technology, allowing for hourly prioritization of heat production technologies based on their marginal costs. This cost model is used to develop scenario analysis where various potential evolutions of the DH network are studied. Technology, production mix and fuel price evolutions are assessed. In addition to the cost model and case studies, the cost structure of heat production plants were also assessed. The production technologies examined were (1) CHPs, (2) Boiler systems, (3) heat pumps, (4) and solar thermal systems.

In general, it can be said that centralized heat production sources meant for providing the base load and peak load for heat, like CHP and boiler systems, had higher capital and operating costs as they were the primary heat source for the DHN. Water to water heat pumps and solar thermal plants are more used to support the larger heat production sources when the demand for heat is beyond their capacity. Operating costs for these heat production options tend to be lower because the heat energy comes from renewable energy sources, like ground source water for heat pumps and solar irradiation for solar thermal.

Capital cost overview

- More expensive for centralized, baseload production plants
- Investment for decentralized sources of heat depend on scale i.e., number of solar panels and HPs that are built

Operating cost overview

- Operating costs largely depend on fuel source – fossil fuels tend to be more expensive whereas waste heat and solar energy is essentially free.

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Cost model basis

The cost model for the assessment is based on a marginal cost model where the costs are calculated for a DH network on an hourly basis. This cost model is used to calculate the multi-year heat production mix in the Tartu and Belgrade DHN. This model includes the energy simulation and the fuel cost evolution along different scenarios of specific DH networks. The input variables for this model are the main characteristics of the heating network:

- Total demand of the district
- Nominal capacity [kW/MW]
- Nominal efficiency
- Availability of heat
- Fuel prices
- Supply and Return Temperature of the network

The cost model developed for this task is valid for every type of DH network without regard to the characteristics of the network. The model simulated the instant production with hourly frequency of every facility to cover the full demand in the district. This study is extended to a period of 20 years, which is considered the long-term period for a DH intervention. In this time period, the expected changes in DH characteristics, such as demand variation, new production plants etc. are introduced in the model so that the operational changes are shown.

Results of case studies

The district heating cost modelling section assessed the costs associated with different heat production plants. This assessment was done in the context of two case studies, one of the Belgrade, Serbia DH network and one of the Tartu, Estonia DH network. The following results were obtained:

Tartu

- Current state of the network results to be a highly-efficient energy system with very competitive heat price.
- An increasing demand in the buildings' side can exceed the production capacity of the existing heating plants.
- Recovery of waste heat results to be a very efficient and economically feasible option. The optimal functioning mode for this DH network starts form the gradual reduction of the supply temperature, increasing the efficiency of all the plants.
- The next step is the introduction of RES (most optimally waste heat) to the production mix. Heat pump introduction shall be considered only with heat pumps at greater performance levels.

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Belgrade

- The functioning mode (increased interconnection of DH networks) together with the incorporation of some RES to the generation mix will reduce the total cost of the heat and the CO2 emission to the environment.
- Large RES utilization factors are achieved, with ~3000 full time operational hours for large solar thermal installations. Thus, greater installed capacity should be explored for RES. The next step is the introduction of RES (most optimally waste heat) to the production mix. Heat pump introduction shall be considered only with heat pumps at greater performance levels.

Conclusion

The main takeaway for this section is that the specific costs for heat production are highly dependent on the location. This is also the case with the integration of renewable energy resources as a fuel source for heat production. For example, in the case of Tartu, waste heat is a much more feasible renewable energy source for their network compared to solar thermal energy. Whereas for Belgrade, solar energy could be collected for longer periods throughout the year because it is in a warmer climate. However, both cases indicated that the integration of more renewable energy sources and lowering the supply temperature could increase the efficiency of the network, reduce GHG emissions from heat production, and lower the cost for DH.

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