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# Smart Energy Systems – District heating, industrial sector and marine transportation transformation

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**ABSTRACT**

This 49th volume of the International Journal of Sustainable Energy Planning and Management presents articles from the 11th Smart Energy Systems Conference held in Copenhagen, Denmark in 2025. The conference invites academia, industry, consultancy, and utilities to engage and discuss the transition of the energy system. District heating has always been a strong focus point of the conference, as is also evident in the present 49th volume of the IJSEPM. Topics presented in this volume include a study on alternative heat sources for heat pumps in district heating, such as wastewater and river water. District heating continues to be a focal point, in a study exploring hybrid network solutions for further development of district heating systems, and in a study on decarbonisation of combined district heating and cooling systems. Also connected to district heating, this volume presents work on novel methods for estimations of heat demand and heat sources for district heating across the European Union, in addition to a study on the mapping of waste heat potentials, and lastly, the global warming potential of district heating in Finland. Finally, this volume presents work on industry transformations and prominent barriers to this transformation, and a rare study on the maritime sector and the modelling of sustainable fuel pathways.

***Keywords***

District heating;
Spatial heat demand;
District heating planning tool;
Alternative marine fuels;
Industrial transformation

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## *1. Issue Contents*

Several studies have focused on the role of heat pumps in future energy systems as a means of transitioning heating supply to variable renewable electricity sources and for helping to keep the balance in the electricity system. In this issue Sieglar [1] investigates low-temperature heat sources in the shape of wastewater and river water for heat pumps in Hessen, Germany and combining this with potential district heating areas, assesses potential contributions to heating. The authors find similar magnitudes of potentials from heat pump-based production from the two sources - 4.5 TWh/y for river and 4.9 TWh/y for wastewater. This is based on a relatively modest heat demand density threshold of 175 MWh/ha/y. Applying a higher threshold of 415 MWh/ha/y reduces the potential more for rivers than for wastewater.

Previous work in the IJSEPM has also focused on low-temperature heat sources – Pieper's work [2,3] included similar assessments of rivers, wastewater and more. Trabert and coauthors [4] analysed the economics of river water-based heat pumps, finding that flexible operation would decrease electricity costs.

Vallese [5] looks into scenarios for district heating with Hybrid Network Solutions in Germany, including technologies such as waste heat, rooftop PV, electric heating, heat pumps and decentralised heat storage. Heat pumps show significant potential, but their deployment should align with electricity decarbonisation, and the overall Hybrid Network Solutions

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concept can serve as a model for district heating development.

Marx and coauthors [6] also address district heating decarbonisation but consider this in combination with district cooling. The main contribution of the work is the assessment of screening approaches ahead of more formal hourly techno-economic feasibility studies. The framework is tested against more traditional hourly analyses, showing cost deviations, but the methods prove adequate for screening of district heating and cooling options.

In [7], Georgati and coauthors focus on the spatial distribution of heating demand and potential heating sources for district heating across the European Union countries. The work draws on previous work like the Pan-European Heat Atlas, contributing here with open data sets and tools, and the work supports decision-making towards 55% district heating share in the EU. Also in this issue, Sommer and coauthors [8] present their F|Heat extension for QGIS, which facilitates early-stage district heating planning, factoring in demand density, network dimensioning and routing, among other aspects. The extension is tested on a case in Nordrhein Westfalen in Germany. In this journal, Moreno previously presented the ODHeatMap Tool [9] and Möller & Nielsen presented a first heat atlas[10]. Volkova presented an approach for district cooling planning [11] and Röder and coauthors presented an approach for district heating planning with particular focus on storage systems in the network [12].

Previous work in the IJSEPM has underlined the importance of spatially explicit heat planning, from the development of high-resolution heat atlases for demand and supply mapping [10], to building-level analyses combining heat atlases, end-use heat savings and heat supply costs [13], and open-data tools supporting district heating feasibility assessments [9]. Broader analyses have also highlighted the role of excess heat, low-temperature heat sources and district heating in climate-neutral energy systems [14]. Building on this line of research, Menapace and coauthors [15] address the mapping of waste heat potentials for district heating systems, focusing on both industrial and tertiary sector sources. The authors develop a replicable methodology combining open geospatial datasets, statistical information and literature-based coefficients to estimate annual waste heat potentials at different temperature levels and derive hourly availability profiles. Applied to the Milan metropolitan area, the screening of sources close to the Milan West district heating network identifies around 101 GWh/y of technically suitable waste heat potential, mostly available at low temperature and therefore requiring heat pumps for integration. The work adds an important temporal dimension to waste heat mapping, showing that detailed hourly analysis is needed to assess the operational feasibility of waste heat integration in district heating expansion and decarbonisation.

Vassallo & Kontu [16] apply the energy systems analysis model energyPRO to assess the influence of global warming on district heating systems in Finland. Reduced heat demand can cause problems to current energy systems due to lower sales, but a concurrent switch to, e.g., biomass will provide a more stable economy. Previously, Sernhed [17] addressed district heating prices in Sweden, focusing on prices reflecting system costs and better through the split between fixed and variable costs. Odgaard & Djørup [18] addressed district heating prices from a benchmarking and regulatory perspective, focusing simultaneously on ownership models.

Ozen [19] focus on industrial transformation, and while financial feasibility is important, other factors are also. Indeed, an expert survey found that *"Organizational challenges were found to outweigh financial ones"*. One of the issues their survey revealed as a potential barrier for transformation measures was Spare requirement. Appiah previously investigated the adoption of renewable energy sources by small and medium-scale industry [20]. Barkhodar [21] investigated the rebound effect of industry, showing that with energy efficiency measures in industry, demand will, to a certain extent, rebound.

Reiter and coauthors [22] focus on the transition of the energy demand of the maritime sector to sustainable fuels. They establish a modelling framework in the form of a Python library to enable the modelling of different fuel pathways in the maritime sector. The library is tested on different fuel pathways on a Dutch case where its ability to model such systems is confirmed. The maritime sector is responsible for approximately 3% of global energy demand, but the topic is underrepresented in the IJSEPM, with the exception of a targeted analysis of offshore charging stations [23] and more general analyses where maritime demands are included in energy transition scenarios, like Petersen's work on the Faeroe Islands [24] where, e.g., ammonia for the maritime sector is investigated.

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