FUTURE DECARBONISATION PATHWAYS FOR DISTRICT HEATING SECTOR: A POLICY AND PRIVATE BUSINESS PERSPECTIVE.

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Overview

DISTRICT HEATING refers to a central supply of heat to fulfil the space heating and hot water demand of buildings. District heating network comprises of central production units along with distribution network and occasionally, a transmission network for larger district heating networks. District heating offers many local environmental and economic benefits like reduced air pollution by eliminating individual heating at houses, utilising local energy resources, flexibility in choice of heat production technology, creating more jobs, and eliminating energy poverty[1]. At a national level, high penetration of district heating makes the whole energy system more efficient and increases the share of renewable energy, as evident from the experiences of Denmark and Sweden [2], [3]. While the penetration of district heating is very high in Nordic countries of Denmark, Sweden, and Finland, a substantial potential of district heating expansion exists in other European countries where about 50% of heat demand at the European level can be supplied by district heating to achieve decarbonisation that is affordable [4].

The district heating sector faces the challenge of decarbonisation just like the whole energy sector. Furthermore, the reduced heating demand resulting due to temperature increase and investment in energy renovations of buildings due to ambition policy push [5] threaten the profitability of existing district heating companies in the future.

In this study, a comprehensive assessment of the future development of the district heating sector is conducted from the perspective of a whole energy system. This study tackles the challenges concerning future optimal fuels and technology shifts to achieve decarbonisation in future when heat demand is expected to reduce. The implications of future development in the district heating sector on policymakers and district heating companies are discussed.

Methods

The Danish district heating sector is among the most energy-efficient systems globally and it is selected as a case study for this article. The Danish district heating sector is very mature with more than 65% of buildings in Denmark connected to district heating networks. The Danish government has set forth an ambitious climate target of 70% GHG reduction till 2030, compared to 2005 levels, and net-zero GHG emissions till 2050. This necessitates the need for decarbonisation of district heating sector.

Future investments are optimised using an energy system model Balmorel to study the future development of the district heating sector in Denmark. Balmorel models a detailed representation of Denmark's power as well as heating sector and neighbouring countries and their interconnections. It maximises social welfare by minimising the total cost. Balmorel is a deterministic partial-equilibrium model that is open source and available at [6]. The general description and different studies conducted using Balmorel can be found here [7].

The heat demand covered by the existing district heating network and the individual heating technologies outside the district heating network is modelled separately. In addition to investment into individual and district heating generation technologies, two new modules are developed to consider investments into energy renovations of buildings stock to reduce heat demand and expanding the existing district heating network. Such a comprehensive model can take into account the complex interaction and competition among investments in energy renovations, expansion of heating grid, and/or new generation capacities.

Four different scenarios are modelled to take into different developments at the sectoral level. The first scenario is a benchmark scenario with no constraint on GHG emissions. The second scenario introduces GHG emission reduction targets in accordance with current Danish targets, and this scenario is called the policy scenario. The last two scenarios add a reduction in exogenous heat demand to energy renovations and an increase in temperature due to climate change on top of GHG emission constraints. The heat savings scenario takes into account a reduction in heat demand due to very ambitious energy renovations, which is projected to reduce 75% of total heating demand in 2050. Similarly, 2 degrees scenarios consider a demand reduction of 12% compared to 2020 level in 2050 due to a 2 degrees temperature increase in Denmark according to projections from IPCC.

Results

The preliminary results are presented below:

- The expansion of district heating is small in all four scenarios (about 5% expansion). This is expected as Denmark already has a very high penetration of district heating.
- In all scenarios, the endogenous investment in energy renovations to reduce heat demand is minimal. Furthermore, these results are insensitive to energy renovation price reduction. This represents the economic infeasibility of energy renovation investments from an energy system perspective.
- All fossil fuel based capacity, with a notable exception of natural gas, is phased out till 2030.
- The present high reliance on biomass is expected to be reduced primarily due to the phase out of coal-based capacity by 2030.
- Like biomass, natural gas has a substantial share in the present fuel mix of the district heating sector. The earlier phase out of coal-based capacity increases the share of natural gas in district heating. The complete phase out of natural gas is only achieved under climate scenarios with stringent emissions reduction targets.
- In general, the present lion share of CHP based capacity is expected to decrease to include greener heating options like utilisation of excess heat, and electrification via heat pumps.
- Share of electrification via heat pump is increased in all scenarios in both sectors (district heating and individual heating sectors). However, the uptake is more accelerated under climate scenarios with the exception of heat savings scenario due to a substantial reduction in demand under this scenario.
- Overall, the decarbonisation of district heating is achieved by a cocktail of technologies comprising biogas, biomass with carbon capture and storage, excess heat, heat pumps, and municipal waste.

Conclusions & Policy Recommendations

The decarbonisation of the heating sector is achieved by a combination of technologies, each with its unique benefits and challenges. The uptake of heat pumps can offer flexibility to integrate variable renewable energy but also exposes the district heating sector to the uncertainty of the power sector. Similarly, utilisation of excess heat in district heating offers a cheap source of heat which is also green, but uptake of excess heat requires opening of district heating network to the third party which require a comprehensive policy framework. Biogas is a relatively new fuel in district heating fuel mix but its mismanagement could result in significant methane leakage.

Limited expansion potential for conventional district heating along with increased uptake of heat pumps and industrial excess heat requires a substantial change in the business model of existing district heating companies, from a centralised, economy of scale production logic to decentralised production as potential sources for excess heat are decentralised. The future reduction in CHP based capacity makes such transition a necessity. The uptake of heat pumps, in combination with a small potential for expansion of district heating network, necessitates a potential shift in business model to be more service oriented offering different energy services ranging from initial planning to manage the operation and active engagement with customers & stakeholders. Such a service-oriented approach could allow district heating companies to tap into customers that are not connected to the district heating network.

References

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