International Energy Agency Technology Collaboration Programme on District Heating and Cooling including Combined Heat and Power

Annex XII final report summary for a non-technical audience

Stepwise transition strategy and impact assessment for future district heating systems

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STEP

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Summary report

IEA DHC Annex XII project "Stepwise transition strategy and impact assessment for future district heating systems" (STEP) set out to study the transition to 4th generation district heating (DH) systems (4GDH) in Finland, Sweden, Norway and Denmark. 4GDH is a concept including the integration of new, renewable heat sources, lower distribution temperatures, closer links with the surrounding energy system, flexibility in operation and integration with other long-term infrastructure projects like city planning.

The project focuses on the benefit, the impact and the requirements of low distribution temperatures; arguably the most significant aspect of the 4GDH concept. Low-temperature distribution poses requirements for the buildings, but enables new low-carbon heat sources in the DH systems. The stepwise transition refers to specific temperature levels in the DH distribution network. Figure 1 below presents these temperatures along with additional requirements and resulting DH system benefits which were used in this study .

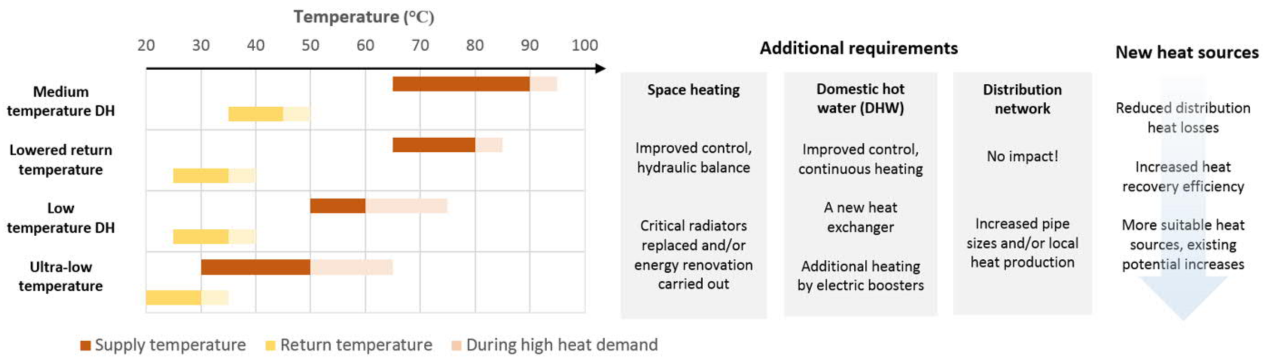


Figure 1. Stepwise transition temperature levels, building requirements and DH system benefits.

The project was divided into three parts; the building-level actions, the new enabled heat sources and the energy system impact.

Building-level actions

Supply temperature and pressure in the network are controlled by DH operators, whereas achieving lower return temperatures in the substations is driven only by the end-users' secondary systems and the ways how these are operated and controlled. Hence, the actions inside the buildings are very important for the district heating community to start the stepwise transition toward future low-temperature district heating systems.

It is economically feasible to invest in improving the heating system control to reduce the operating temperatures and return temperatures of 25–30 °C are possible without any changes in the building heating systems or buildings themselves, simply by correctly controlling the systems. The DH companies face the challenge to help building owners to improve and maintain the building heating system operation. Since errors, malfunctions, or misinformation will appear on a continuous basis over time, the work on identifying and correcting these problems also has to take place continuously.

To support this, real-time data from smart heat meters, heat cost allocators and temperature controllers is opening new multidisciplinary approaches for operational data analytics and continuous commissioning, combining traditional engineering skills and modern data science.

Motivation tariffs by the DH operators is a very effective strategy to engage with end-users and represents an economic incentive to take action inside the buildings to improve the heating systems and reduce the operating temperatures

New heat sources

Eight different heat sources for 4GDH were studied during the project:

1) excess heat (waste incineration, industrial processes and nuclear plants)
2) large solar collector fields
3) geothermal heat
4) biofuels
5) large electric boilers and heat pumps
6) flexibility in DH systems which compensate for variable electricity generation
7) large heat storages
8) urban, low-temperature excess heat sources

Heat recovery from high-temperature excess heat (EH) sources were estimated both at a national level (in Sweden and Denmark) and an international level (in EU), in which the EH sources could largely contribute to providing heat demand. Centralized solar collectors' fields together with seasonal storage have a lower levelized cost of heat than block heating systems with roof-mounted collectors and diurnal storage. Geothermal heat was shown to be a realistic contributor to urban heating. Biomass (forest residues/wood chips and wood pellets) could replace fossil fuels in CHPs, but biomass is a limited resource, especially in a wider European context and it may also be used for production of transportation fuels, chemicals and plastics in bio-refineries. Large heat pumps in DH systems can play a key role in absorbing surplus electricity from intermittent technologies and in utilizing low-temperature EH. Flexibility in DH systems due to existence of large heat pumps and heat storage capacities increases options to integrate variable renewable electricity production. Low DH return temperature will improve efficiency of CHPs, heat pumps and solar collectors and thus, increase the potential of heat recovery from industrial and urban EH.

Pinch analysis widely used within process industry was applied for the case of data centres in order to present a method for assessing the potential of an urban excess heat source. Figure 2 illustrates an example where the available excess heat increases when the DH distribution temperature is lower, i.e. 65/40 °C results in 0.3 kW while 45/30 °C provides 0.6 kW of excess heat.

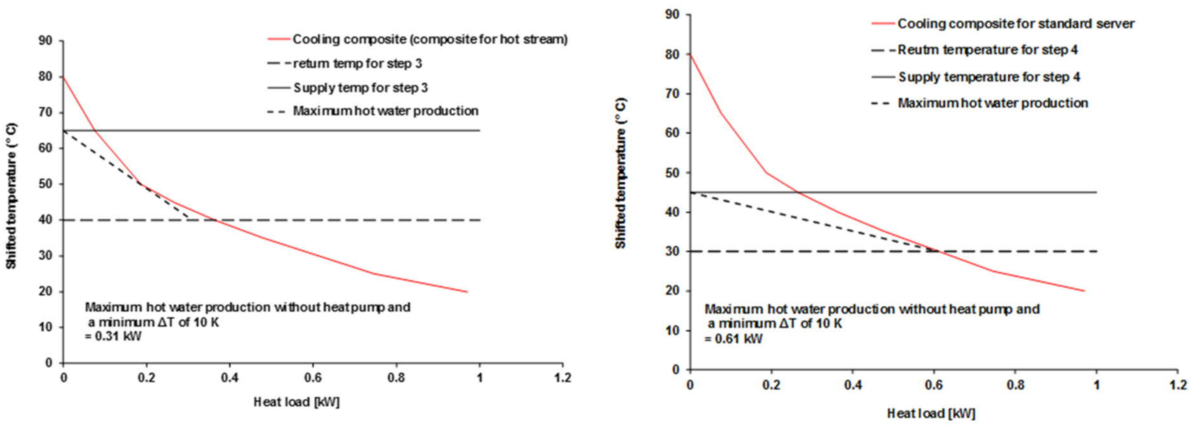


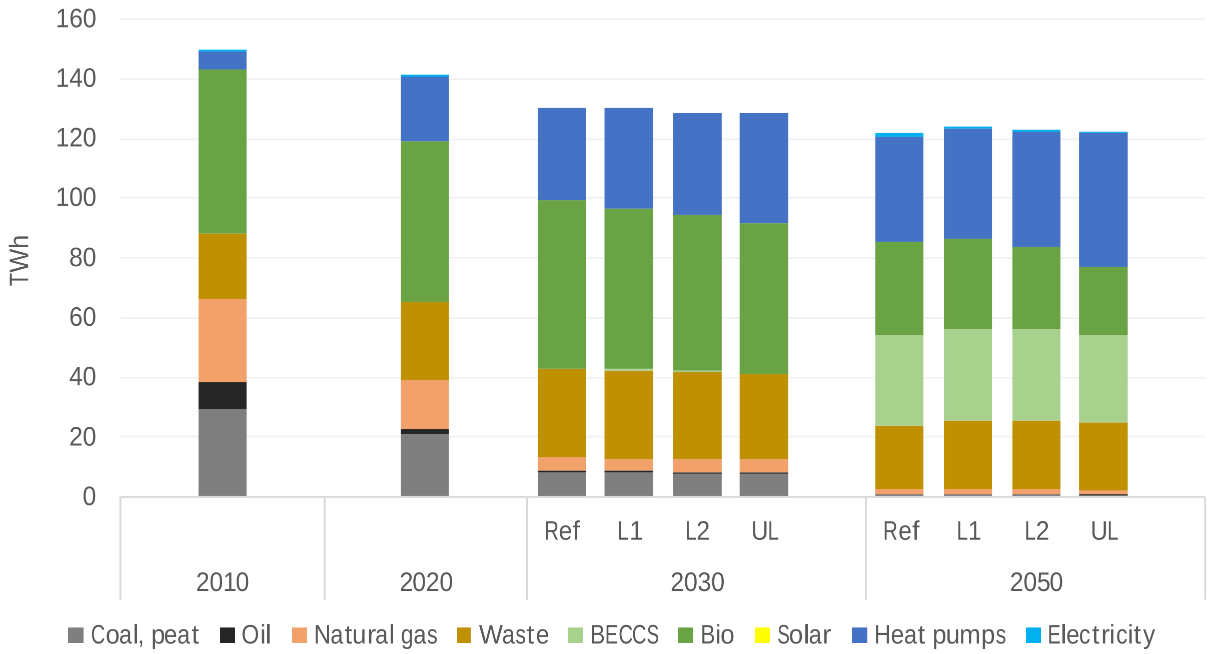
Figure 2. Heat available from a specific server cluster with step 3 (65/40 °C) and step 4 (45/30 °C)

Energy system impact

Previous studies have shown that DH potentially has a significant role in future low-carbon energy system, e.g. by providing flexibility for the power system. In this project, the energy system impacts of different steps along the transition corresponding to defined temperature levels for DH distribution were analyzed. The method used was the TIMES-VTT energy system model for Nordic countries that includes production, transformation, distribution and consumption of all energy and GHG emissions.

The main results in the modelled scenarios are that the existing fossil fuel based capacity to generate DH would be replaced by large heat pumps, waste-to-heat plants, and biomass boilers. Towards 2050, these biomass boilers could be equipped with carbon capture and storage units to compensate the GHG emissions from other sectors, such as agriculture, where emission reductions are much harder to achieve. By 2040 and 2050, the Nordic DH generation could be based almost only on waste-to-energy, biomass, and large heat pumps. The Nordic-level results for DH supply are illustrated below. The results are in line with current development towards 2020 and with previous studies on energy system impact of DH in general.

With lower DH distribution temperatures, more heat pump based heat supply was used and the efficiency of biomass boilers and waste-to-heat plants increased. This frees up more biomass to be used in other sectors enabling cheaper emission reduction measures.



The results are also presented on a country level, and especially Finland divided into two separate regions (metropolitan region and the rest of the country) provided interesting results. As the demand for electricity increases, and the fossil-based CHP capacity is decommissioned and replaced by heat pumps, biomass boilers and BECCS plants, the electricity balance shifts dramatically from 5 % electricity being imported in 2010 to 65 % in 2030. This has a significant impact on the transmission and local distribution grid. Similar impact would be expected in other Nordic urban areas. The issue will definitely require more research.