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Transition to low temperature distribution in existing systems

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Abstract

One key aspect of the 4th generation district heating systems [1] is a low temperature solution for distribution – i.e. the supply temperature in the distribution network is set to a lower level (30-70 °C, depending on design) than traditionally (80-115 °C). The temperature level has a defining impact on the efficiency of the distribution through heat losses and it improves the potential for integrating new sources of heat into the system. These new heat sources include heat pumps, renewable energy sources and excess heat from communities and industry. Combined heat and power (CHP) production and boiler based heat supply benefit from a lower temperature level as well.

At the same time the transition to lower temperature level imposes challenges on pipe capacities within the distribution network, heat exchanger and secondary side design and heat distribution systems within buildings. While low temperature distribution is simply a design choice for new systems, refurbishing existing systems is much less straightforward and a current challenge in countries with developed district heating systems. Although technically feasible, the changes needed should be studied on a system level for a throughout evaluation of the cost-efficiency in terms of both energy savings and emissions. The needed investment and the benefits can end up to be unevenly distributed among the involved parties, e.g. the local utility and customers. This can represent a practical barrier impeding or blocking the transition process.

This paper studies the effects and impacts of the transition to low temperature distribution in existing district heating systems, the needed technical solutions and the improved potential of utilising new, enabled heat sources. A systematic method and tools for evaluating the system level benefits of the transition are described. This study lays the groundwork for a system specific case study of a major refurbishment of an existing district heating system.

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1. Main text

The current ambitious greenhouse gas (GHG) emission reduction targets set by European Union (EU) pose a serious challenge for the energy systems in the member countries. Industrial heat consumption and heating and cooling of buildings corresponded to approximately half of total final energy consumption in EU in 2013 [2], [3]. The importance of the sector has been recognised in an EU Strategy on Heating and Cooling, announced 16th February 2016, setting up a framework for improving energy efficiency and sustainability within the industry, in buildings and their heating and cooling systems as well as for integrating heating and cooling into the electricity system. [4] District heating and cooling as a technological solution can potentially have a crucial role in the implementation of the strategy.

Replacing building specific heating systems by expansion of district heating can potentially reduce primary energy consumption, fossil fuel consumption and CO_2 emissions in Europe by 7%, 9 % and 13 %, respectively. [5]

Utilising renewable energy sources as heat supply in district heating systems can have a major impact on share of renewables in heating sector due to sheer volume of connected building stock. Currently, the share of renewable energy in heating sector within EU is only 15 % [6]. Share of renewable energy in district heating in Finland reached 33 % in 2015 [7].

Integrating heating and cooling into the electricity system is an issue where district heating also has the potential to be one of the key solutions facilitating the integration of more variable electricity production such as wind and solar power into an energy system. [8]

District heating is currently developing towards a concept coined as 4th generation district heating (4GDH). Its main characteristics are closer connection to other long-term infrastructure planning processes, low temperature heat distribution systems within the buildings, a smart low temperature distribution network, improved excess heat and renewable heat source integration and in overall closer integration with the surrounding energy system. [1]

One of the key aspects the 4GDH concept is the low temperature distribution, i.e. low temperature district heating (LTDH). This is typically defined as a system with supply temperatures between 30 °C and 70 °C [1].

A low temperature level in distribution greatly improves the potential for excess heat recovery, and use of renewable energy sources such as solar heat or heat pump technology utilising available, natural heat sources. It also improves the efficiency of more conventional heat supply technologies such as boilers and CHP plants.

This paper investigates the transition process from high or medium distribution to low temperature distribution in context of existing district heating systems. It describes the changes involved, and discusses the effects and relations between the different components in a district heating system.

The barriers due unevenly distributed benefits and needed investments caused by the transition process are discussed and potential solutions presented.

The objective is to construct a framework and a systematic method for evaluating the benefits and challenges of moving towards 4GDH systems. The study will lay the groundwork for a system specific case study of a major refurbishment of an existing district heating system. District heating system design in Finland is used as example when relevant.

2. Component specific impacts

Transition to low temperature distribution will have an effect on the district heating network itself, on the heat supply and on the requirements for consumer equipment. The specific impacts on each of these are explained and their interactions discussed.

Existing systems e.g. in Finland typically use outdoor temperature dependent supply temperatures, resulting in temperature level varying from about 80 °C to 115 °C depending on the season. Transition to LTDH implementation would lower the supply temperature to a constant temperature within the region of 30 to 70 °C. This change is illustrated in the Figure 1 below.