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

Annex XI final summary report

Transformation Roadmap from High to Low Temperature District Heating Systems

Project short title: Transformation roadmap

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Executive Summary

Background

The world is now planning and organizing a transition from the current fossil fuel based energy system to a future sustainable energy system based on renewables with greatly enhanced energy efficiency. This system transformation will of course also involve the current district heating (DH) technology, mainly developed within the fossil-based energy system, characterised by high temperature heat sources. However, the global district heating community has already performed similar system transformations twice before. Accordingly, the current best available district heating technology is labelled as the third generation. Consequently, the future sustainable technology generation should be labelled as the fourth generation of district heating technology.

This international research project has been focusing on identification of early and vital information about this transformation to a future fourth generation of district heating technology from previous technology generation shifts, current generation experiences, and early research attempts for this new district heating technology.

Every new technology generation for district heating has been characterized by lower distribution temperatures in the thermal grids, revealing that the temperature levels in these grids are important performance indicators. This conclusion is also valid for the new fourth generation, aiming at even lower temperatures in the thermal grids. Hence, the title of this project was chosen as ‘Transformation Roadmap from High to Low Temperature District Heating Systems’.

Research issues

The research work performed was based on seven identified research issues:

1 What experiences are available from previous shifts of technology generations for district heating?
2 What are the current temperature levels and the corresponding hydraulic situations used in district heating systems?
3 What are the possible solutions to reduce the current temperature levels used in district heating systems to a level close to the temperatures needed in the buildings?
4 What are the current temperature levels used in customer heating systems?

5 What are the possible solutions to reduce the current temperature levels used in customer heating systems while still satisfying heat demand with a correctly working heating system?

6 What temperature levels can be achieved in future district heating and customer heating systems and what are the corresponding low temperature heat sources?

7 What are the operational, technical and general conditions for concurrent operation of current and future parts of a district heating system with respect to their different temperature levels?

Conclusions

The conclusions provide the answers to the seven research questions:

1 What experiences are available from previous shifts of technology generations for district heating?

Answer: Hot water DH systems offer well-known economic and ecological advantages compared with steam DH systems. The dedicated shift from steam to water is accomplished either by installing new hot water DH systems indirectly connected to existing steam systems or by substituting existing steam systems with new water systems. Adding hot water circuits to a steam back-bone network can be implemented quite easily without significant impact on the steam system. Further transformation to low temperature DH is also possible: for example, return pipes in existing systems can be used as supply lines for low temperature DH.

2 What are the current temperature levels and the corresponding hydraulic situations used in district heating systems?

Answer: Annual average temperature levels in current systems are typically about 50-60 °C higher than ambient temperatures. These temperatures are elevated by about 10-15 °C compared with expected temperature levels because of temperature errors in distribution networks, customer substations, and customer heating systems. These errors increase the network return temperatures which in turn lead to higher supply temperatures, since the current hydraulic arrangements require a specific difference between supply and return temperatures. Use of indirect connections with heat exchangers in substations also incurs higher temperature levels.

3 What are the possible solutions to reduce the current temperature levels used in district heating systems to a level close to the temperatures needed in the buildings?

Answer: Three main strategies can be identified from the analysis of current temperature levels. First, all identified temperature errors in distribution networks, customer substations, and customer heating systems in current systems should be eliminated. Second, longer thermal lengths should be used in substation heat exchangers. Third, customer temperature demands in both new and existing buildings should be reduced, either by reducing the heat demand or by means of larger heat transfer surfaces.

4 What are the current temperature levels used in customer heating systems?

Answer: The research carried out in Switzerland revealed the only source of in-depth information of this kind. Here, the operational supply temperature for Space Heating (SH) is generally between 40 and 70°C. In new buildings equipped with underfloor heating systems, the operational supply temperature is typically between 25 and 35°C. The temperature required for Domestic Hot Water (DHW) preparation is mainly driven by the prevention of legionella generation (50-60°C is internationally considered as usual). DHW production often implies higher supply and/or return temperatures than SH because of legionella risks. Therefore the DHW production profile may influence the required supply/return temperatures of low temperature district heating networks.

5 What are the possible solutions to reduce the current temperature levels used in customer heating systems while still satisfying heat demand with a correctly working heating system?

Answer: Customer temperature levels can be decreased by optimizing the heat distribution in buildings. Potential ways to do this include buildings' envelope refurbishment to lower the heat demand; better supply temperature management; hydraulic balancing; use of variable-speed pumps; ensuring internal system components (eg thermostatic valves) are working properly. When carrying out envelope refurbishment, existing radiator sizes should be retained, and in new buildings, the use of small radiators should be avoided. Instantaneous production of DHW (without storage thus at lower temperature) is preferred, implying longer thermal lengths in substation heat exchangers.

Hydraulic schemes in substations should be conceived and adopted in order to achieve the lowest possible return temperature.

6 **What temperature levels can be achieved in future district heating and customer heating systems and what are the corresponding low temperature heat sources?**
Answer: The typical supply and return temperatures in district heating systems may in future be 55°C/25°C. In some areas with old buildings with low level of energy renovation temperatures of 70°C/40°C may be optimal in the coldest periods of the year. In areas with low-density heat use district heating with supply temperatures down to 35°C may be used in combination with local electrical supplementary heating of the DHW. The space heating system temperatures may be marginally lower by use of high performance heat exchangers.The following low temperature heat sources may be used for supply: waste heat from processes, deep geothermal heat, central heat pumps, solar heating plants with seasonal storage. Waste heat from incineration plants and backup power plants will contribute to the supply.

7 **What are the operational, technical and general conditions for concurrent operation of current and future parts of a district heating system with respect to their different temperature levels?**
Answer: It should be possible to elaborate effective strategies for concurrent operation to facilitate parallel use of current systems together with new low temperature parts with respect to operational, technical, and general conditions. The demand for concurrent operation will occur since new system parts will be introduced before the current system parts can apply the new low temperature technology. Some years will be required to lower the customer temperature demands in existing buildings by energy efficiency measures.

<u>Condensed Transformation Roadmap</u>

The condensed Transformation Roadmap can be expressed as:

1. Eliminate temperature errors in existing distribution networks and substations in order to make existing systems more efficient. This will reduce existing temperature levels.

2. Avoid these temperature errors in new network parts and in new substations.

3. Use heat exchangers with longer thermal lengths in substations for indirect connection of customer heating systems and closed hot water preparation. This will reduce the temperature differences between the warmer distribution waters and the colder fluids to be heated.

4. Reduce existing customer temperature demands by elimination of local temperature errors, reduction of heat demands by means of energy efficiency measures, and by installation of larger heating surfaces in radiator and ventilation systems.

5. New low temperature network parts in conjunction with existing systems can be connected by concurrent operation of these parts as secondary networks.

6. The long-term vision is to deliver heat to substations with a supply temperature of 50°C, while obtaining a return temperature of 20°C as annual average. However, the technical solutions for obtaining this low return temperature have yet not been defined.