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Essential improvements in future district heating systems

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Abstract

The major common denominator for future efficient fourth generation district heating systems is lower temperature levels in the distribution networks. Higher efficiencies are then obtained in both heat supply and heat distribution. Heat supply becomes more efficient with respect to combined heat and power, flue gas condensation, heat pumps, geothermal extraction, low temperature excess heat, and heat storage. Heat distribution becomes more efficient from lower distribution losses, less pipe expansion, lower scalding risks, and plastic pipes. The lower temperature levels will be possible since future buildings will have lower temperature demands when requiring lower heat demands. This paper aims at providing seven essential recommendations concerning design and construction strategies for future fourth generation systems. The method used is based on a critical examination of the barriers for lower temperature levels and the origins of high return temperatures in contemporary third generation systems. The two main research questions applied are: Which parts of contemporary system design are undesirable? Which possible improvements are desirable? Key results and the corresponding recommendations include temperature levels for heat distribution, recirculation, metering, supervision, thermal lengths for heat exchangers and heat sinks, hydronic balancing, and legionella. The main conclusion is that it should be possible to construct new fourth generation district heating networks according to these seven essential recommendations presented in this paper.

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Keywords: Low-temperature; System design; Recirculation; Thermal lengths; Hydronic balancing

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1. Introduction

1.1. Policy

District heating systems are an important component in achieving future sustainable energy systems. The main idea is to utilise heat from sources otherwise unutilised [1, 2]. Effectively, this decrease energy demand and dependency of energy imports. Furthermore, implementation of district heating systems reduces the strain of scarce energy resources. Lower system costs and less anthropogenic climate change is a ripple effect of more district heating.

Due to the local nature of district heating systems, the technology has often been overlooked in international policy assessments. This did, however, change in the Heat Roadmap Europe studies [3], wherein it was concluded that the European Union may reach its target of annual greenhouse gas emissions reduction to a lower cost with district heating compared to other proposed alternatives. Furthermore, the economic value of district heating was shown to be higher in a future scenario with a large degree of end-use energy efficiency measures [3] compared to a scenario with no end-use energy efficiency measures [4], when related to the reference alternative.

Some major recognition of district heating at a policy level can be observed in the United Nations Environment Programme report 'District Energy in Cities' [5] and by the European Union heating and cooling strategy [6, 7].

1.2. Technology change

In order to meet future conditions, the current district heating technology must be further developed. This technology has been referred to as third generation of district heating systems (3GDH) [2]. Hereby, the term for future development have been labelled as the fourth generation of district heating systems (4GDH), which has been defined in [2]. The basic idea is to maintain the best part of the current 3GDH technology while weak parts should be enhanced in 4GDH design.

1.3. Future conditions

Heat demands are expected to be lower in future buildings, as new buildings within the European Union are required to have a very high energy performance, referred to as nearly zero-energy buildings, from 2019 for public authorities and 2021 for others [8]. Furthermore, buildings which undergo major renovation should be upgraded to meet minimum energy performance requirements [8].

Lower heat demands entail opportunity, as adequate temperature requirement for space heating decrease as well, enabling lower temperature levels in distribution. In a long term structural perspective, levelling of adequate temperature requirements between supply, distribution, and end-use increase performance as there will be a better quality match between supply and demand and thus a better exergy utilisation rate [9].

Increased heat distribution costs are a consequence of future low heat demand energy systems. This relation is of concern regarding feasibility of future district heating systems. However, the distribution cost component generally constitutes a smaller proportion of the total cost structure and thus have a moderate impact on feasibility [10].

Improved efficiencies in district heating systems are also centred on lower temperature levels in the distribution networks. In heat supply, low-temperature operation entail improved performance in combined heat and power, flue gas condensation, heat pumps, low temperature excess heat, geothermal extraction, solar thermal, and heat storage [11]. In heat distribution, low-temperature operation entails improvements by lower distribution losses, less demand for pipe expansion, lower risk for scalding, and potentially use of other piping materials, e.g. plastics [11].

Currently identified barriers to lower temperature levels in district heating systems consist of demand side limitations, legionella issue, substations faults, and by-pass flows in networks [11]. From a technical system design perspective it is a challenge to overcome barriers which will allow low-temperature district heating operation. In current documentation of low-temperature systems, no annual average system return temperature below 30 °C has been recorded [11].