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Achieving low return temperature for domestic hot water preparation by ultra-low-temperature district heating

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Abstract

District heating (DH) is a cost-effective method of heat supply, especially to area with high heat density. Ultra-low-temperature district heating (ULTDH) is defined with supply temperature at 35-45 °C. It aims at making utmost use of the available low-temperature energy sources. In order to achieve high efficiency of the ULTDH system, the return temperature should be as low as possible. For the energy-efficient buildings in the future, it is feasible to use ULTDH to cover the space heating demand. However, considering the comfort and hygiene requirements of domestic hot water (DHW) preparation, supplementary heating devices should be combined, which can affect the return temperature in different extents. This study analysed the return temperatures of different types of substations for DHW preparation with ULTDH, and developed improvements in the substation for better energy efficiency. Both the instantaneous and storage-type electric heating methods were Long-term measured as supplementary heating for ULTDH in the case substations in Denmark. We analysed the seasonal impacts of the return temperature from the DHW loop on the overall return temperature of district heating. To achieve lower return temperature and higher efficiency for DHW supply, an innovative substation was devised, which replaced the bypass with an instantaneous heat exchanger and a micro electric storage tank. The energy performance of the proposed substation and the resulting benefits for the DH system by the lower return temperature were investigated

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Keywords: Ultra-low temperature district heating; domestic hot water; micro tank; electric heater; return temperature; heat loss

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1. Introduction

District heating is a cost-effective way of utilizing renewable and recycle energy as heating sources for covering the heat demand of the high-heat-density areas. The temperature levels of district heating systems is of great importance for better efficiency. Low supply temperature can increase the efficiency of recovering heat from industrial excess heat and geothermal heat, and can also improve the coefficient of performance (COP) of a heat pump for heat production [1]. Low return temperature can improve the efficiency of flue gas condensation in the heat plant. In addition, the distribution heat loss will be reduced if the distribution heat loss is lowered. Therefore, to implement low-temperature district heating (LTDH) plays an important role in improve the whole district heating system.

However, the comfort and hygiene requirements for heat supply should be taken into account when reducing the DH supply/return temperatures. In Nordic countries, such as Denmark and Sweden, DH supply covers both the space heating (SH) demand and domestic hot water (DHW) demand. For space heating, a comfort room temperature (20-22 °C) can be reached with a supply temperature at 40 °C if efficient heating equipment and operation methods are applied [2]. Regarding to DHW supply, the DHW should be able to be produced at 60 °C and circulated at 50 °C to avoid Legionella [3], and the water temperature at the faucet is required to reach 45 °C for the comfort reasons [4].

This study is based on an ultra-low-temperature district heating project in Denmark, where the heat demand of the test houses are covered by a DH system with supply temperature at 46 °C most of the year. To guarantee comfort and hygiene heat supply for DHW, different types of supplementary heating devices were installed in the house substations. However, the return temperatures of the DHW circuits are various according to the different substation layouts. This study investigated the return temperatures and energy performances resulted by different substations. In addition, a new DHW preparation method with ULTDH was devised, which aims at improving the overall system efficiency and reducing the return temperature to DH.

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2. Background of the ULTDH case study

The case project is located in Denmark. The heat source is the industrial excess heat from a local pump factory. A heat pump is used to recover the waste heat and deliver the heat to the heat consumers at 46 °C most of the year. The supply temperature is able to be increased to compensate the extreme cold climate during the winter

2.1. Comparison of return temperatures from different DHW configurations

The DHW preparation configurations play an important role in the average return temperature of the DHW circuits to DH. Two single-family houses in the area were selected for the analyses of this study. Both of the houses have the in-house substation. House #1 uses a storage tank for DHW preparation, while house #2 uses an instantaneous heat exchanger (IHEX) and a direct electric heater. House #1 and house #2 were built in similar time, and both of the houses have two occupants.

The schematics of the substations of the two case houses are shown as the following: