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DIGITALIZATION OF THE DEMAND-SIDE:

The enabler for low-temperature operations in existing buildings connected to district heating networks

By Michele Tunzi, Tecnical University of Denmark, DTU Construct, Department of Civil and Mechanical Engineering,
and Svend Svendsen, Professor at Technical University of Denmark

Abstract

The digitalization of the demand side increased significantly in the last few years. This was mainly due to the impulse of the European Energy Efficiency Directive (EED 2012/2018), binding member states to have all energy meters remotely readable by January 2027. In collaboration with the Danish industrial partners and the local district heating (DH) operator in Viborg, the innovative use and integration of data from heat cost allocators, DH energy meters, and temperature sensors helped secure low-temperature operations in existing buildings. It was documented that existing buildings connected to the local DH network can be comfortably heated with a supply and return temperature of 55/30 ˚C in the DH at 0 ˚C outdoor temperature without any deep energy renovation in the building or investments, yet secure correct control and operation of the heating systems.

Introduction

The new Green Deal set the new strategy for the transition towards a sustainable European energy system. The ambitious goals aim to achieve a carbon-free society by 2050 by integrating renewable energy sources, energy efficiency, and other sustainable solutions. In this direction, due to its high flexibility to integrate several energy sources and recover locally available excess heat, DH has been recognized as a key technology to sustain the green transitions and ensure the security of supply to the end-users.

The current DH technological challenge is to develop new solutions to sustain the 4th Generation DH (4GDH) shift. The core idea is to secure the expected comfort and hygiene for space heating and domestic hot water systems in buildings with low average supply and return temperatures in the range of 55 ˚C and 25 ˚C in the networks. Reducing the operating tempera-

tures in networks can secure the phase-out of fossil-fuel-based heat generation, minimize heat losses in the distribution networks, and reduce the energy use and overall cost of heating. Under the assumption of a future European DH sales of 950 TWh and a temperature reduction of 30 ˚C, it was estimated that low-temperature district heating (LTDH) could secure a potential yearly cost reduction of 14 billion euros.

The DH operators can control the supply temperatures and the pressure in the networks according to the seasonal variation of the heat demand. In contrast, the DH return temperature depends exclusively on the operations of the heating systems. Several studies found that existing buildings may be comfortably heated with supply temperatures below 55 ˚C for most of the heating season, but this is rarely the case. In fact, the inefficient control of space heating and domestic hot water systems limits low-temperature operations, particularly for large existing multi-storey buildings. Another common issue is related to the non-uniform heat distribution among different flats leading the entire building to be operated with unnecessary high supply temperatures. Hence, the buildings are seen as one of the major bottlenecks for the green transition of the DH industry.

Role of the digitalization of demand-side

The new European Energy Efficiency Directive 2018/2002 is binding member states to have all energy meters, including submeters in multi-storey buildings with central heating or connected to DH networks, remotely readable by 1 January 2027. While the primary intention of the policy is to secure billing transparency for the end-users, the impulse to digitalize the demand side is opening new opportunities to monitor the heating systems, improve the operation, and ensure the expected comfort in existing buildings with lower temperatures.

Innovative integration of data from heat cost allocators (mounted on each radiator), DH energy meters, and temperature sensors were developed to estimate the minimum supply temperature necessary to secure the indoor comfort based on the apartment with the greatest heat demand in multi-storey buildings. A strategy to gradually reduce the supply temperature in existing multifamily buildings was investigated in collaboration with industrial partners and the local DH operator in Viborg (Denmark).

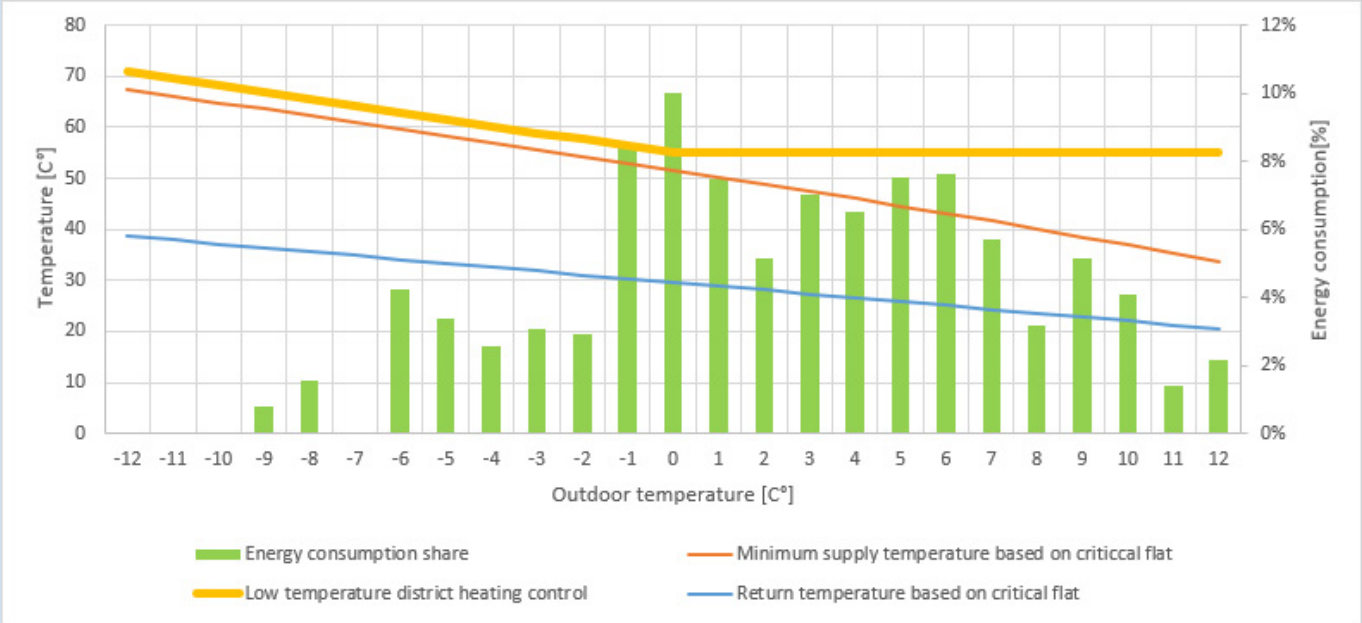
Experience from a local Danish district heating network

The experiment was carried out in five existing multifamily buildings connected to the local DH network. None of them went through a deep energy renovation, representing a sample of ordinary Danish residential buildings. The results documented that it was possible to ensure the heating comfort in the apartments with supply temperatures below 55 ˚C at outdoor temperatures of 0 ˚C in all buildings.

This was in line with the general low-temperature DH requirements, as illustrated in Figure 1. The new minimum supply temperature curve for the space heating system, presented in the figure, was estimated for the apartment with the highest heat demand in one of the buildings. This was below the corresponding DH supply temperature control curve, highlighting that low-temperature heating can be introduced in typical residential properties by simply adjusting the central weather compensation controller settings.

The figure also reported the real energy distribution for 2021 according to the different outdoor temperatures. Over 70% of the total heat consumption was used at outdoor temperatures above 0 ˚C. This suggests that for the most significant part of the heating season, the DH networks can be operated with a supply temperature of 55 ˚C. Furthermore, outdoor temperatures below -9 ˚C were never recorded in 2021, showing that the design conditions rarely happen in actual operations and that the heating systems are generally oversized and therefore suitable for being operated with lower temperatures.

Figure 1: Minimized operating temperatures in a multifamily building and DH low-supply temperature control curve.



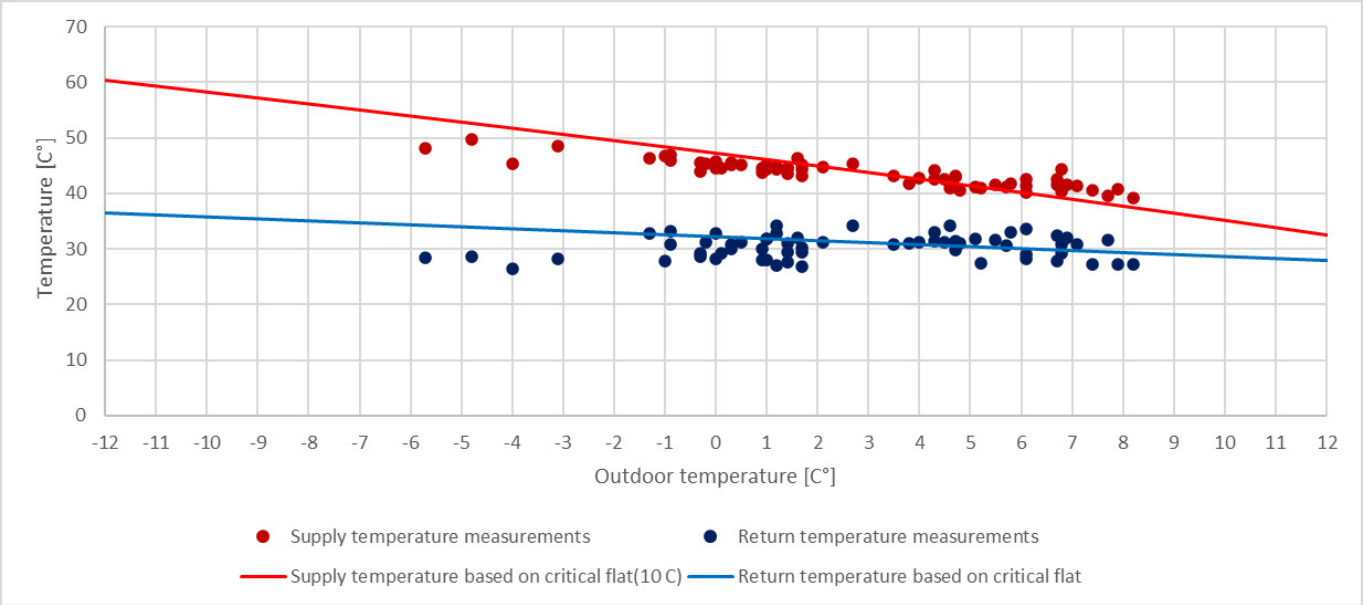


Figure 2: Minimum supply temperature based on the critical flat compared to the daily average measured supply temperature for January 2022 and February 2022

The experimental findings in one of the buildings documented an excellent fit between the heating system's measured daily supply and return temperatures and the innovative control curve calculated using the data from the heat cost allocators and central district heating energy meters, as presented in Figure 2. Hence, existing buildings can be comfortably heated with low operating temperatures even without deep energy renovation, and during the test period, the supply temperature was never above 50 °C.

Finally, the possibility of minimizing the operating temperatures inside buildings will be reflected accordingly in the network. This is crucial for the overall economy of the system.

The local DH operator in Viborg is shifting the heat generation from natural gas to sustainable alternatives. Investments in large heat pumps represent the first step of the green transition plan, and lower supply temperatures will reduce heat generation costs due to lower electricity consumption. This will also benefit the end-users with lower heating bills.

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