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Editorial

District Heating and Cooling towards Net Zero

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District energy is undergoing a deep transformation towards higher efficiency and greater flexibility through the promotion of renewable energy and waste energy sources. Sustainable solutions at the local level in cities and communities are essential to place citizens and consumers at the heart of the energy transition process. Dense urban areas are the ideal location for district heating and cooling (DHC), as well as industrial parks. Several ongoing projects are based on the construction and expansion of DHC networks, with the aim of building the smart energy systems of the future, while reducing both primary energy consumption and local emissions. Indeed, the market for district cooling (DC) is currently smaller than for district heating (DH), but it is expected to keep growing.

DHC technology has evolved, since its introduction at the end of the 19th century, towards operation at low temperatures. In fact, traditional systems, in which a centralized power station feeds hot water or steam into pipes for heat distribution, suffer from significant heat losses and high installation costs, due to piping insulation. Current research trends are focused on 4th and 5th generation DHC networks: the goal is to exploit a multitude of low-temperature heat sources while achieving a higher efficiency. Moreover, the inclusion of renewable heat sources can be easily pursued. Network supply temperatures, although dependent on the nature of thermal sources, can be as low as 15–25 °C in the latest generation.

In line with this concept, Calixto et al. [1] proposed two modelling procedures—at different levels of complexity—of a neutral-temperature DH network with decentralized heat pumps, where the supply temperature is close to the ambient temperature. An existing plant in Northern Italy was considered for quantifying its environmental advantage compared to individual boilers, while waiting for the experimental campaign necessary for model validation.

However, the impact of reducing the DH supply temperature on final users cannot be neglected, as highlighted by Grassi et al. [2]. Thermodynamic considerations of space heating clash with the current situation in most European countries, where heating systems in existing old buildings were designed for high-temperature operation. In light of this, a large-scale dynamic analysis of a building-thermal systems complex was carried out to estimate indoor thermal comfort. The main assumptions were the indirect connection of the user heating system to the primary DH through a plate heat exchanger and the presence of radiator-based user heating systems. The method was applied to buildings connected to a typical Northern Italian DH network to provide practical suggestions. It was found that the most severe discomfort conditions are experienced in buildings built before 1990. Nevertheless, long time periods of moderate discomfort may occur even in recent buildings due to poor radiator performance at very low temperatures.

The challenges arising from the integration of low-grade industrial waste heat into a DHC network were evidenced by Zhang et al. [3]. This shows that the industrial waste heat recovery system should meet the fluctuating district energy demand. A heat recovery loop was suggested as a possible solution, with hot water being the intermediate fluid. A mixed integer nonlinear programming model was formulated and solved to obtain the optimal operation plans for different time periods. The complex methodology yielded

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encouraging results, since the estimated annual benefits derived from the integration exceeded the annual cost.

The modelling of DHC networks is often seen in the published literature, featuring a diverse array of objectives. Performance assessment, from different points of view, was the main topic of the study by Corradi et al. [4]. Primary energy savings, the amount of CO_2 avoided, and economic indicators were computed for a DH network, in Central Italy, characterized by multiple technologies and energy vectors. The analysis was conducted whilst considering the perspectives of both the cogeneration plant and the end user. A very different subject was explored by Liden et al. in a two-part article [5,6]. They addressed the problem related to the thermal degradation of DH pipe insulation over time, which is highly difficult to quantify without excavation. A method relying on measuring the temperatures of a shutdown valve and a drainage valve, during the cooling period after shutdown, was conceived to attain the actual temperature in the supply pipe. This is fundamental for deducing the thermal status of the pipe insulation [5].

As a next step, a diagnostic protocol was developed and established for application to DH pipes in operation [6]. In particular, the choice of the drainage valves as measurement points has proven to be the most appropriate for capturing the temperature decline in the DH pipe during the above-mentioned cooling period. These data might be used for accurately predicting the thermal status of the pipe network, with the help of a numerical finite difference method.

Another aspect pertaining to DH management was discussed by Kováč et al. [7]. Their research focused on the short-term prediction of the thermal energy demand during the winter heating season. They started from the real environment of a DH system, in which historical data of the outdoor temperature, heat load, and heat-consumer configurations are stored in a database, but the control is based only on mathematical calculations. Different prediction methods for the control of the heating process were applied to choose the best algorithm, namely, a neural network, or a combination of wavelet transform and neural network. The main outcome is a MATLAB GUI application that can support the work of dispatchers.

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