World Academy of Science, Engineering and Technology
International Journal of Energy and Power Engineering
Vol:18, No:04, 2024

Decarbonising Urban Building Heating: A Case Study on the Benefits and Challenges of Fifth-Generation District Heating Networks

Authors : Mazarine Roquet, Pierre Dewallef

Abstract : The building sector, both residential and tertiary, accounts for a significant share of greenhouse gas emissions. In Belgium, partly due to poor insulation of the building stock, but certainly because of the massive use of fossil fuels for heating buildings, this share reaches almost 30%. To reduce carbon emissions from urban building heating, district heating networks emerge as a promising solution as they offer various assets such as improving the load factor, integrating combined heat and power systems, and enabling energy source diversification, including renewable sources and waste heat recovery. However, mainly for sake of simple operation, most existing district heating networks still operate at high or medium temperatures ranging between 120°C and 60°C (the socalled second and third-generations district heating networks). Although these district heating networks offer energy savings in comparison with individual boilers, such temperature levels generally require the use of fossil fuels (mainly natural gas) with combined heat and power. The fourth-generation district heating networks improve the transport and energy conversion efficiency by decreasing the operating temperature between 50°C and 30°C. Yet, to decarbonise the building heating one must increase the waste heat recovery and use mainly wind, solar or geothermal sources for the remaining heat supply. Fifth-generation networks operating between 35°C and 15°C offer the possibility to decrease even more the transport losses, to increase the share of waste heat recovery and to use electricity from renewable resources through the use of heat pumps to generate low temperature heat. The main objective of this contribution is to exhibit on a real-life test case the benefits of replacing an existing third-generation network by a fifth-generation one and to decarbonise the heat supply of the building stock. The second objective of the study is to highlight the difficulties resulting from the use of a fifth-generation, low-temperature, district heating network. To do so, a simulation model of the district heating network including its regulation is implemented in the modelling language Modelica. This model is applied to the test case of the heating network on the University of Liège's Sart Tilman campus, consisting of around sixty buildings. This model is validated with monitoring data and then adapted for low-temperature networks. A comparison of primary energy consumptions as well as CO2 emissions is done between the two cases to underline the benefits in term of energy independency and GHG emissions. To highlight the complexity of operating a lowtemperature network, the difficulty of adapting the mass flow rate to the heat demand is considered. This shows the difficult balance between the thermal comfort and the electrical consumption of the circulation pumps. Several control strategies are considered and compared to the global energy savings. The developed model can be used to assess the potential for energy and CO2 emissions savings retrofitting an existing network or when designing a new one.

Keywords : building simulation, fifth-generation district heating network, low-temperature district heating network, urban building heating
Conference Title : ICAE 2024 : International Conference on Applied Energy
Conference Location : Tokyo, Japan
Conference Dates : April 22-23, 2024