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GIS-BASED ASSESSMENT OF 5TH GENERATION DISTRICT HEATING AND COOLING (5GDHC) SYSTEMS WITH SEASONAL THERMAL ENERGY STORAGE

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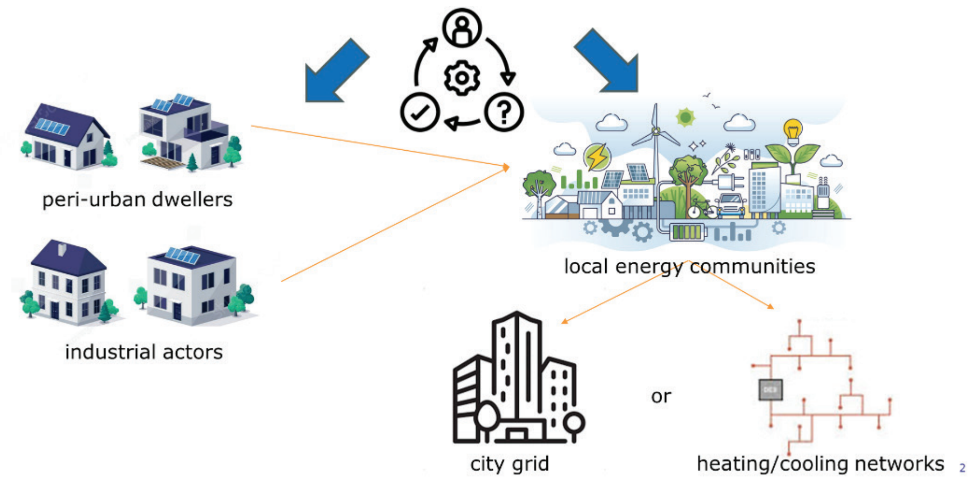
Abstract – The transition to sustainable energy solutions necessitates innovative approaches to district heating and cooling (DHC) systems. Fifth-generation district heating and cooling (5GDHC) systems, integrated with seasonal thermal energy storage (TES), offer a promising pathway to enhancing energy efficiency while reducing environmental impact. This study, conducted within the OPTIMESH project (OPtimized Thermal prosumer Integration in a Multi-Energy System), explores the robust design of 5GDHC systems tailored for business parks in Flanders through Geographic Information System (GIS) assessment. OPTIMESH aims to optimize the integration of thermal prosumers – buildings that act as both consumers and producers of thermal energy – within multi-energy systems. By leveraging GIS-based methodologies, we identify and analyse potential locations, evaluate energy exchange feasibility, and configure network layouts. The study incorporates multiple data sources, including operational data on waste heat availability, building models, and HVAC system data, to ensure accurate and efficient network design. A high linear heat density is essential for 5GDHC system viability, necessitating a rigorous assessment of more than 40 potential locations across Flanders. GIS tools are employed to assign EPC labels, detect waste heat sources, and map underground utilities such as cables, gas, and water pipelines. We systematically compare three standalone heating solutions – natural gas boilers, air-source heat pumps, and ground-source heat pumps – to assess the relative benefits of 5GDHC deployment. To achieve an optimal configuration, our methodology evaluates up to 60 different network configurations per location. The integration of GIS-generated spatial data with graph-theory-driven simulations allows for a comprehensive assessment of potential layouts, ensuring efficiency in both thermal energy distribution and seasonal storage utilization. The results of these simulations are exported, post-processed, and visualized for further analysis. Key methodologies presented in this study include GIS assessment, thermographic imaging, image recognition, exergy analysis, and steady-state simulations. Our findings highlight the critical role of high-resolution data in designing effective 5GDHC networks. The results cover various aspects, including input assumptions, location selection, network configurations, energy exchange dynamics, and feasibility metrics. This research underscores the economic and ecological advantages of 5GDHC systems, particularly in business parks where simultaneous heating and cooling demands can be efficiently met. By systematically integrating diverse data sources and advanced simulation techniques, this study provides a robust framework for the development of next-generation DHC systems, contributing to a more sustainable and resilient energy infrastructure.

Keywords – Energy efficiency; network configuration; sustainability; thermal prosumers; waste heat



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