VRIJE UNIVERSITEIT BRUSSEL

The faculty of Engineering of the Vrije Universiteit Brussel invites you to attend the public defense leading to the degree of

DOCTOR OF ENGINEERING SCIENCES

of **Afraz Mehmood Chaudhry**

The public defense will take place on **Tuesday 4th February 2025 at 5pm** in room **I.0.01** (Building I, VUB Main Campus)

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ROBUST DESIGN AND OPERATIONAL OPTIMIZATION OF DISTRICT HEATING AND COOLING NETWORKS

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Abstract of the PhD research

Today, most of the global population lives in urban areas, spending most of their time inside buildings or commuting between them. Buildings require heating and cooling to ensure comfort, often involving burning fuels for heating and using electricity for cooling or heating. This reliance on fossil fuels and electricity from non-renewable sources drives up costs and significantly contributes to environmental harm, including greenhouse gas emissions.

New district heating and cooling (DHC) networks of the fifth generation (5GDHC) offer a promising solution by operating at lower temperatures. This enables them to incorporate waste heat, renewable energy sources, and decentralized prosumers (buildings that both consume and produce energy). These networks can lower costs and emissions by reducing reliance on conventional fuels and optimizing energy usage. However, designing and managing 5GDHC networks is complex, as uncertainties in future energy prices, demands, and technologies make it difficult to plan for optimal performance and sustainability.

The biggest hurdle in using 5GDHC networks is optimizing their design and operation under these unpredictable conditions. This involves identifying which uncertainties matter most and ensuring the network is efficient and cost-effective.

For existing networks, a smarter control system was developed to improve how they operate. This system adjusts heating based on real needs rather than just the weather, leading to better energy recovery and lower costs. For future 5GDHC networks, a framework was created to test different designs and their costs, emissions, and performance under various future scenarios. The framework uses advanced mathematical and machine learning techniques to find the best balance between economic and environmental goals.

Testing the new operational strategy on an existing network at the VUB campus cut energy costs by 18%, emissions by 8%, and improved efficiency by 6%. For 5GDHC networks, the framework showed that environmentally friendly designs can lower emissions by 13%, though they cost 10% more upfront. These designs still offer long-term savings and better financial returns in some cases.

This research helps improve existing heating networks and supports the transition to more sustainable 5GDHC networks. It gives operators tools to save money and cut emissions while ensuring comfort for users. Investors can use the findings to decide between cheaper or greener designs based on their financial and environmental priorities.