DC Number	DC7
Title of the PhD Project	Robust and optimal planning of district heating networks for next-generation energy systems
Keywords	District heating networks, Topology optimization, Robust optimal design
Recruitment organisation	Flemish Institute for Technological research (VITO)
Enrolling university	KU Leuven
Supervisors names and contacts	Robbe Salenbien (robbe.salenbien@vito.be) and Maarten Blommaert (maarten.blommaert@kuleuven.be)
Scientific context and objectives	Heating networks are considered one of the core technologies to enable renewable space heating, and to overcome the current reliance on gas and oil. Using thermal storage, they offer a cost-effective way to provide flexibility for electrical grids that become more and more subject to the intermittency of renewables like wind and PV. In addition, next-generation heat networks that operate at low temperatures, are able to incorporate high shares of renewable-based heat sources and waste heat sources. However, the planning of such systems is no straightforward task, especially in existing systems that were built for high-temperature, fossil fuel-based operation. Moreover, the physics of the system is nonlinear in nature and their optimal planning is case specific and involves several uncertain parameters that impact the viability of the project. Therefore, automated design methods can seriously facilitate this process. To fundamentally tackle the design problem, the PhD student starts from the novel optimal design approach that was recently developed in a collaboration between KU Leuven and VITO in the framework of EnergyVille, which is the first to realize physics-based optimal design of network topologies for heating networks of practical size [1-3]. On this basis, a framework will be developed for the optimal retrofitting of existing infrastructure to robust, flexible, and energy-efficient low-temperature networks. By considering heat production, network changes, and redesign of substations as part of the optimization, the limits of waste heat integration are aimed for through an optimal decrease of operational temperatures. Simultaneously, robust operation has to be guaranteed to ensure user comfort. The PhD student will be part of VITO's THES group in EnergyVille and will work in close collaboration with KU Leuven's IDEAL group [4]. Through the strong collaborations between researchers of both groups, the PhD research keeps a close link to both the development of model-based optimal design algorithms, as well as to the application in district heating development projects in Belgium. Moreover, the successful applicant for this position will be enrolled in the excellent doctoral training program of KU Leuven's Arenberg Doctoral School.
Required skills	You are a highly motivated, enthusiastic and communicative researcher, and you are strongly interested in the development of models and optimization procedures for the design of next-generation district heating networks. Moreover, you are a team player that enjoys collaborating with people within the research group, the project, and beyond, and have: • A master's degree in Engineering with a background in mechanical engineering, computer science, or related field, from a reputable institute, with outstanding study results, • A background in numerical modelling, • The qualities to carry out independent research, demonstrated e.g., by the grades obtained on your MSc thesis, • A critical and practical mindset, • Very good knowledge of English.

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	Additional research/educational experience in any of the following topics is considered a strong advantage: • Coding in languages such as MATLAB or python. • (Gradient-based) numerical optimization, • District heating and cooling, • Flow and heat transfer modelling, • Topology optimization.
References	[1] Wack, Y., Sollich, M., Salenbien, R., Diriken, J., Baelmans, M., Blommaert, M. (2024). A Multi-Period Topology and Design Optimization Approach for District Heating Networks. Preprint in arXiv:2401.15976 [2] Wack, Y., Baelmans, M., Salenbien, R., Blommaert, M. (2023). Economic topology optimization of District Heating Networks using a pipe penalization approach. *Energy*, *264*, Art.No. 126161. doi: 10.1016/j.energy.2022.126161 [3] Blommaert, M., Wack, Y., Baelmans, M. (2020). An adjoint optimization approach for the topological design of large-scale district heating networks based on nonlinear models. *Applied Energy*, *280*, Art.No. 116025. doi: 10.1016/j.apenergy.2020.116025

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