

Integrated modeling and simulation of electricity, gas and heat networks underlying a sustainable city infrastructure

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Wiet Mazairac is runner-up award winner of the DHC+ Student Award. As PhD Fellow at VITO and Eindhoven University of Technology, The Netherlands, he is developing a city energy networks model, which enables the integrated modeling and simulation of electricity, gas and heat networks underlying a sustainable city infrastructure.

Integrated Modeling and Simulation of Electricity, Gas and Heat Networks Underlying a Sustainable City Infrastructure

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The energy sector faces numerous challenges, e.g. the depletion of fossil fuel reserves and the impact of fossil fuels on our environment. A transition towards a renewable energy system will resolve these issues. However the current energy distribution system, which was designed to distribute energy from few producers among many consumers, is not able to cope with mass integration of renewable energy systems.

Multi-carrier hybrid energy distribution networks will be able to cope with mass integration of renewable energy systems. Instead of a network connecting few producers to many consumers, future networks will interconnect energy units, which are simultaneously producer and consumer. Hybrid energy networks also provide flexibility in the case of network malfunctions, energy shortages or price fluctuations. The strong interconnection between the different energy carriers makes it possible to convert energy from one form to another, which enables consumers to change from carrier or to bypass a broken connection.

This paper presents the ongoing PhD research project in which an approach is being developed to determine the optimal topology of a hybrid energy distribution network. This approach determines the location of energy distribution lines, conversion and storage units, given the location of energy producers and consumers in order to find the optimal balance between capital, operational and maintenance costs on the one hand and revenue on the other hand.

Two optimization techniques have been applied, first to single-carrier networks and then to multi-carrier networks. The first, the cross-entropy method, clearly separates the model and the optimization algorithm, which allows for a flexible, detailed model. The second, the linear programming method, integrates the model and the optimization algorithm, which imposes a restricted model. Both methods return plausible results, however the cross-entropy method is computationally expensive.

In the near future an algorithm, which determines the optimal location and characteristics of possible storage units, will be added to the optimization model. This requires a dynamic optimization model for which load profiles are generated by a hidden Markov model.