Designing a model for the cost-optimal decommissioning and refurbishment investment decision for gas networks: application on a real test bed in Austria until 2050

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Overview

The already ongoing defossilization of the provision of energy service needs leads to declining natural gas demands. Given that and under the expectation that green gases are very limited in their availability/potential, a transparent and critical discussion regarding the future development of gas networks without any taboos is needed. This also includes decommissioning of (parts of) the existing gas network infrastructure. The primary goal of this paper is to investigate the most cost-effective decommissioning and refurbishment investment decision for gas networks. An optimization model is developed and tested on a real test bed in an Austrian federal state. The analysis is performed from the network operator's perspective and depicts different network decommissioning or refurbishment options under the decision of supplying or not supplying available gas demands. Whether or not there is ensured supply, we find that smaller gas networks (in terms of pipeline capacity and network length) are needed in the future. Analyzed shadow prices indicate that a balance/trade-off between the cost-optimal gas network design with and without ensured supply could lead to a robust and economically competitive future for downsized gas networks. The results demonstrate that it is necessary to socialize network operators' costs among the remaining consumers connected to the network in the future. This adds a cost component to consumers, which needs to be considered when determining the profitability of sustainable alternatives to natural gas.

Methods

The method used is the development of a linear optimization model. Thereby, the objective function is to minimize the network operator's net present value over time. Particularly, the optimal solution of the model includes the decommissioning and refurbishment investment decision of parts of the network and single pipelines. This includes deciding whether or not to supply available gas demand. The dual variables of the local gas balance constraints allow us to assess the techno-economic range of supply alternatives for each node in the network.

The numerical example examined is a small portion of the existing Austrian gas network infrastructure in the NUTS2 region Vorarlberg, Austria. This area is distinguished by a wide range of energy service requirements that are met by natural gas (e.g., residential, and industry). Furthermore, the gas network infrastructure includes not only high- and mid-pressure network connections but also cross-border connections to neighboring countries Germany and Lichtenstein (i.e., transmission network level). There is also the possibility of producing green gas and injecting it into the existing gas network infrastructure.

Results & Conclusions

We find that smaller gas networks (in terms of pipeline capacity and network length) are needed in the future regardless of ensured supply or not. However, the results indicate a wide range of possible network developments until 2050 resulting from the treatment of available gas demand. That reveals crucial trade-off decisions for gas network operators in the future and includes, the decommissioning decision of gas pipelines despite possible gas demand. Moreover, the conducted analysis of shadow prices of the local gas balance constraint shows that a balance/trade-off between the cost-optimal gas network design with and without ensured supply could lead to a robust and economically competitive future of gas networks.

Nevertheless, the results demonstrate that it is necessary to socialize network operators' costs under the remaining consumers connected to the network in the future. This fact has several important implications. First and foremost, that brings an additional cost component to consumers, which needs to be considered when dealing with the profitability of sustainable alternatives substituting natural gas. Analyses elaborating on trade-offs between natural gas and other sustainable supply options are often neglecting this network-related cost component, which brings a bias into the decision process.