

Moving from Natural Gas to Hydrogen: Optimal Network Rededication and Investment Over Time

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Extended Abstract

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Abstract Summary

The transition from natural gas to hydrogen requires decisions on network rededication and expansion that account for both long-term infrastructure needs and the physical characteristics of gas transport. Against the background of planned hydrogen backbone infrastructure, the paper addresses the question of how existing natural gas networks can be transformed in a cost-efficient way while including nonlinear network flows due to the ruling nonlinear physical characteristics of gas transport. To this end, we formulate a mixed-integer nonlinear optimization model that combines discrete investment and repurposing decisions with nonlinear gas flow physics. The model allows for the construction of new pipelines and compressors, the rededication of existing natural gas pipelines to hydrogen, and the discrete decision for each pipeline to either natural gas or hydrogen transport. By extending the model over several time steps covering demand shifts from natural gas to hydrogen, the approach determines suitable network structures for the transformation process. The results compare alternative transformation pathways, in particular network development with and without the option to repurpose existing infrastructure. We analyze resulting network structures, flow patterns, and investment decisions over time, and assess the economic implications of these alternative pathways. In this way, the paper contributes to the literature on hydrogen infrastructure planning by providing a mathematical framework for evaluating the role of network repurposing under realistic gas transport conditions.

Presenting Author Biography

Johannes Wirth was a research associate at the Chair of economic theory at FAU Erlangen-Nuremberg from May 2023 to February 2024 in the research area Energy Markets and Sector Coupling. Since March 2024, he has been part of the Energy Systems and Market

Design lab at University of Technology Nuremberg (UTN). His research interests include regional and global hydrogen markets, sector coupling of hydrogen and electricity systems and markets as well as infrastructure development for expanding hydrogen networks and the transformation of gas networks. He studied industrial engineering at FAU Erlangen-Nuremberg.