Exploring the role of hydrogen pipeline infrastructure in a sector-coupled European energy system towards 2050

Themenbereich 2 und 3
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Motivation und zentrale Fragestellung

With Europe's desired independence from Russian gas, following the war on Ukraine and the growing use of renewable energy to reduce CO_2 emissions, hydrogen use in the EU is set to increase in the future [1]. In this context, transport via pipelines will play an increasingly important role, either by using parts of the existing natural gas infrastructure or by building new pipelines [2]. Using the Global Energy System model (GENeSYS-MOD), this paper investigates how the transport of hydrogen in existing natural gas pipelines affects production, transport options, and regional localization of hydrogen generation and demand in the EU.

Methodische Vorgangsweise

For this work, a model setup used in the Horizon 2020 project openENTRANCE is used in which low-carbon transition pathways for Europe were modeled in GENeSYS-MOD (see Figure 1) as part of an open modeling platform. The four pathways represent three very ambitious scenarios and one slightly less ambitious, yet still compatible with a 2 °C climate target, considering different political, societal, and technological developments [3,4].

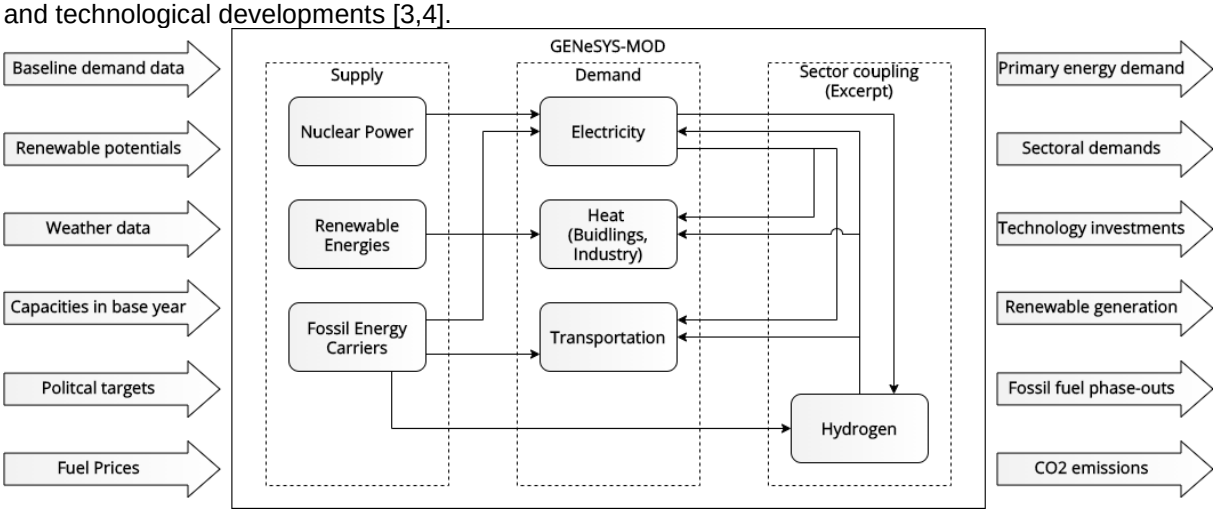

Figure 1: Stylized structure of GENeSYS-MOD, including relevant inputs and outputs

The Gradual Development scenarios is used as the baseline in this work, representing a moderate mixture of all three dimensions [3]. Europe is disaggregated into 30 regions (mainland EU-25, Norway, Switzerland, UK, Turkey, and an aggregated Balkan region) and a pathway from 2018 to 2050 is calculated in 5-year steps. 2018 is used as a reference year for calibration purposes. To ensure an adequate representation, hydrogen production and hydrogen transport technologies are refined within the model. This includes the possibility of retrofitting natural gas pipelines to allow hydrogen transport. Then, to address the question of how different proportions of hydrogen in natural gas pipelines affect hydrogen production and transportation infrastructure, various sensitivities in the form of model runs allowing different shares of hydrogen are computed and the results compared.

Ergebnisse und Schlussfolgerungen

Preliminary results suggest that increasing hydrogen transport through existing natural gas pipelines has a significant effect on regional distribution and trade of hydrogen within Europe (see Figure 7). However, the overall demand for hydrogen is highly inelastic given the high CO_2 prices and emission

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reduction targets (100% in 2050). With an increasing share of hydrogen in existing gas pipelines, hydrogen trading is increasing in countries with high generation potential. Simultaneously, the use of methanation, an alternative for storing and trading produced energy, is decreasing. In general, production and trade increase until a hydrogen share of around 20% is reached in existing pipelines, and then stagnate.

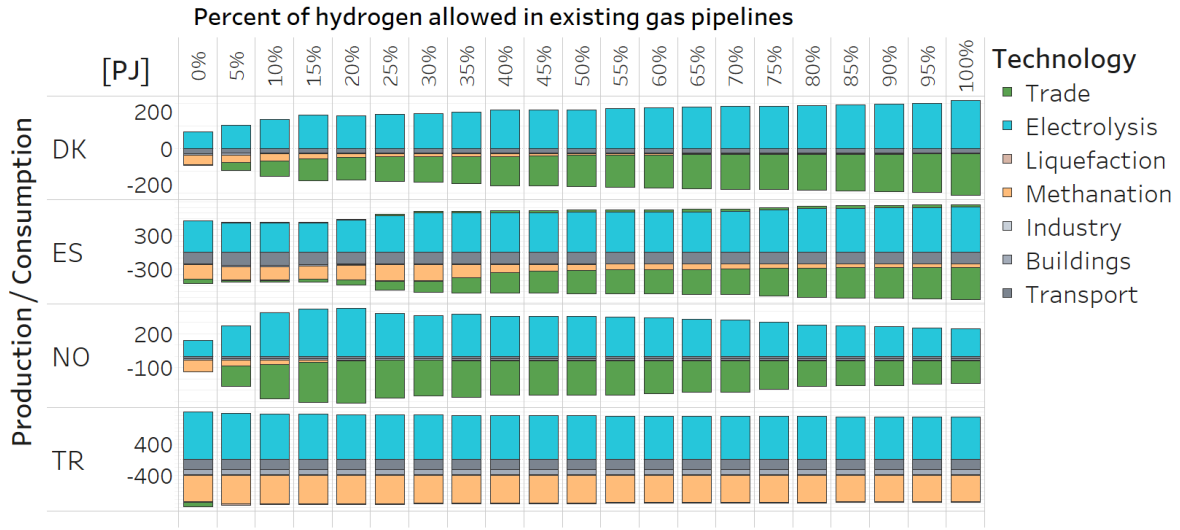

Figure 2: Hydrogen generation and use at country-level for select countries.

The use of existing gas-pipelines may be beneficial for European trade, but since renewable hydrogen is a limited resource, preference should be given to measures where hydrogen use is the most sensible in terms of energy efficiency and cost-effectiveness, given the available technology options. To refine the analysis, the impact of different infrastructure assumptions on system costs is required. Furthermore, more in-depth research on the potential of the current European natural gas grid and other transport options, such as liquid hydrogen or ammonia, and the impact of global hydrogen trade on European markets is required.

Literatur

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