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## **EVALUATING THE ROLE OF HYDROGEN BACKBONE INFRASTRUCTURE IN GERMANY'S ENERGY SYSTEM**

Hydrogen is expected to play a key role in decarbonizing energy systems. The planning of hydrogen generation, transportation and storage infrastructure is thus a critical area of research [1]. In this study we compare the impact of the hydrogen backbone in Germany using the open source model MyPyPSA-Ger [2].

### **Methodology**

We use MyPyPSA-Ger, a high-resolution capacity expansion energy system model. In this study, Germany is represented with 32 spatial clusters and hourly resolution (8760 hours/year). The model follows a myopic, cost-optimization approach from 2020 to 2050. We compare two configurations of the energy system: one including the hydrogen backbone, and one without it. Industrial hydrogen demand is included and can be met by electrolyzers using grid electricity.

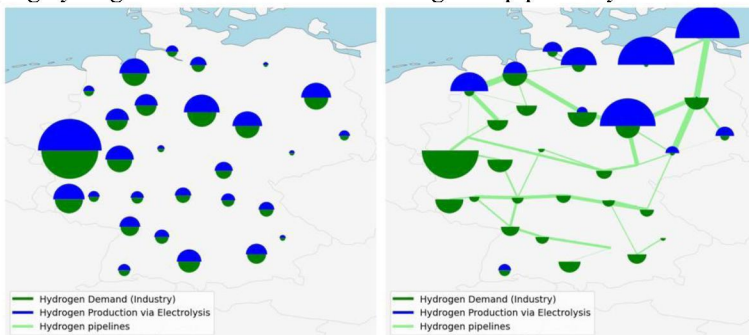
### **Key Results**

Including the hydrogen backbone results in higher installed capacity of hydrogen-related infrastructure, such as electrolyzers, fuel cells, and hydrogen storage, as well as greater investment in OCGT, CCGT, and wind power. Despite the higher installed capacity, the system with the backbone results in lower total system costs, being approximately 15% cheaper in the final year of the simulation. Curtailment levels and overall technology usage remain similar in both configurations.

Figure 1 compares hydrogen production across clusters in 2050. While hydrogen demand remains similar, the system without the backbone leads to decentralized production across all clusters. In contrast, the model with the backbone concentrates hydrogen production in northern nodes, where wind resources are abundant and electricity is cheaper. This centralized approach enables cost-effective hydrogen transport via pipelines, avoiding the need for expensive local electrolyzer installations in suboptimal locations. It also reduces the need for additional AC transmission expansion, since hydrogen demand represents a substantial increase in electricity demand through electrolysis.

It is important to note that the model is myopic and operates on a yearly basis. For example, in 2028, when the hydrogen backbone is not yet fully developed, the model installs electrolyzers at all nodes with hydrogen demand to meet local needs. However, by 2035, when the backbone is nearly complete, the

model shifts its strategy and installs more electrolysis capacity in the north, supplying hydrogen to all demand nodes through the pipeline system.



a – Without hydrogen backbone; b – With hydrogen backbone

Figure 1 – Hydrogen production and demand in 2050.

### Conclusions

The hydrogen backbone allows a more efficient energy distribution. While installed capacity increases, it is strategically deployed to reduce operational costs. This national-level study provides valuable insights about the benefits of the hydrogen backbone in Germany and also a basis for future regional analyses of hydrogen infrastructure in Germany.

### REFERENCES

1. Neumann, F., et al. (2023). The potential role of a hydrogen network in Europe. *Joule*, 7(8), 1793-1817.
2. Abuzayed, A., & Hartmann, N. (2022). MyPyPSA-Ger: Introducing CO2 taxes on a multi-regional myopic roadmap of the German electricity system towards achieving the 1.5° C target by 2050. *Applied Energy*, 310, 118576.