

# **Scaling Hydrogen Production and Storage: Lessons from Supply Chain Optimisation Across all Spatial Scales**

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Hydrogen and hydrogen-based synthetic energy carriers will play a central role in storing and utilizing renewable energy (RE) within a carbon-neutral energy system. While the round-trip efficiency is lower than that of batteries, molecular energy storage becomes indispensable when capacities exceed the GWh scale, when storage durations extend over months, or when energy must be transported across international distances. Moreover, hydrogen and its derivatives expand the use of renewable energy into hard-to-electrify sectors and offer a valuable sink for surplus electricity.

But where is the tipping point between batteries and hydrogen storage, and how does it shift with technological progress? How can both options be combined synergistically? What advantages does hydrogen bring to energy systems with abundant versus scarce RE potentials? And how should hydrogen storage be operated in practice? Insights into these questions can be gained through modelling of hydrogen supply chains.

Fraunhofer ISE conducts simulation and optimisation across all spatial scales, from the plant level to global PtX supply chains. This presentation will share results from a range of research projects, including efficiencies and costs of hydrogen production and storage as a function of RE potential, the role and challenges of cavern storage, and the benefits of optimised operation strategies. The distilled lessons aim to support stakeholders and decision-makers from industry and politics in shaping effective investments and policies and contribute to improved understanding of the role of hydrogen (storage) in a carbon-neutral energy system.