Fraunhofer ISE

Fraunhofer Institute for Solar Energy Systems ISE

Hydrogen System Analysis

Optimizing the Hydrogen Economy

ise.link/hsa

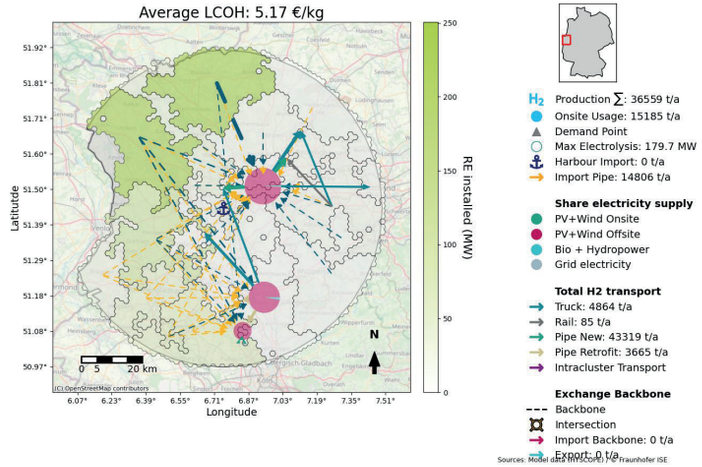
Optimizing the Hydrogen Economy

Efficient production of hydrogen and its derivatives requires integrated planning, design, and operation across the entire value chain. Our holistic system analysis tools, covering technological, economic, ecological, temporal and spatial dimensions, enable us to deliver tailored solutions for our partners' needs.

Our Offer

- Identification of the most promising locations for hydrogen and Power-to-X (PtX) hubs worldwide
- Geo-techno-economic analysis of regional and global hydrogen production and supply chains
- Optimization of PtX plant configurations and systems
- Development and assessment of advanced operating concepts and business models for electrolyzers
- Analysis of the optimal means of transport and distribution (ship, train, truck, pipeline) of hydrogen and its derivatives from the production site to the point of application/usage, including port infrastructure requirements
- Prospective life cycle assessments to analyze environmental impacts, resource use and energy requirements under future conditions

On the right: GIS-based analysis identifies promising locations for hydrogen and Power-to-X production.



Analyzing renewable electricity potentials and industrial H_2 demands.

Regional Hydrogen and Power-to-X Production and Supply Chains

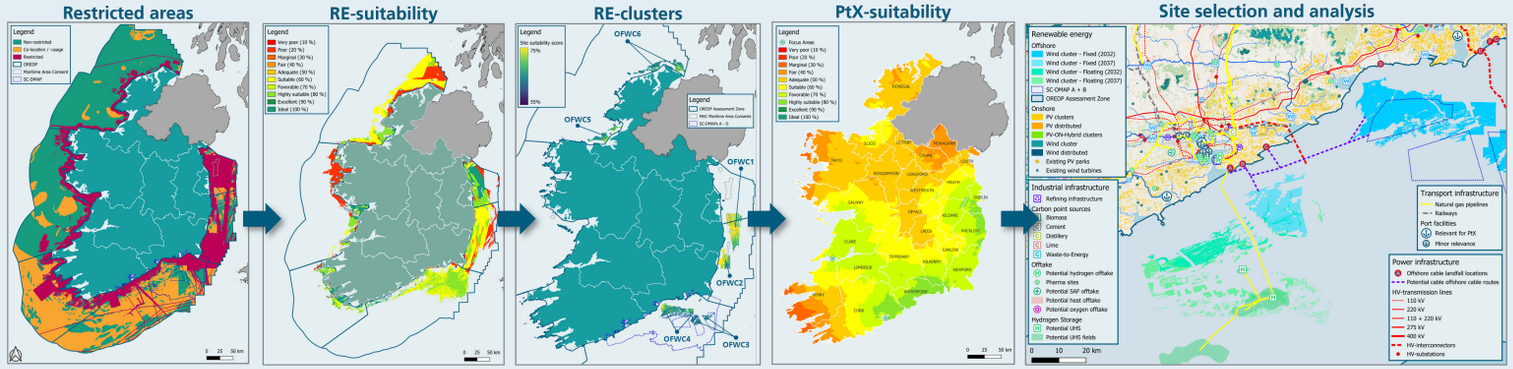
We map, analyze, and optimize the upgrading and construction of regional infrastructure and the full value chain of regional supply networks in geo-techno-economic terms. Using GIS and our HYSCOPE toolbox, we identify cost-efficient sites for hydrogen and Power-to-X (PtX) plants, storage and direct air capture (DAC) facilities. This yields a spatial, time-resolved view of demand and production. By linking this data, we develop a cost-efficient, locally optimized hydrogen landscape that avoids stranded assets and considers transport costs, renewable energy potential and offtake requirements.

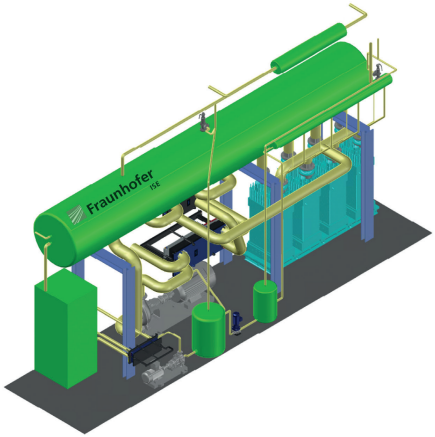
Global Hydrogen and Power-to-X Production and Supply Chains

For the techno-economic evaluation of global production and supply chains, we use dynamic system modeling based on our in-house H2ProSim library to design and optimize hydrogen and derivative supply chains – from feedstock provision through hydrogen and syngas production, conversion and storage to transnational or hinterland transport and the offtake point. Key pathways include liquid hydrogen, ammonia, methanol, eSAF and dimethyl ether (DME). We assess renewable energy potential and identify sites for renewable energy clusters and PtX hubs via GIS data. Building on this, we calculate electricity costs for promising sites, and, accounting for losses, storage and transport, derive the final costs of hydrogen and green molecules.

Process Simulation of Power-to-X Plants

All our assessments rely on detailed process simulations to capture reaction kinetics and conversion efficiency in synthesis and reforming processes involved. We optimize synthesis and reforming plants with Aspen Plus and in-house modeling tools, incorporating material/energy integration (CO_2 capture, heat recovery) and cost models with optimized algorithm packages. This enables consideration of key specifications across the entire production and supply chain.





Technical design of a 10 MW PEM electrolysis system by Fraunhofer ISE: Plants according to customer specifications.

Detailed Analysis and Concept Development of Hydrogen Systems

We develop tailored concepts for electrolysis and conduct market and feasibility analyses. Leveraging advanced techno-economic assessments, we evaluate and optimize electrolysis systems and hydrogen-based infrastructure for performance and cost-effectiveness across operating scenarios. Our H2ProSim toolbox enables dynamic modelling, simulation, optimaziation, and digital twins – delivering reliable, efficient and economically viable hydrogen solutions.

Prospective Life Cycle Assessment

LCA provides a holistic view of environmental impacts, inputs and energy demands across the life cycle of hydrogen and PtX pathways. We assess under current boundary conditions and future defossilization scenarios. Our methodologies enable the comparison of processes and products in light of current regulatory frameworks (e.g., RED II, CBAM). Besides this, they focus on material demand and criticality in the context of transformation and fully defossilized scenarios.

Further Information

Hydrogen System Analysis

H_2ProSim

Contacts

Hydrogen Technologies – Hydrogen System Analysis

Dr. Christoph Hank
+49 761 4588-2247
Anna Wunsch
+49 761 4588-2543
hydrogen@ise.fraunhofer.de

Fraunhofer ISE
Heidenhofstr. 2
79110 Freiburg, Germany
www.ise.fraunhofer.de/en

© Fraunhofer ISE
03-81120-26

Cover © Nataraj – stock.adobe.com