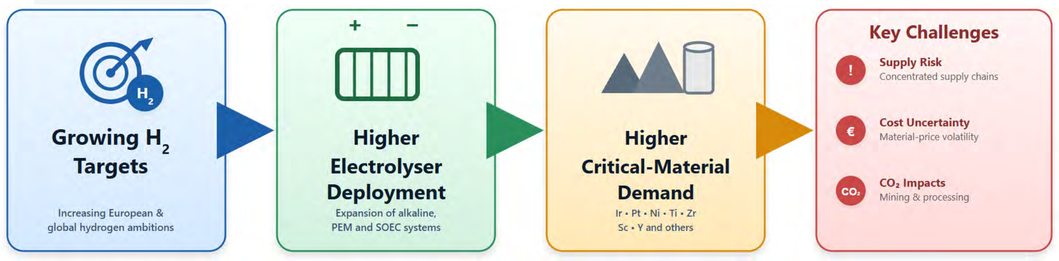
Techno-Economic Analysis of Electrolyser Stack for Hydrogen Energy: Assessment of Critical Materials, Cost and CO_2-eq Content

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This study assesses electrolyser scale-up through critical-material demand and supply, stack cost evolution, and material-related CO_2 emissions. It highlights recycling, material substitution and supply-chain diversification as key strategies for sustainable hydrogen deployment.

Problem Description

Rapid green hydrogen deployment will require a major increase in electrolyser production. However, electrolyser technologies depend on critical raw materials that may face supply constraints, geographic concentration, cost instability, and significant CO_2-equivalent impacts.



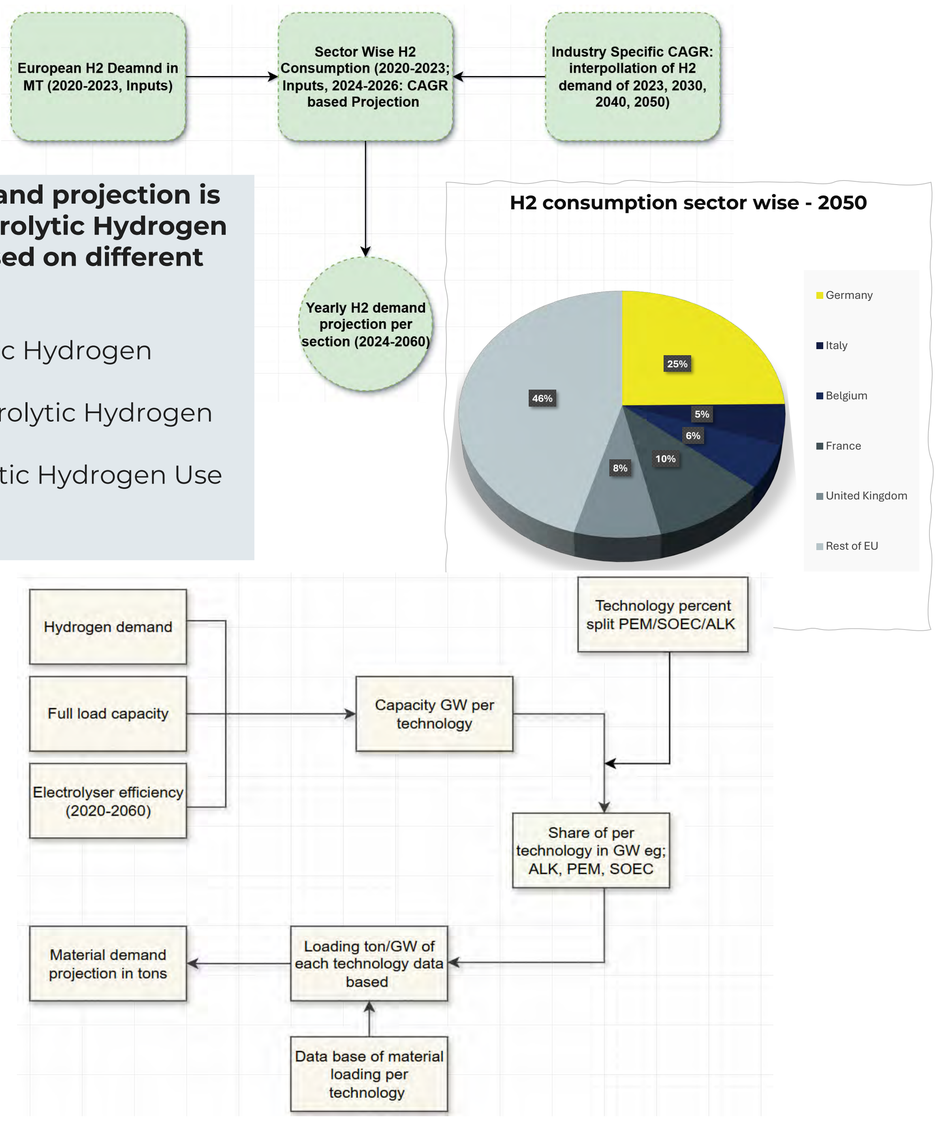
Research Objectives

Forecast critical-material demand and supply risks. Assess recycling and material-efficiency potential.

Compare ALK, PEM and SOEC deployment scenarios and evaluating stack costs and CO_2-eq impacts.

Methodology

Methodological framework for sector-wise hydrogen demand projection in Europe (2024–2060)

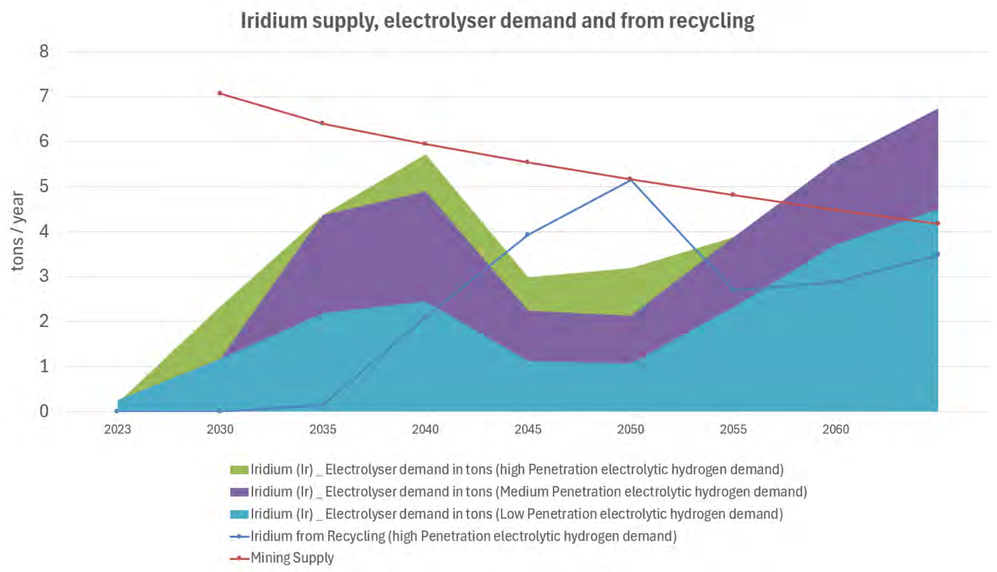


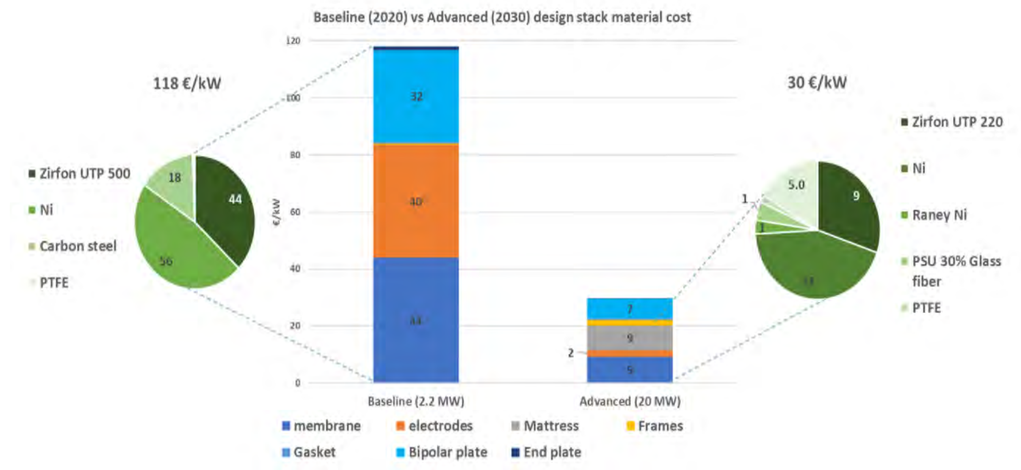
Hydrogen Demand projection is uncertain. Electrolytic Hydrogen penetration based on different scenarios:

1. Low Electrolytic Hydrogen Penetration
2. Medium Electrolytic Hydrogen Penetration
3. High Electrolytic Hydrogen Use Penetration

Results

Demand vs supply and recycled quantity estimation





Baseline and advanced stack material cost for PEM electrolyser

Supply–demand analysis shows growing material constraints for iridium, nickel, scandium, and yttrium as electrolyser deployment expands, with the highest risks for iridium, scandium, and yttrium. Recycling, material efficiency, and diversified sourcing are therefore essential for sustainable scale-up.

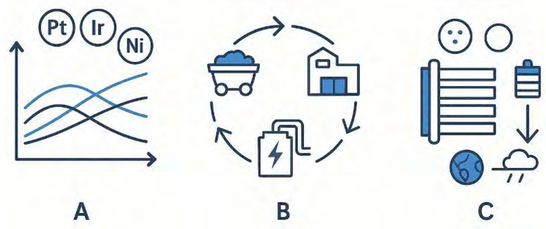
Outlook

(A) Integrate **dynamic material cost** fluctuations into the projection model. Train models on real-time market data to account for volatility in stack cost.

(B) Expand analysis beyond "cradle-to-gate" to cover the full lifecycle. Evaluate **end-of-life** scenarios including recycling and material recovery.

(C) Incorporate studies on reducing **Critical Raw Materials (CRM)**.

Optimize catalyst loading to lower costs without compromising performance.



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