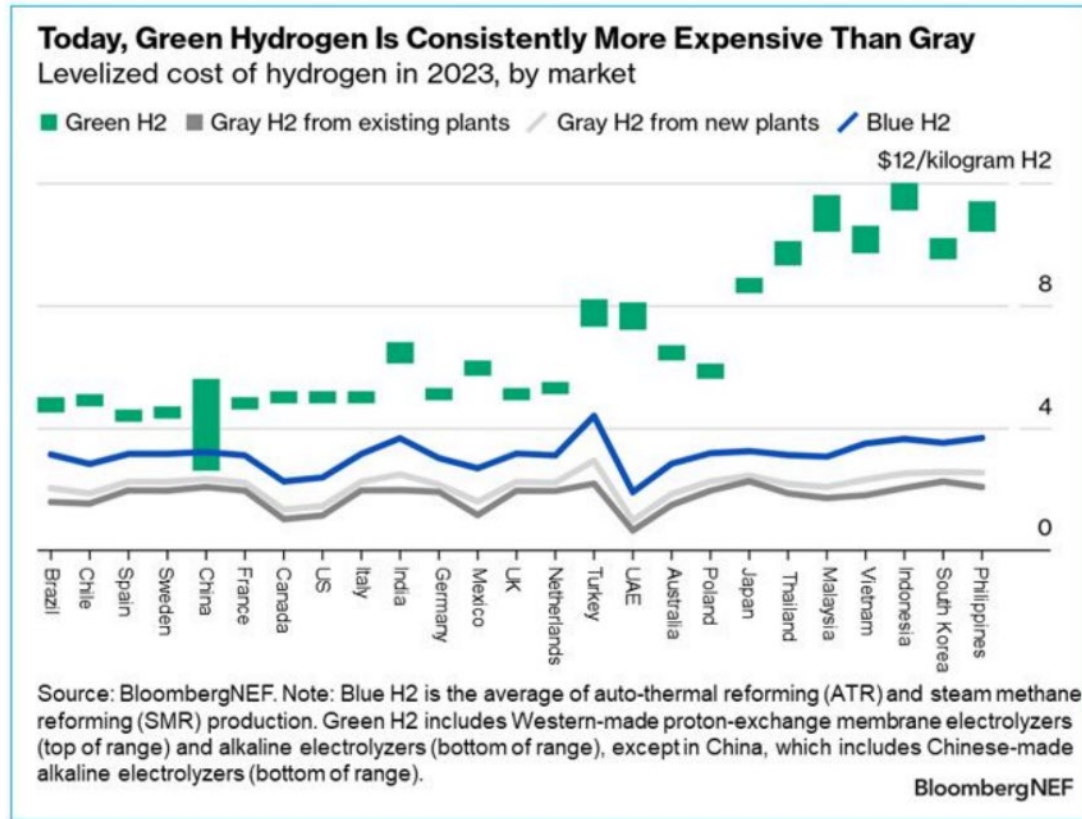
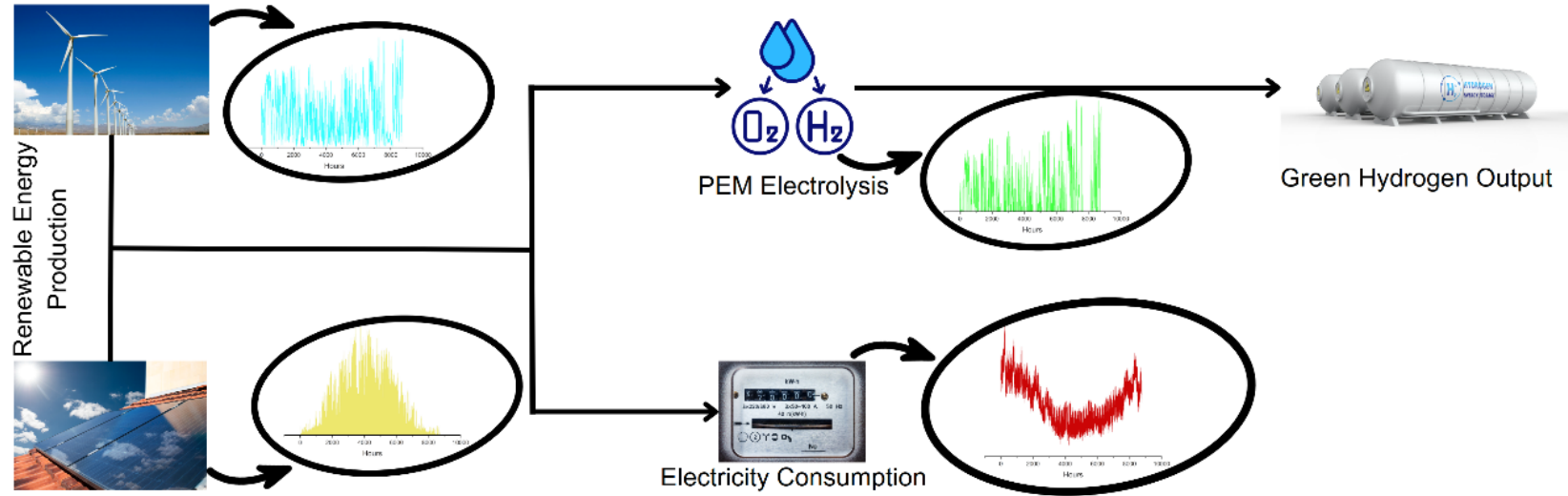


Data-driven optimization of PEM electrolysis during dynamic operation

Motivation



Motivation



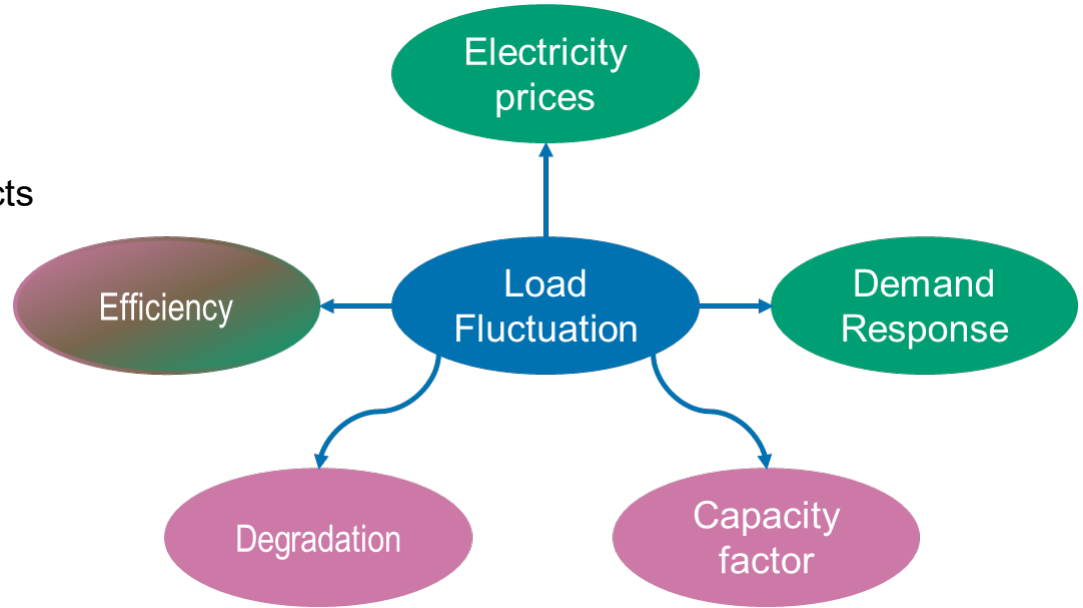
Wind production, solar production, and electricity consumption of Finland in 2022 are obtained from "data.fingrid.fi". Total energy produced by wind and solar energies are upscaled to supply 120% of the electricity consumption. The hourly difference between electricity production and consumption is used to illustrate the dynamic operation of PEM electrolysis

Source: H. Sayed-Ahmed, Á.I. Toldy, and A. Santasalo-Aarnio. "Dynamic operation of proton exchange membrane electrolyzers—Critical review". Renewable and Sustainable Energy Reviews, Volume 189, Part A, 2024. DOI: 10.1016/j.rser.2023.113883



Motivation

- Dynamic operation contradicting effects
- OPEX vs CAPEX

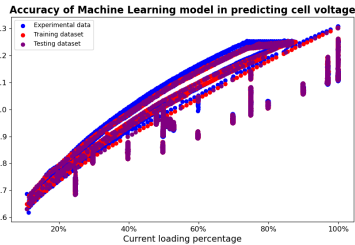


Source: H. Sayed-Ahmed, Á.I. Toldy, and A. Santasalo-Aarnio. “Dynamic operation of proton exchange membrane electrolyzers—Critical review”. Renewable and Sustainable Energy Reviews, Volume 189, Part A, 2024. DOI: 10.1016/j.rser.2023.113883



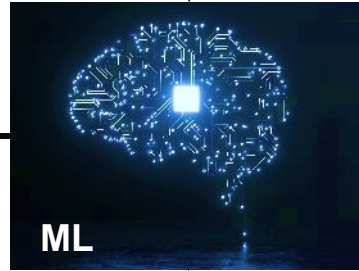
Methodology

Machine Learning + Aspen plus



- Stack efficiency

- Experimental data
- Economics



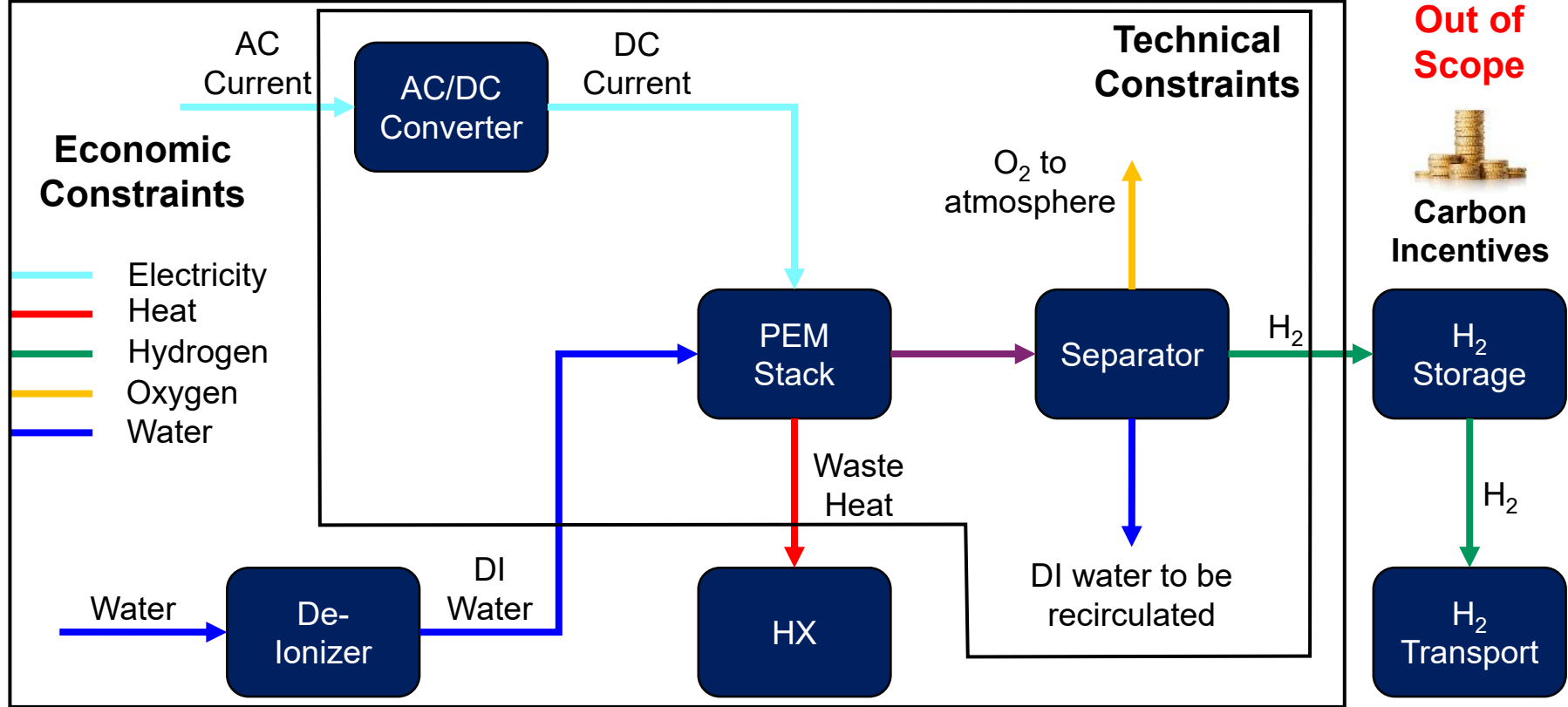
- Optimization

Aspen
model

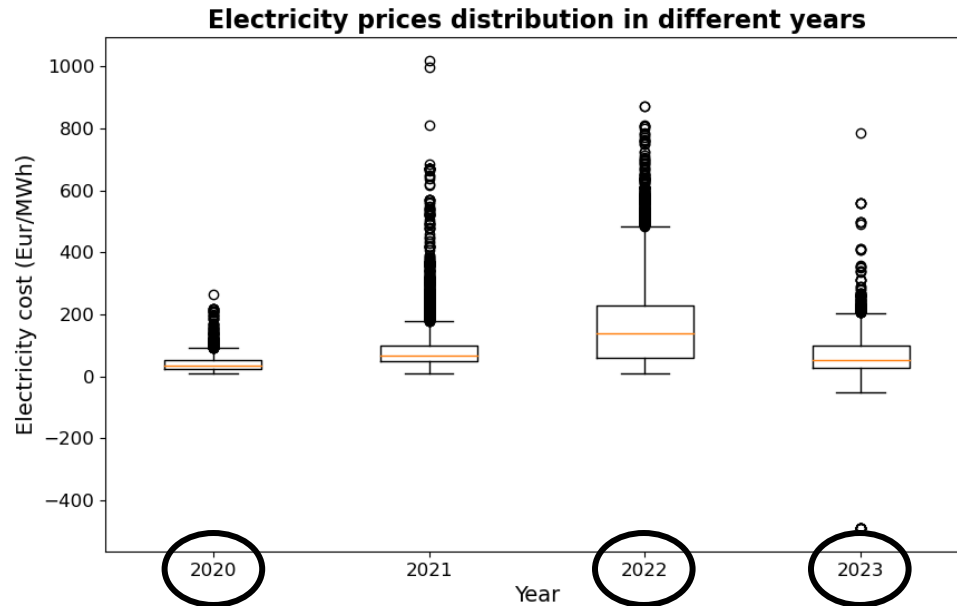
LCOH

- Waste heat
- Auxiliary Power

System Boundaries



Economic Assumptions



	Low Boundary	High Boundary
Capital cost	550 EUR/kW _p	2350 EUR/kW _p
Fixed OPEX	1%	3%
Interest rate	3%	8%
Water cost	0.07 EUR/kg _{H2}	
Plant lifetime	20 years	

Hourly spot prices + taxes + transmission and distribution fees

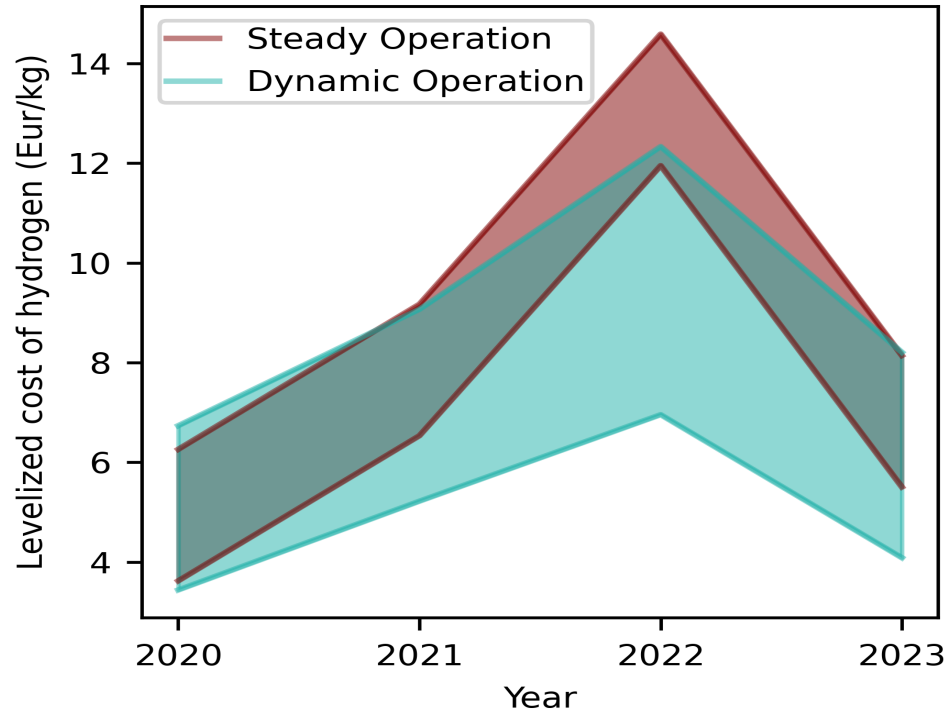
Source: H. Sayed-Ahmed, Á.I. Toldy, K. Nikiforow, S. Saxelin, O. Himanen, and A. Santasalo-Aarnio. "Strategies and challenges for reducing green hydrogen cost: Operation mode and revenue streams". Submitted to Energy and Environmental Science journal, 2024

7.10.2024

Results

Dynamic operation using spot prices

- Electricity prices
- Capital costs

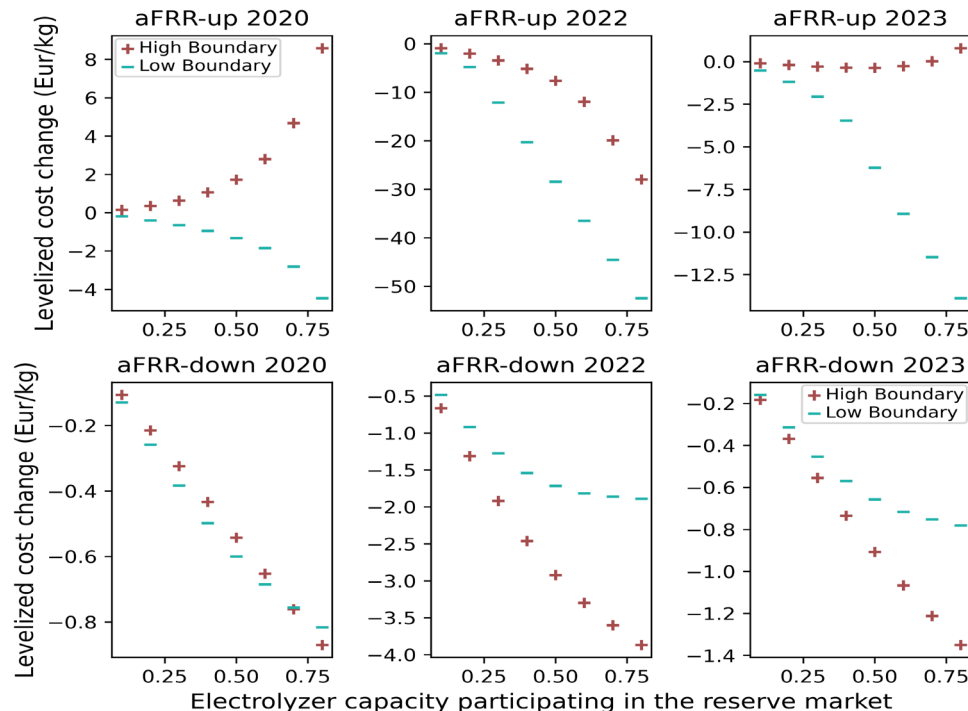


Source: H. Sayed-Ahmed, Á.I. Toldy, K. Nikiforow, S. Saxelin, O. Himanen, and A. Santasalo-Aarnio. "Strategies and challenges for reducing green hydrogen cost: Operation mode and revenue streams". Submitted to Energy and Environmental Science journal, 2024

Results

Demand response

- Capital costs
- Flexibility of electricity grid

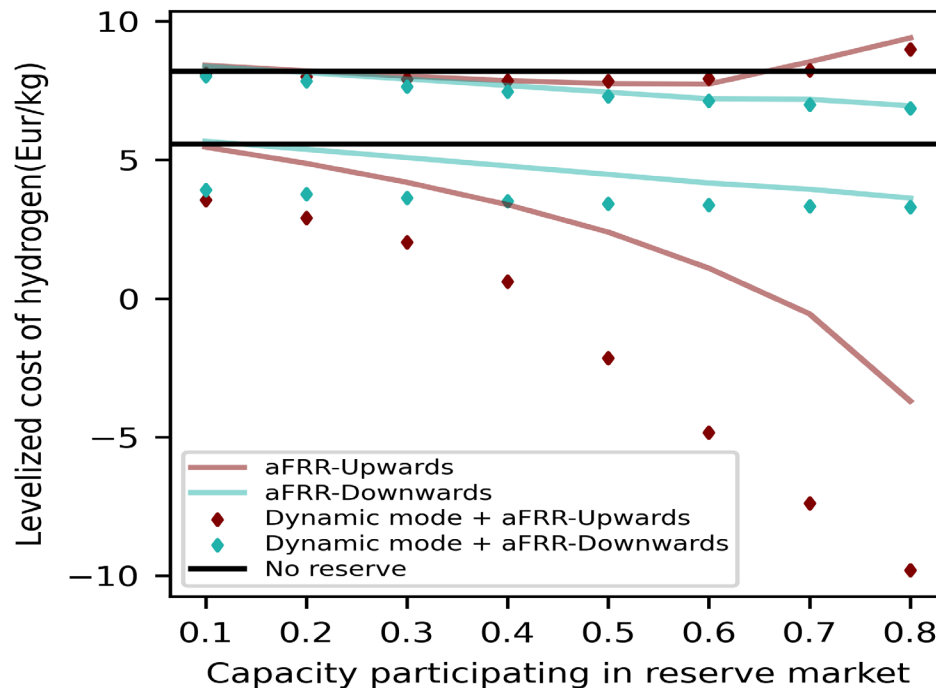


Source: H. Sayed-Ahmed, Á.I. Toldy, K. Nikiforow, S. Saxelin, O. Himanen, and A. Santasalo-Aarnio. "Strategies and challenges for reducing green hydrogen cost: Operation mode and revenue streams". Submitted to Energy and Environmental Science journal, 2024

Results

Demand response

- PPA vs Spot prices
- Upwards reserve markets and capital costs



Source: H. Sayed-Ahmed, Á.I. Toldy, K. Nikiforow, S. Saxelin, O. Himanen, and A. Santasalo-Aarnio. "Strategies and challenges for reducing green hydrogen cost: Operation mode and revenue streams". Submitted to Energy and Environmental Science journal, 2024

Conclusion

- Dynamic operation decreases the LCOH at low capital costs
- At high capital cost, PPA is a better option than buying electricity in spot market
- Participating in electricity reserve markets decreases the LCOH, if optimized correctly
- The reserve market prices and technical specifications is crucial for minimizing the LCOH

Thank you for your attention!

Collaborator



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