Hydrogen Research & Innovation Days
24-25 November 2025

REFHYNE – 10 MW PEM ELECTROLYSER

Anders Ødegård, SINTEF

Clean Hydrogen Partnership

Co-funded by the European Union

10 MW electrolyser in **commercial** operation

- At Shell Energy and Chemicals Park Rheinland
- Deploy and operate a 10 MW electrolyser in **Power to Refinery/fuel production** setting.
- Validate the **business model for using green hydrogen** as input to refineries, as well as providing primary and secondary grid balancing
- Provide input to the **policy/regulatory** changes needed to underpin the hydrogen market.

=> First of a kind full integration of a MW-sized PEM electrolyser in a refinery process plant

COORDINATION: SINTEF, Shell

DEMONSTRATION: ITM, Shell

DATA ANALYSIS & DISSEMINATION: SINTEF, sphera, ITM, ERM

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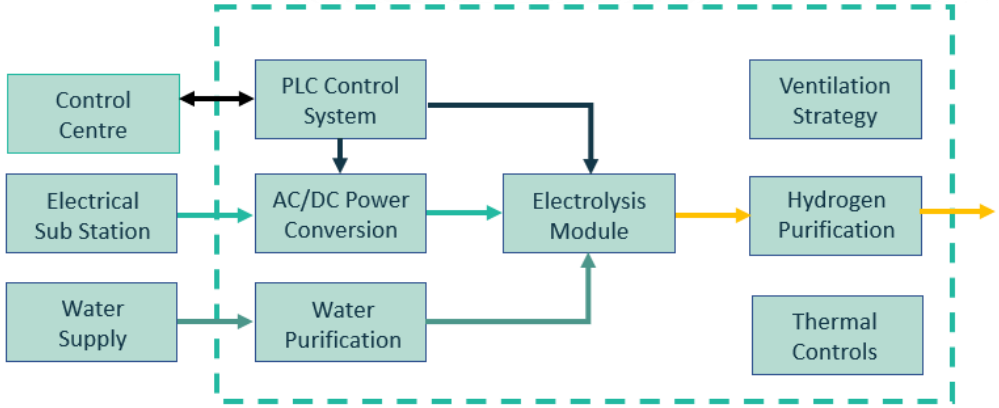
Enabling production of cleaner fuels

- The traditional route for hydrogen production at large scales is Steam Methane Reformation (SMR), directly producing CO_2.
- Electrolysers split water into oxygen and hydrogen using an electro-chemical reaction, and thus, when using renewable electricity will reduce the emissions when producing hydrogen.
- ITM Power's electrolyser is a fully integrated and autonomous system, with the plant combining 5 x 2 MW modules to reach a capacity of 10 MW.
- At maximum output, the system can produce four tonnes of hydrogen per day



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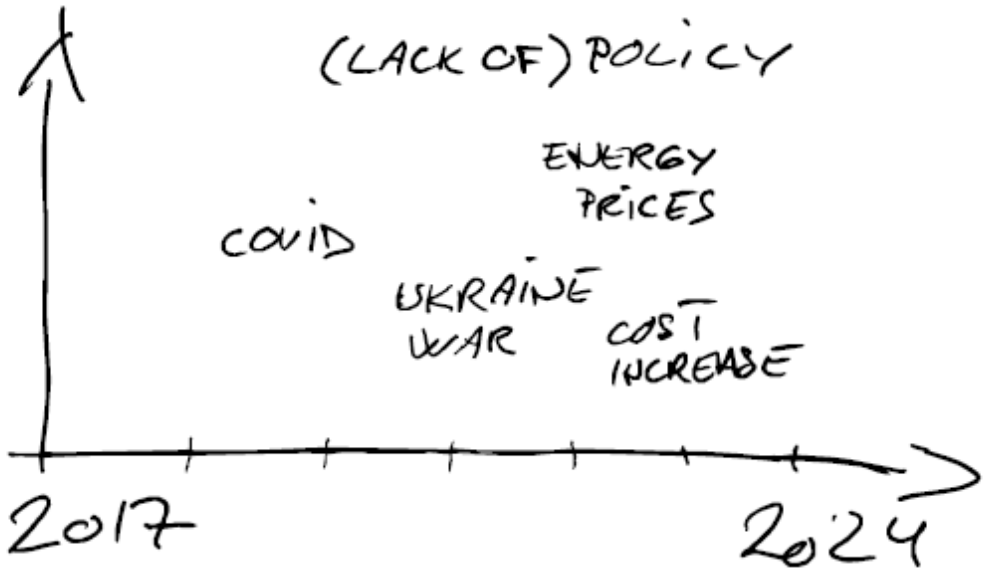
REFHYNE's way not without hurdles

- Travel restrictions
- Unreliable sub suppliers
- General cost increase
- Hydrogen markets?
- Policies and regulations
- Financial/subsidies insecurity
- Electricity price boom



REFHYNE's way to 10 MW: 2017-2024

January 2017
FCH JU Call for 10 MW electrolyser

July 2017
Winning Bid (out of 5)

January 2018
Start of Refhyne project

Q2 2019
Permit approval, start construction, ground laying ceremony

Q2 2020
ITM stacks manufactured

Q3 2020
Start installation of all electrolyser equipment

Q1/Q2 2021
Delivery of ITM electrolyser stacks, Venturi roof mounted

May - July 2021
Loop checks, commissioning and start of operations

June 2024
Electrolyser producing green hydrogen for cleaner fuels

Shell · ITM · SINTEF · sphera · ERM

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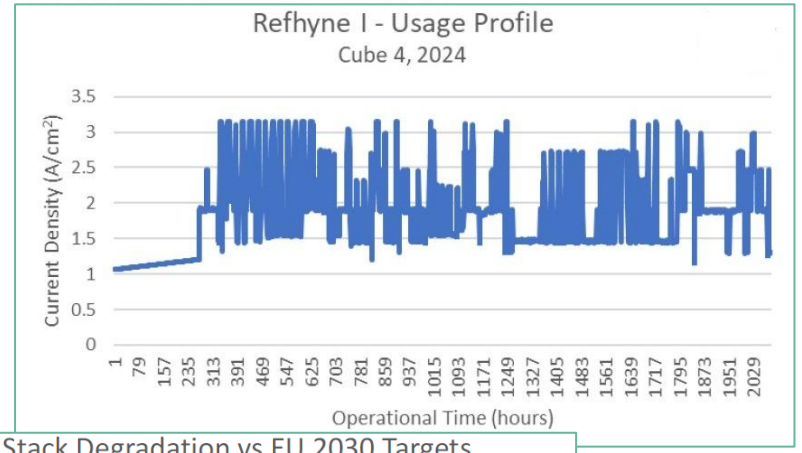
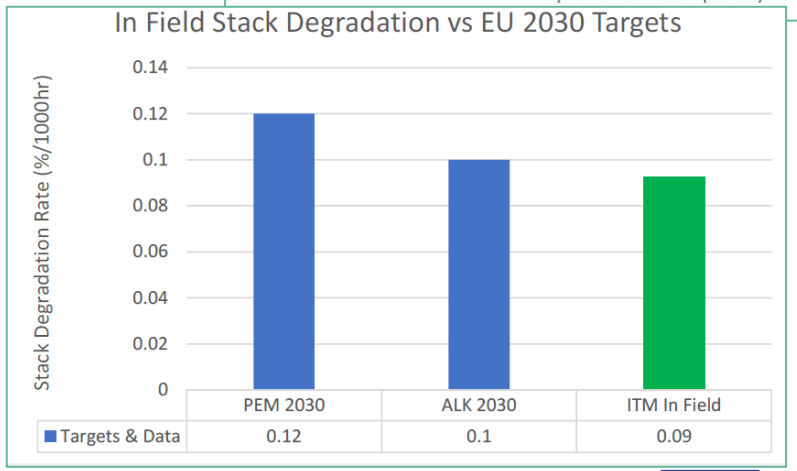
Real plant performance, not just aspirations

- Highly variable and intermittent operation, only possible with PEM
- Sample stack operation taken during the 12 months from May 24 to May 25: ~30,000 cumulative operating hours
- ~1,200 pressure cycles per stack, ~400 power cycles per stack
- **Stack efficiency at average load is <49kWh/kg**
- **In-field degradation measured as 0.09%/1000h = 0.8%/year at full utilisation**
- Lower than EU 2030 targets for both PEM and alkaline
- Growing evidence of in-field performance is an increasing advantage





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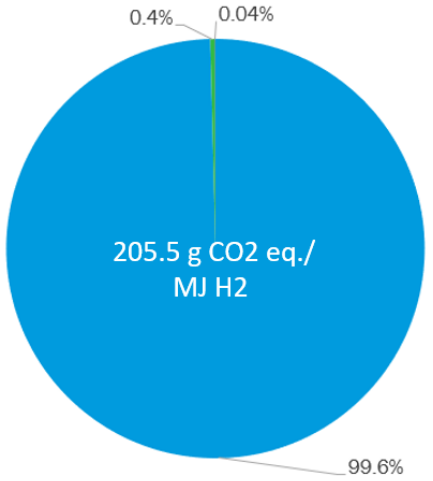
Greenhouse gas emissions

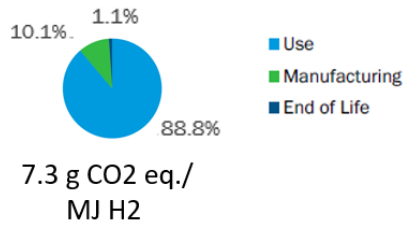
Electricity for the electrolyser sourced from PPAs:

- German grid mix from 2019:
  ~206 g CO2 eq./MJ H2
  ~137 % increase compared to SMR
- Use of 100% onshore wind in Germany:
  ~7 g CO2 eq./MJ H2
  ~92 % reduction compared to SMR

German grid mix



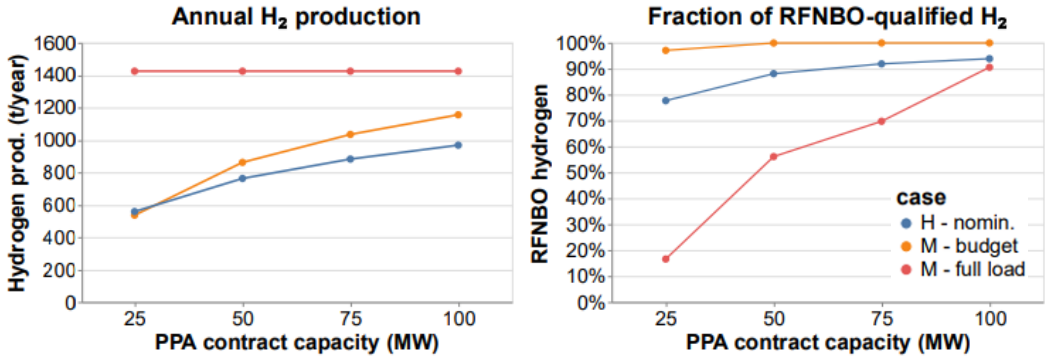
German onshore wind



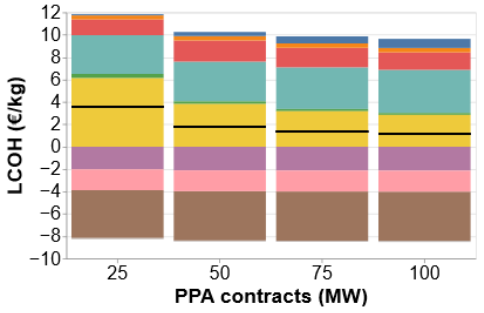
7.3 g CO2 eq./
MJ H2

Policies and operation of electrolysers

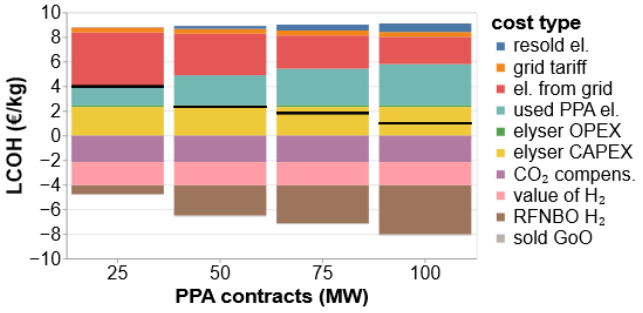
- LCOH depends on many factors
  - Production costs ~ 10 €/kg H2, subsidies required to replace grey H_2
- The economics of a hydrogen production are highly dependent on the location of the deployment because of variation in the availability and cost of renewable electricity.
- Well-defined policies have been slow to develop, and announced timelines for the finalisation of policies have often not been met. The lack of certainty in the policy landscape has limited the amount of investment into new projects.
- Policy-makers will need to ensure that policy continues to evolve, to ensure that other locations and difficult to decarbonise sectors are not left behind



RFNBO monthly correlation



Full load 24/7



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REFHYNE is a flagship project - valuable for the whole hydrogen industry

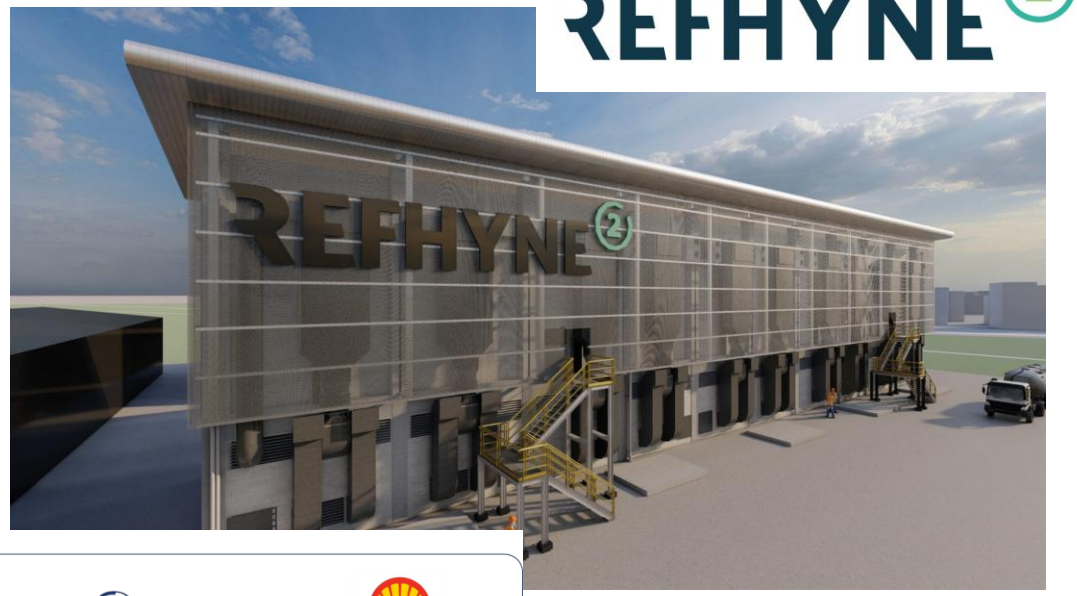
- Numerous organised site visits for politicians, industry leaders, authorities, educational, …
- 6 roundtables, allowing a structured discussion of the project results and the implications for future projects and/or policy changes.
- Participation in 7 hydrogen industry webinars
- Presentations given at more than 19 large hydrogen industry events.

Conclusions and impacts

- After 6.5 years project duration, the 10 MW PEM electrolyser is now operating on a commercial basis
- Demonstrating scale and building confidence
- Scaling production and driving down costs through real-world deployment
- Impact on the development of supportive policy and regulations
- Benefitting the wider hydrogen energy sector

REFHYNE 2 - From 10 MW to 100 MW

- 100 MW PEM electrolyser plant
- Production up to 40 tons hydrogen per day from Q1 2027
- Hydrogen for industrial use (refinery) and as fuel
- Flexible operation of the electrolyser with renewable PPAs
- Explore the use of bi-products oxygen and heat



COORDINATION: SINTEF, Shell

DEMONSTRATION: ITM, ITM LINDE ELECTROLYSIS, Linde, Shell

DATA ANALYSIS & DISSEMINATION: SINTEF, ERM, Concawe, tecnalia

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Thank you!

REFHYNE
CLEAN REFINERY HYDROGEN FOR EUROPE

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DEMONSTRATION	ITM, Shell
DATA ANALYSIS & DISSEMINATION	SINTEF, sphera, ITM, ERM

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