Hydrogen Tech World Conference

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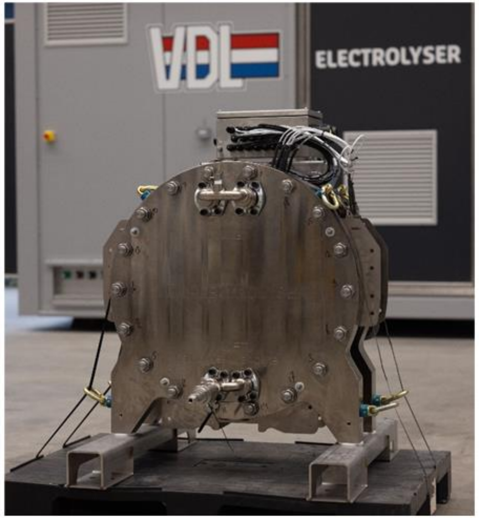
Topics presentation

- Introduction ISPT
- World wide developments
- HyScaling
  - Goals
  - Approach
  - Results
- Outlook

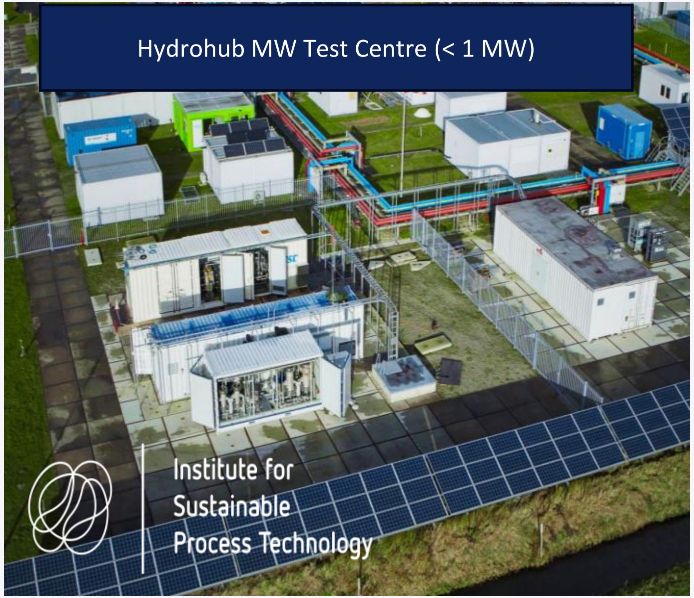


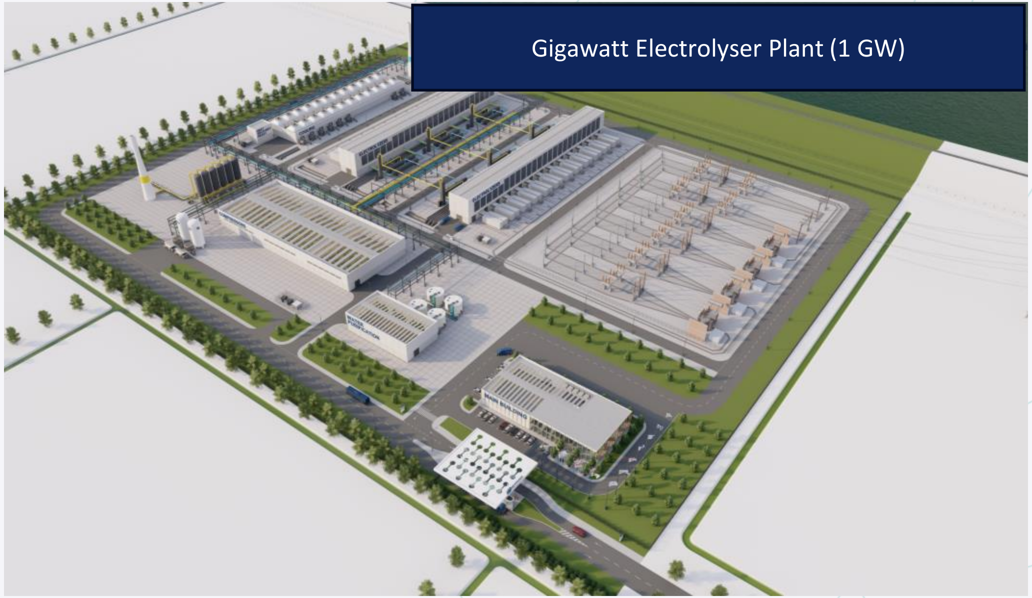
Source: VDL - Marius Ponten

Institute for Sustainable Process Technology (ISPT)

- **Institute for Sustainable Process Technology**
- **Open innovation platform**
- **>180 partners from industry and universities**
- **Projects contributing to**
    - **Energy transition**
    - **Materials transition**
    - **Agrifood transitions**
- **Cooperation in trust-based environment**

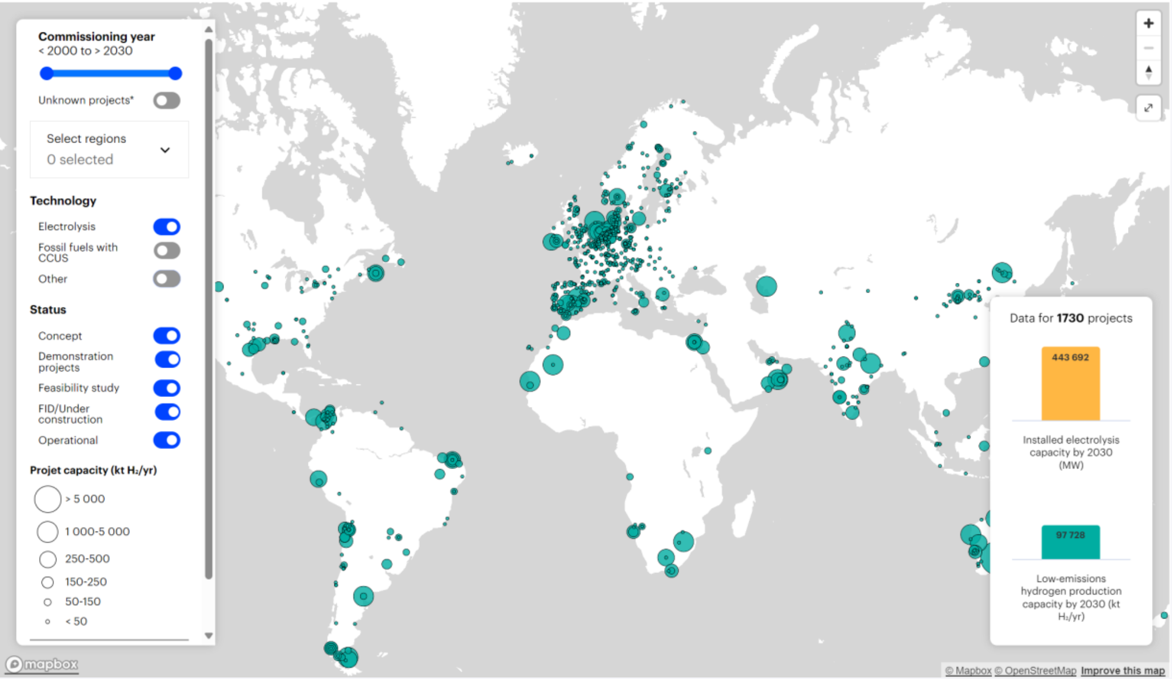
Electrolysis plant





World wide developments

Worldwide hydrogen development



[Hydrogen production projects interactive map – Data Tools - IEA]

Worldwide Electrolysis development

- 1730 Electrolysis projects
- Total 443.696 MW

➢ **Operational**
- 578 projects
- Total 1.100 MW

➢ **Demonstration**
- 178 projects
- 77 MW

➢ **FID/ under construction**
- 215 projects
- 14.679 MW

➢ **Concept and feasibility studies**
- 759 projects
- 427.836 MW

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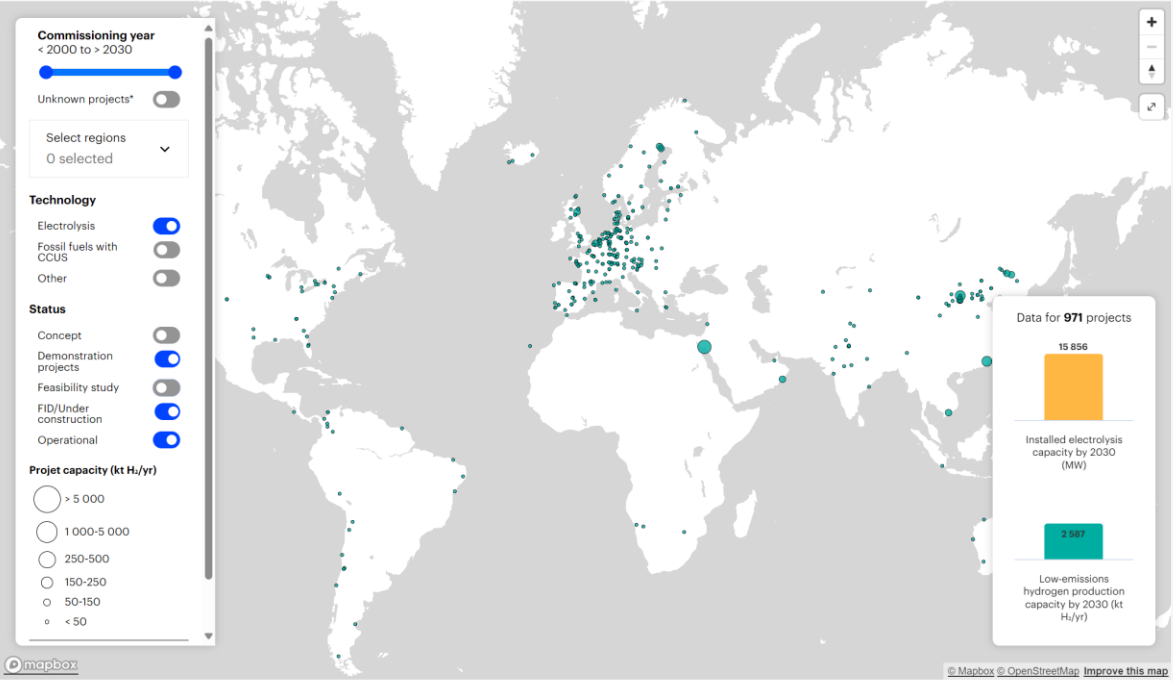
Worldwide hydrogen development



Hydrogen production projects interactive map – Data Tools - IEA

~400 GW (96%) of the total worldwide development is in the study phase

Key challenges:

1. Reliable and affordable supply chain
2. Infrastructure in place
3. Stable and clear policy
4. Green Hydrogen Market

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The global situation

EU capacity 2030:

25GW/year

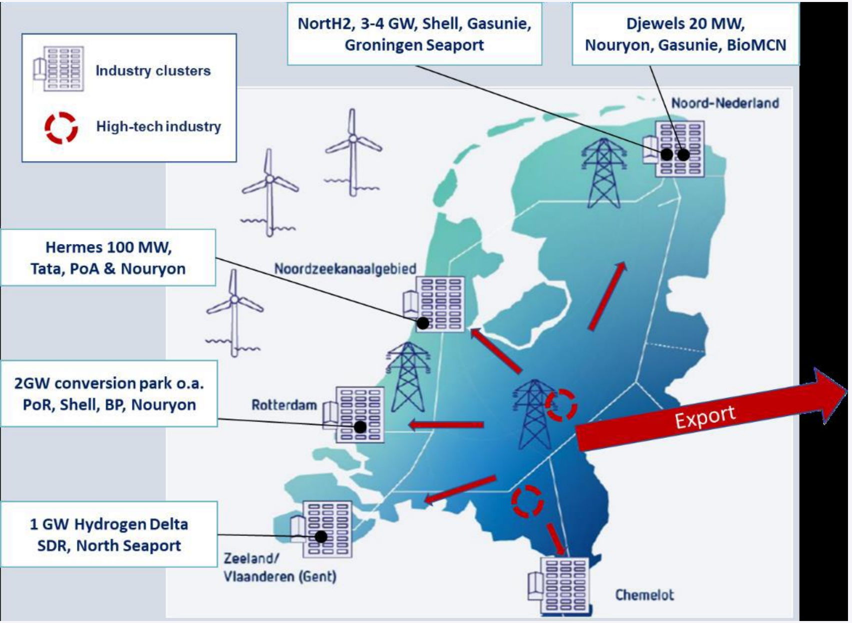
(source IEA)

Despite this, manufacturers have announced further expansions, bringing annual stack assembly capacity to more than 50GW by the end of this year, rising to nearly 75GW in 2025.

On the surface, this rapid scale-up could be good news for green hydrogen project developers, ensuring that gigawatt-scale orders can actually be met, with economies of scale potentially reducing the price per unit.

However, developers have not placed the major orders expected in 2023, mostly due to slower-than-expected rollout of subsidies in the US and EU — leaving electrolyser manufacturers with little to no income from their high-cost investments.

Challenges Hydrogen Development



Green hydrogen still too expensive!

Challenges to scaling up to GW scale:

- System Cost
- Compatibility and reliability

- Lifetime of stacks
- Stack and system efficiency
- Supply Chain Manufacturing
- Supply Chain Process Industry

Green hydrogen investment environment is 'fragile', despite project spend hitting $5bn this year: IEA

Hydrogeninsight

Challenges Hydrogen Development – risk management

Problems at world's largest existing green hydrogen project will not be solved until late 2025, Sinopec admits

Chinese oil giant suggests that the electrolysers at the 260MW Kuqa facility in northwest China are only operating at about 20% of capacity

Hydrogeninsight

Green hydrogen | 'Electrolysers have not fully demonstrated that they are compatible with intermittent renewables': BNEF

Green hydrogen still too expensive!

Challenges to scaling up to GW scale:

- System Cost
- Compatibility and reliability

- Lifetime of stacks
- Stack and system efficiency
- Supply Chain Manufacturing
- Supply Chain Process Industry

Additional efforts necessary

HyScaling project

2021

Creating
a viable Dutch supply chain
for large-scale electrolyser production

28
Partners

16
Companies (suppliers, end-users)

HyScaling project

Reduce the levelized costs of hydrogen by 25-30%

“This project is co-funded with subsidy from the Top Sector Energy by the Ministry of Economic Affairs and Climate Policy.”

2 Technologies
PEM & Alkaline

5 Use Cases

Start:
June 2021

End:
July 2024

3 years
6,8 mln €

Action Plans towards implementation in 2030

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TNO innovation for life

Hyscaling Partners

This project is co-funded with subsidy from the Top Sector Energy by the Ministry of Economic Affairs and Climate Policy."

HyCC – The Hydrogen Chemistry Company

MTSA Technopower

VDL Energy Systems

ZEF – Zero Emission Fuels

TEIJIN

borit

ionbond

HAUZER

SALD – Spatial ALD Innovators – Explore. Develop. Integrate. Together.

mxpolymers

vonk

powall

veco

MAGNETO Special Anodes – an EVOQUA brand

plug

DOTX Control Solutions

VSL

DANIELI CORUS

GT GreenbergTraurig

FME – Powered by Dutch Technology

Hanzehogeschool Groningen – University of Applied Sciences

TU/e – Eindhoven University of Technology

TU Delft – Delft University of Technology

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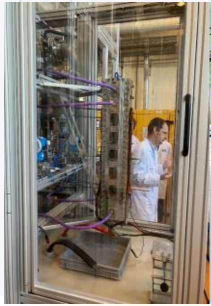
TNO innovation for life

Fraunhofer IPT

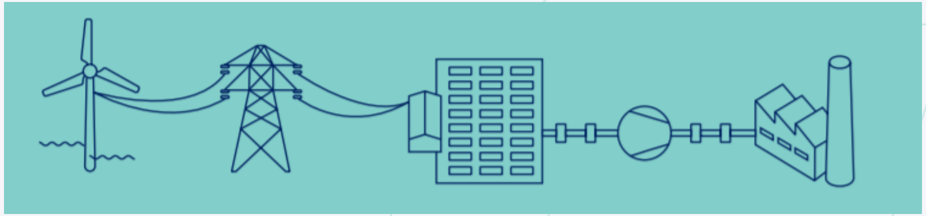
Brabantse Ontwikkelings Maatschappij – BOM

Brainport Eindhoven

Hyscaling project team from 28 companies

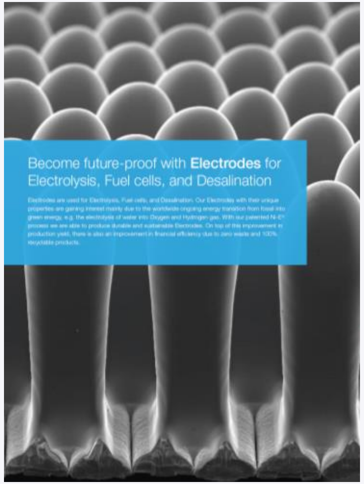


Main goals project

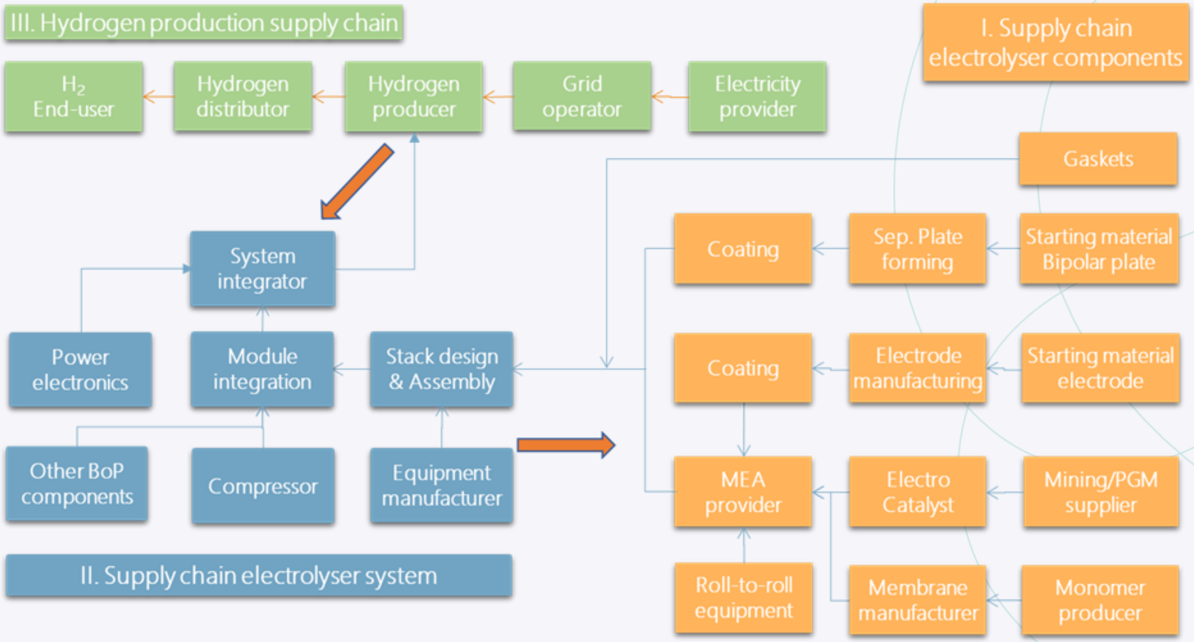


- Reduction of LCOH with 25 – 30% compared to state-of-the-art 2020
- Building a Dutch electrolyser industry and community

Z E F
Zero Emission Fuels



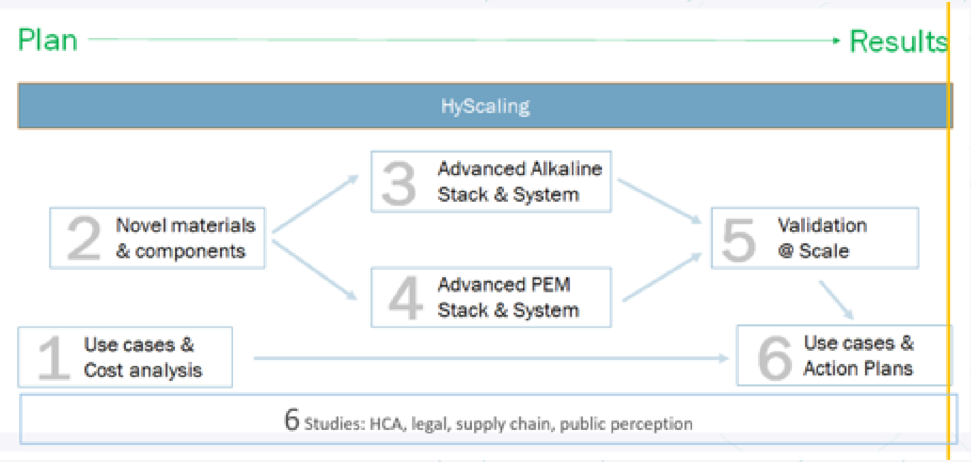
Development challenge – What to optimize?



Scope of Hyscaling project

- Market-driven – use cases

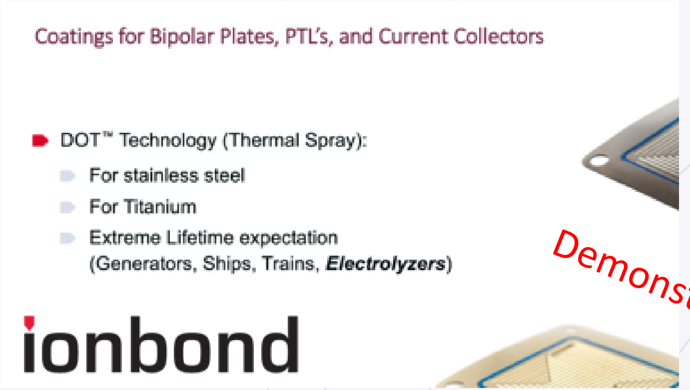
- Standardization of test protocols
- Component Optimization PEM
- Component Optimization AWE
- Validation at scale
- Optimization of small units AWE



- Studies: Effects CBAM, Human Capital Assessment, public perception, metering requirements, grid congestion, required industrial policy, opportunities for the manufacturing industry
- Action plans

Results PEMWE technology

- Electrode coatings (Ionbond):
  less / cost reduction



Demonstrated

- Next generation membrane (Teijin):
  The Quest for Fluorine-free Proton Exchange Membranes / FC

- Ultra-low Ir catalyst (Powall)

Example of type test results

Property	Benchmark (Nafion 115)	TEIJIN PEM
Hydrolytic Stability	0	+
Radical Durability	0	-
Swelling	0	+ +
Tensile Test	0	+ +
Proton Conductivity	0	+

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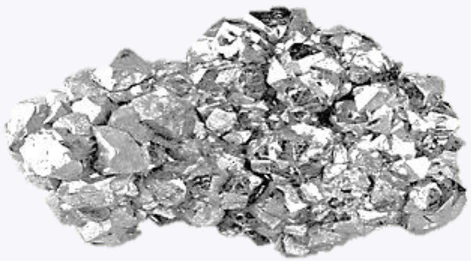
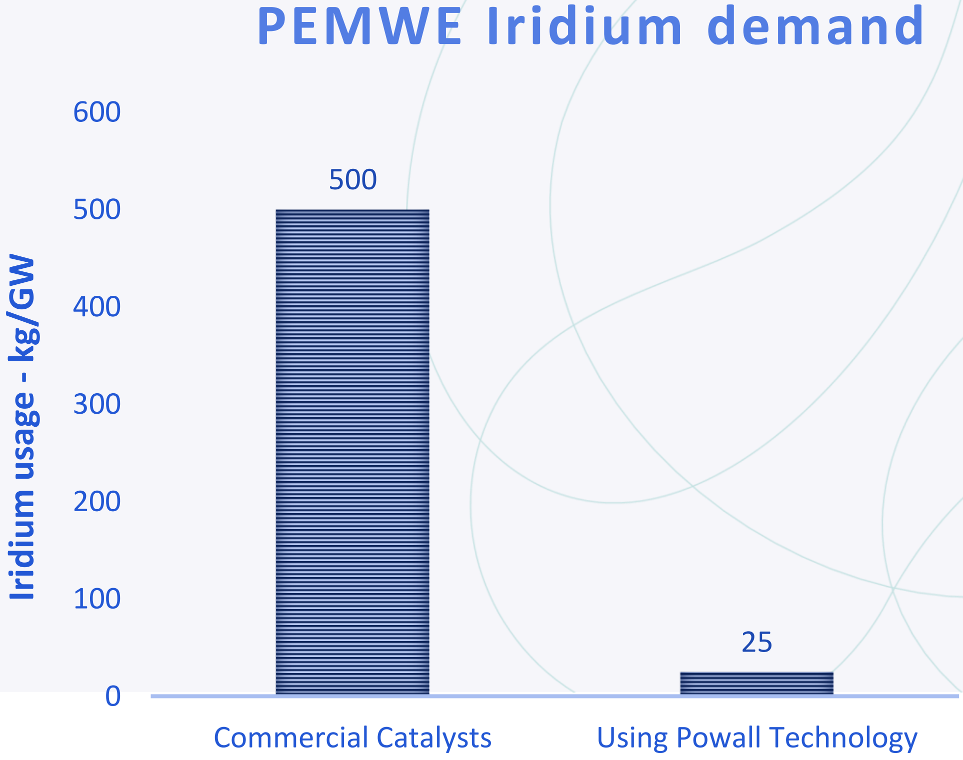
powall

We aim to boost raw material security

Global annual Iridium production is 7000 - 9000 kg





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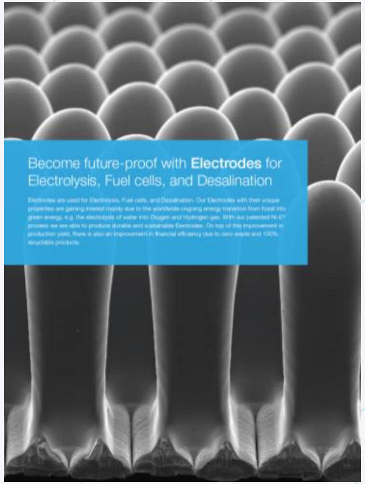
Results AWE technology

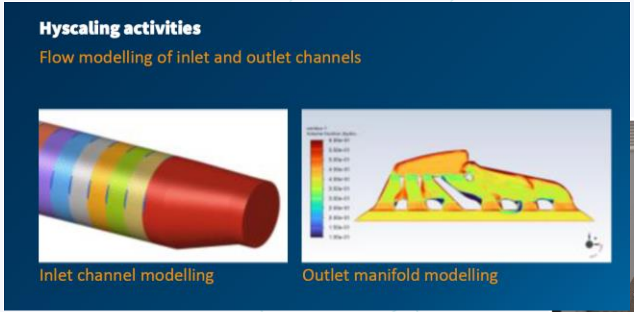
- Advanced 3-d electrode structures (VECO): improved stack efficiency
- Electrode coatings (Magneto)

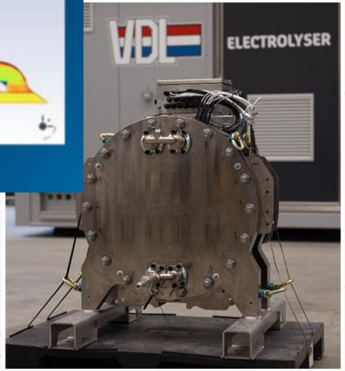


veco

Results system development

- Design and prototype optimized AWE 50kW stack + BoP (VDL)
- Cheap AWE stack for decentralized PV integrated system
- Improved advanced design GW plant (study)



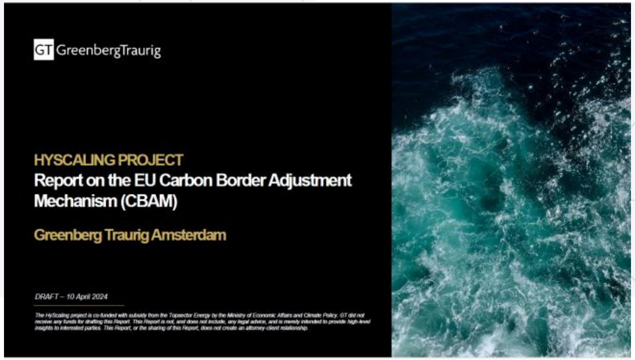


ZEF
Zero Emission Fuels

Results studies

- Use Cases:
  - 1,2 and 3 hydrogen for steel production
  - 4: hydrogen production as a solution for grid congestion
  - 5: use of hydrogen for mid-scale industry using heat temperature heating (e.g. ceramics factory)

- Effects CBAM
- Public perception,
- Metering requirements,
- Solutions for grid congestion
- Vision document autonomous plants
- Required industrial policy
- Opportunities for the manufacturing industry



Hydrogen for Steel production

- Steel making with hydrogen is a two step process is :
  - Direct reduction of iron (DRI)
  - Electric arc furnace (EAF) to achieve high quality iron for steel making
- Developed for NG, large part of natural gas can be replaced by hydrogen (carbon content)
- Process (re-)design by Danieli Corus
  - Different cases considered: optimium case is 80% H_2 and 20% NG [1]
  - Conditions: pressure and purity

Different Use Cases considered

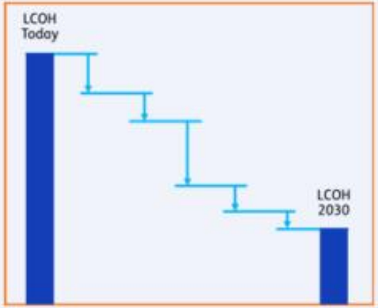
- **Off-shore win**d to on-shore electrolysis (2 cases)
- **Importing** hydrogen from Portugal (by different routes)

DANIELI CORUS

[1] *on energy basis*

Bringing down the Levelized Cost of Hydrogen (LCOH)

Some of the less obvious ones based on the HyScaling project



Scale-up:
- Supply chain, common standards and benchmarks
- Testing at the appropriate scale

Lead time for projects
- Standardisation of permitting procedures & safety analysis (-> public perception)

Under-developed infrastructure leads to:
- Suboptimal solutions for storage and transport
- Underutilisation of initial infrastructure

Conclusions

Customer perspective

- Hydrogen cost are determined by production, *transport and flexibility* cost: the focus today is strongly on production cost
- The perspective of customer requires a broader look:

  Replace "*How to produce the least expensive hydrogen*?"

  By "*How to provide the hydrogen demand of the customer in the least expensive way*"
- Look beyond the "single-source / single user" as a solution

Electricity transport cost

- High cost of electricity transport requires generation of hydrogen close to the source:
  - Analysis confirms that off-shore is important for the Netherlands (cost of E transport to shore)
  - Local use of RES to generate hydrogen will alleviate grid congestion *and* reduce cost of hydrogen

Conclusions

… versus hydrogen transport cost

- Also for the decentralized application (HT heat, HD transport), connection to the distribution and large-scale storage backbone is essential.
- International perspective: there is a big gap between pipelines and transport in the form of other carriers
- No location will be more than 30 km (?) from the backbone in the Netherlands

Storage

- (Connection to) large-scale storage is an absolutely necessary part of the hydrogen business case
  - Optimizing storage: capacity and cycles
  - Import of hydrogen: storage is inherent part of the supply chain – use it!

Use cases

- Capacity factor and conversion losses (for the import routes) are key factors in the system design

Results community

Electrolysis R&D acceleration with many HyScaling partners strongly involved:

- 3 projects in Dutch subsidy Groeifonds NXTGEN HIGHTECH
    - ZEF + consortium
    - Phoenix Alkalina (VDL + consortium)
    - Gen3 Electrolyzer 16 partners (AWE, PEM ,AEM, SOE, CO_2)

NXT GEN hightech

- HyPro – Work Package 1 GroenvermogenNL will start soon

groen vermogennl

HyScaling partners are strongly involved in Dutch National Hydrogen Program – group manufacturing industry and in the Electrolyser Manufacturing industry Platform.

Trust between partners

Take aways from the Hyscaling project

Take aways

- Together we need to improve our electrolysers to meet our goals,
- HyScaling project has delivered useful and interesting results,
- Dutch manufacturing industry is prepared to contribute to 2nd and 3rd generation electrolysers

[HyScaling: making better electrolyzers in a better way (ispt.eu)]

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27th June 2024

Thank you!

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HyScaling: making better electrolyzers in a better way (ispt.eu)