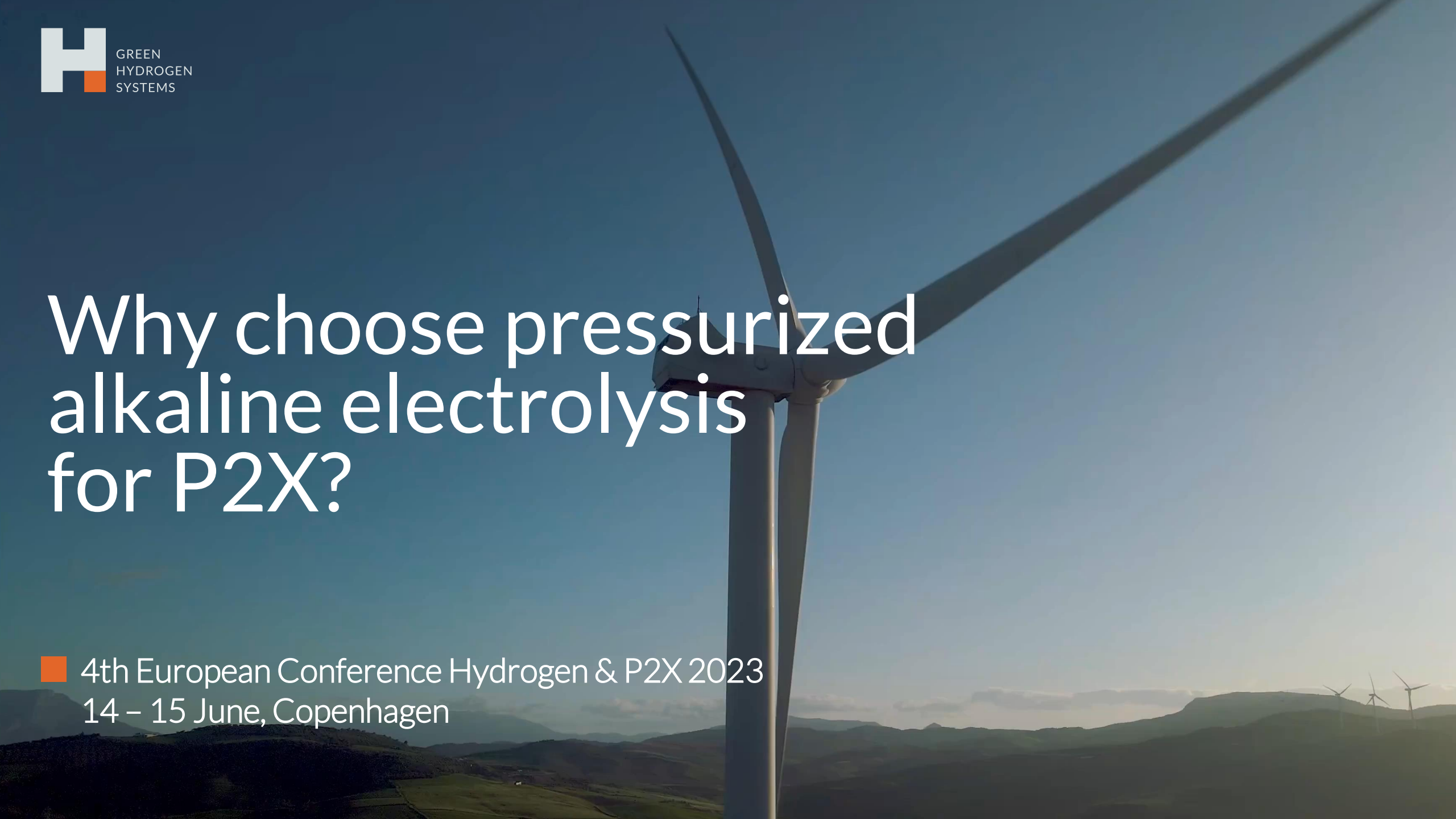
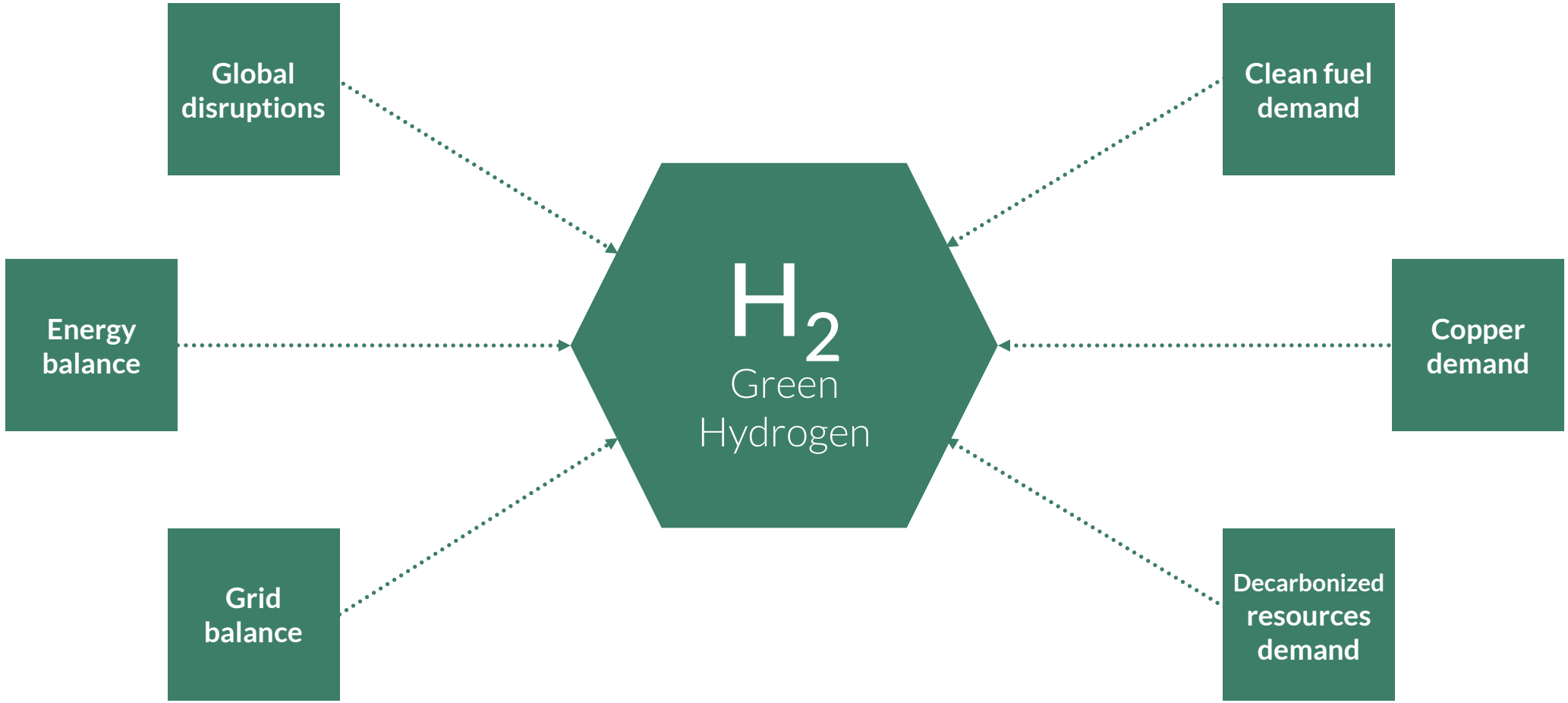


Why choose pressurized alkaline electrolysis for P2X?

4th European Conference Hydrogen & P2X 2023
14 – 15 June, Copenhagen

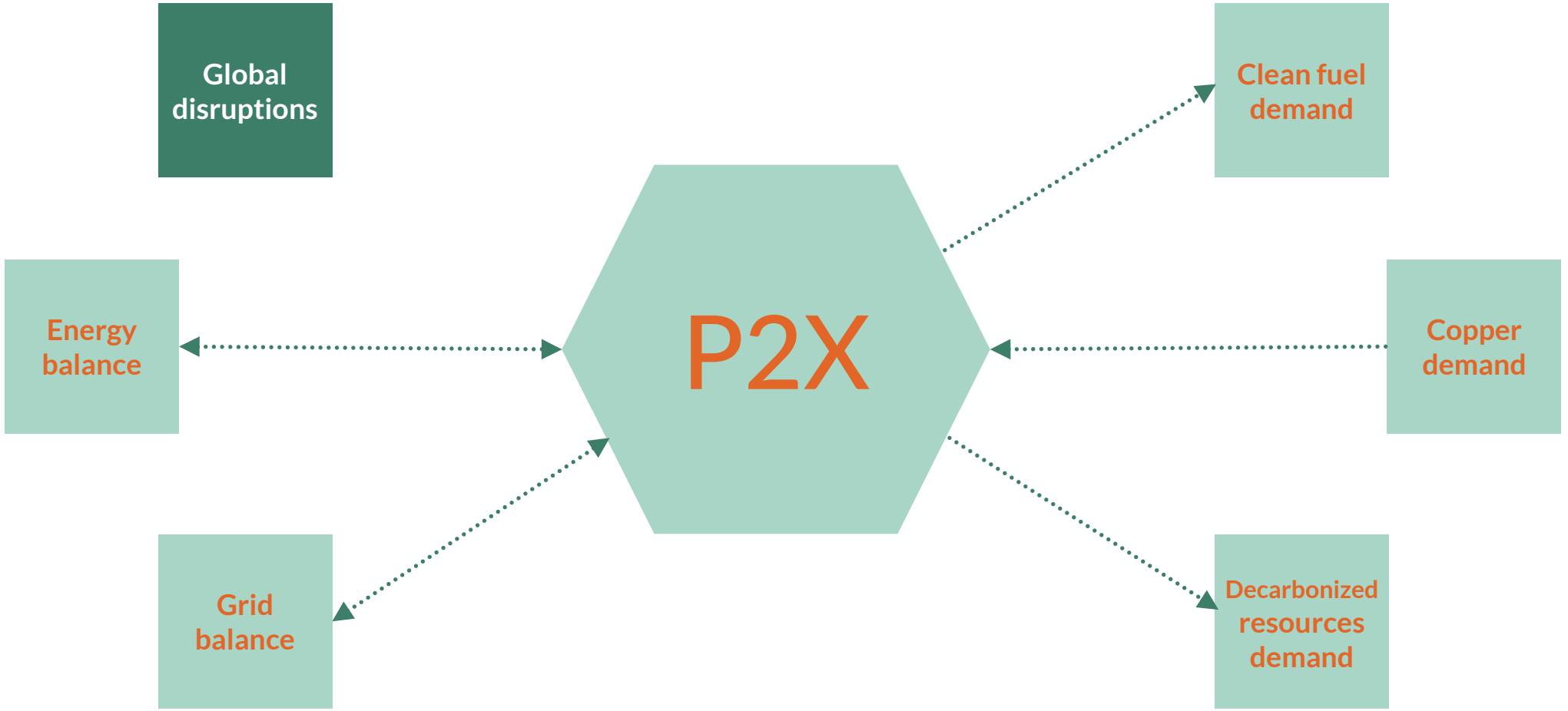
GREEN HYDROGEN SYSTEMS

Challenges in the Energy Transition



GREEN HYDROGEN SYSTEMS

Power to Hydrogen to ‘X’

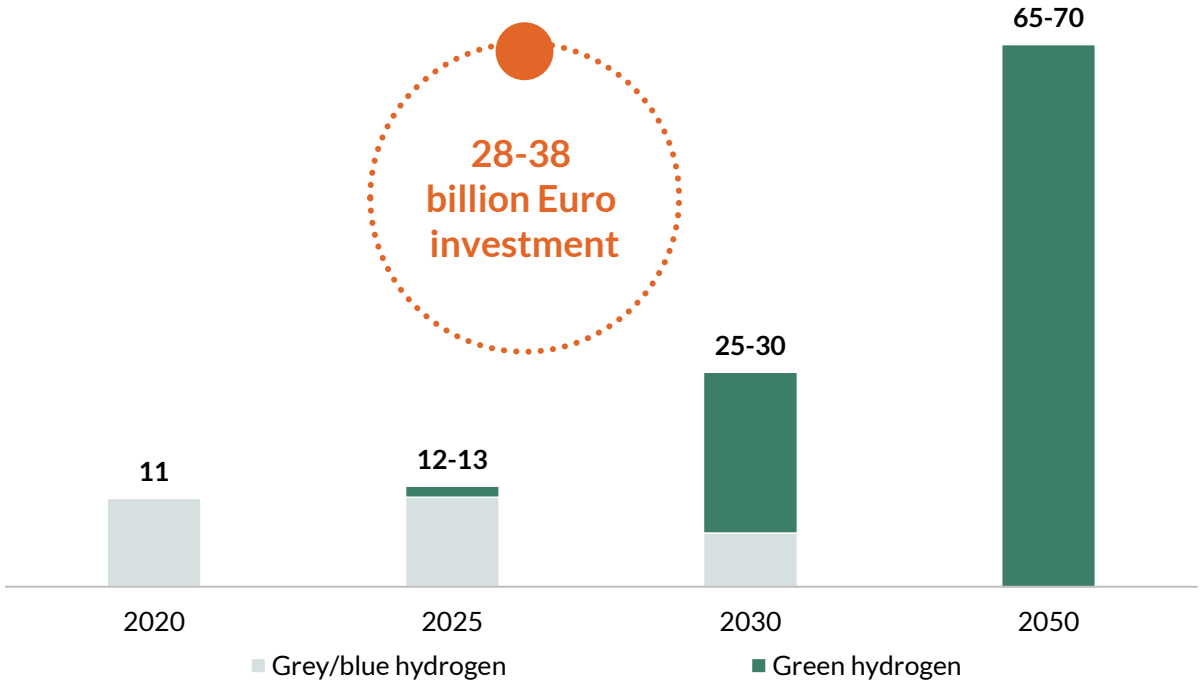


GREEN HYDROGEN SYSTEMS

Increased electrolyser demand

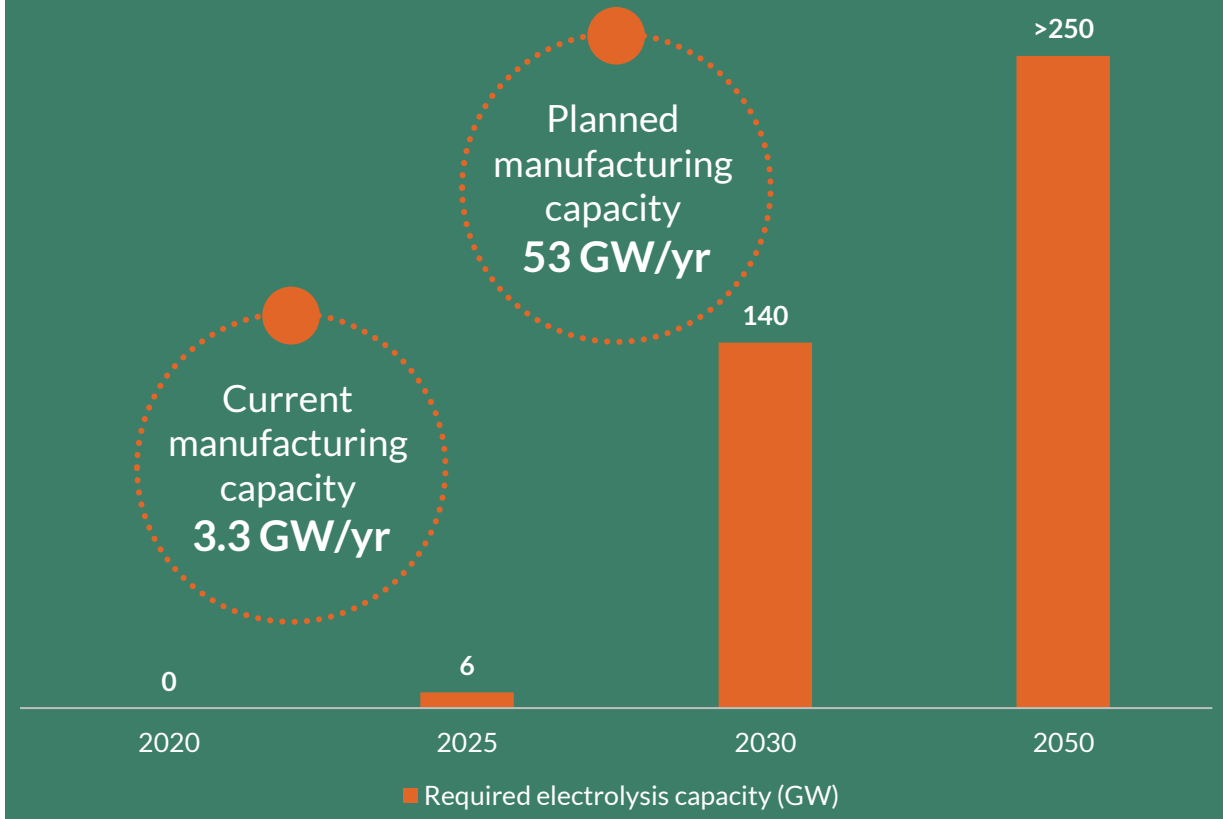
Estimated future demand for hydrogen in the EU

From Dansk Energi. Hydrogen demand in million tonnes H2 2021;
Clean Hydrogen Monitor 2022, Hydrogen Europe; REPowerEU, EU 2022



Demand for hydrogen in Europe is expected to grow significantly

Required electrolysis capacity to meet EU demand

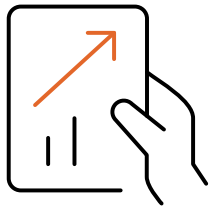


To meet demand, manufacturing capacity must increase considerably

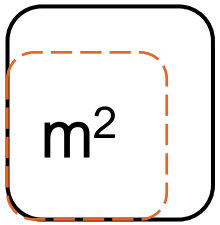
GREEN HYDROGEN SYSTEMS

How to choose between electrolyser technologies

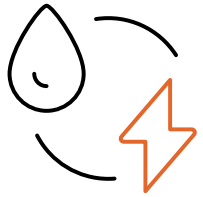
Specific customer requirements will lead to different choices



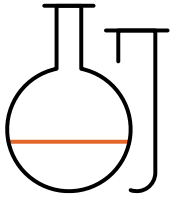
Project size (MW)



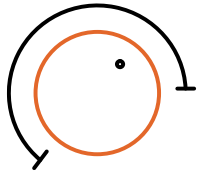
Footprint



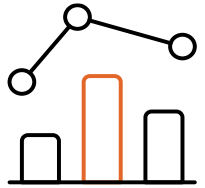
Material use



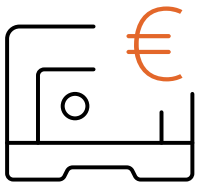
Hydrogen quality



Hydrogen pressure



Dynamic response



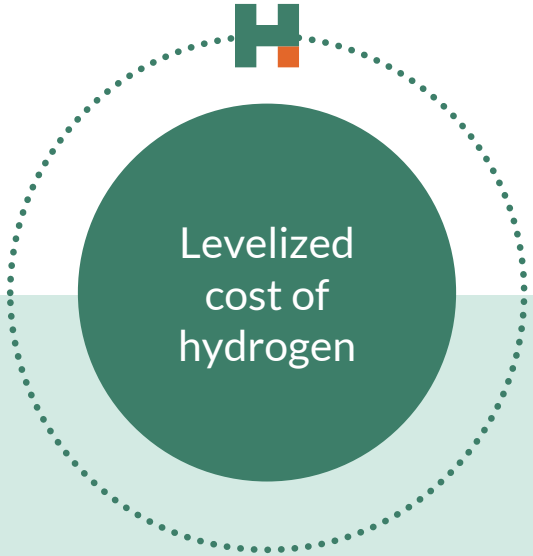
TCO / business case

GREEN HYDROGEN SYSTEMS

How to choose between electrolyser technologies

Specific customer requirements will lead to different choices

TCO / business case



Levelized Cost of Hydrogen

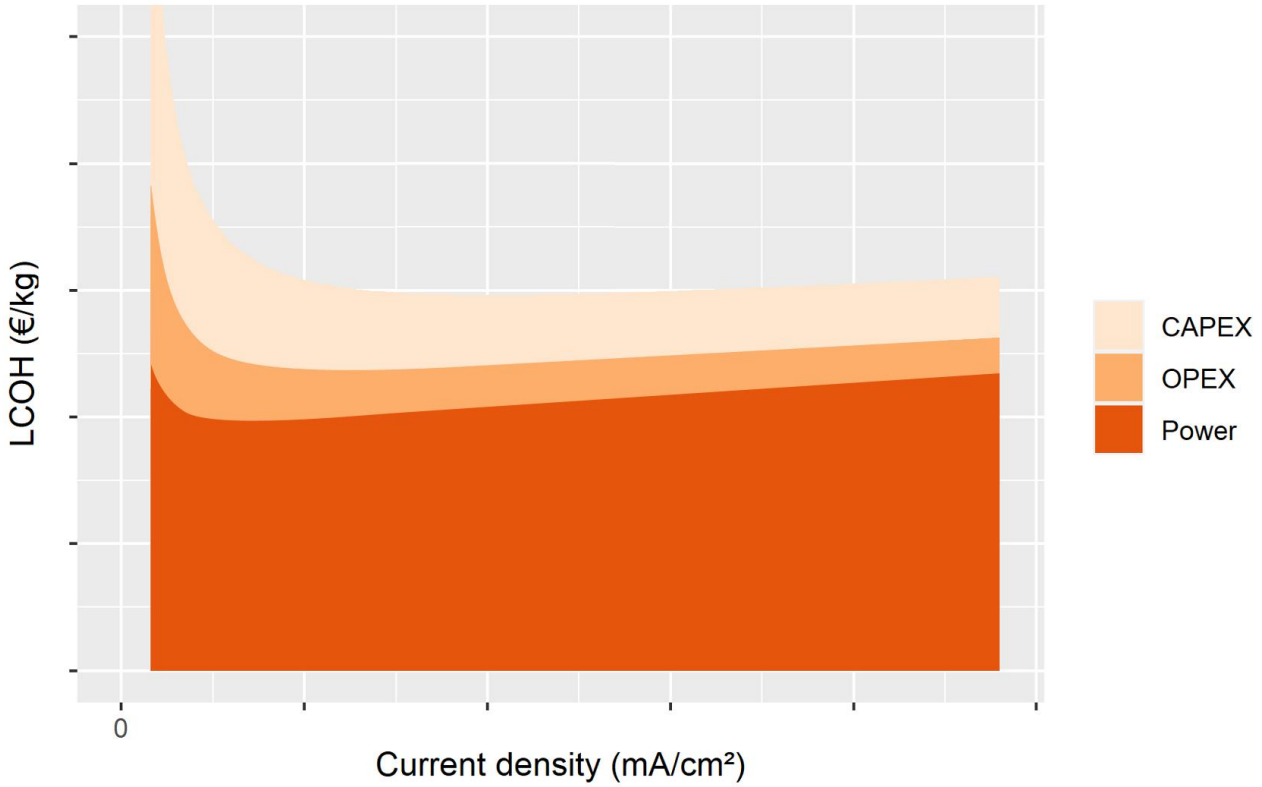
- Cost contributors example*
  - CAPEX 15-25%
  - Efficiency 60-80%
  - OPEX 5-15%

- LCOH insights give strategy to lower LCOH

- LCOH insights can be counter-intuitive

- Note: level of pressurizing not included in LCOH

$$LCOH = \frac{Costs}{H_2 \text{ production}}$$



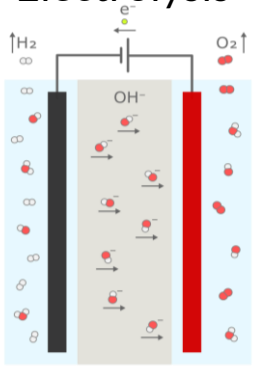
* Electricity spot prices from Denmark's electricity grid in 2023, 75% utilization

GREEN HYDROGEN SYSTEMS

Electrolyser Technologies

AWE

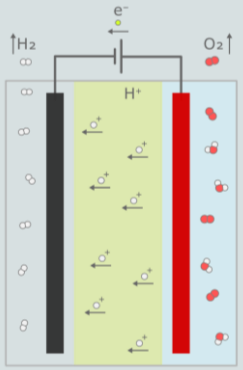
Alkaline Water Electrolysis



- Materials
- CAPEX

PEM

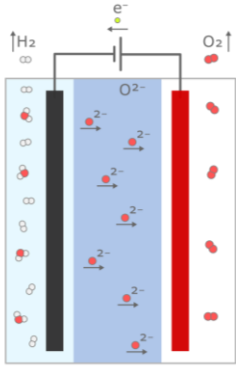
Proton Exchange Membrane



- Dynamics
- Pressure
- Footprint

SOEC

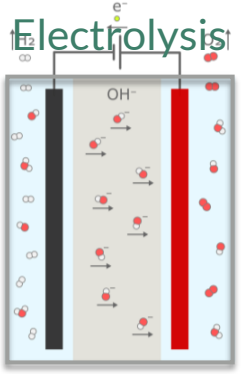
Solid Oxide Electrolysis



- Efficiency

PAWE

Pressurized Alkaline Water Electrolysis



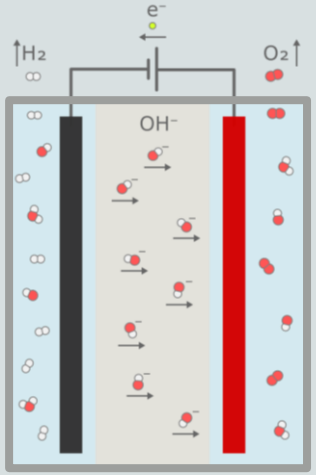
- ??

GREEN HYDROGEN SYSTEMS

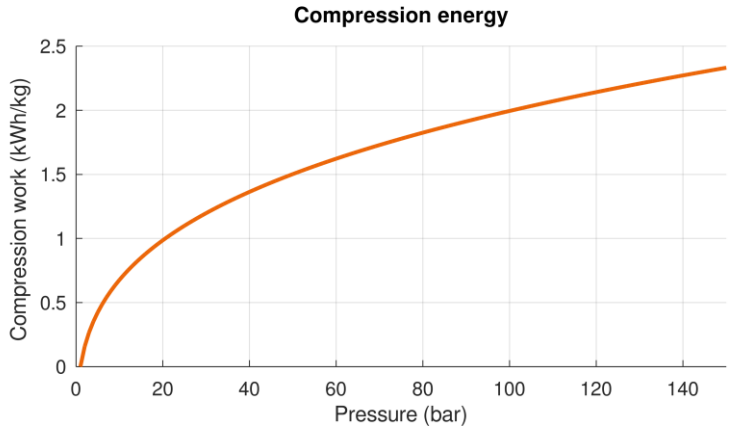
Pressurized Alkaline Water Electrolysis

Electrolyser as pressure vessel
Using the electrochemical reactions to pressurise the system

PAWE

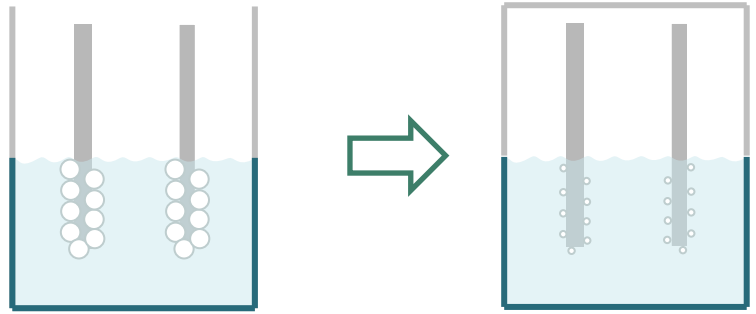


System efficiency
The overall energy demand for producing pressurized hydrogen can be reduced by utilizing the nature of the electrolyser.



Reduced gas volume

- Dynamic behaviour
  Fast ramp rates enable coupling to RE sources.
- Footprint
  Greatly reduced by in-creasing gas density.



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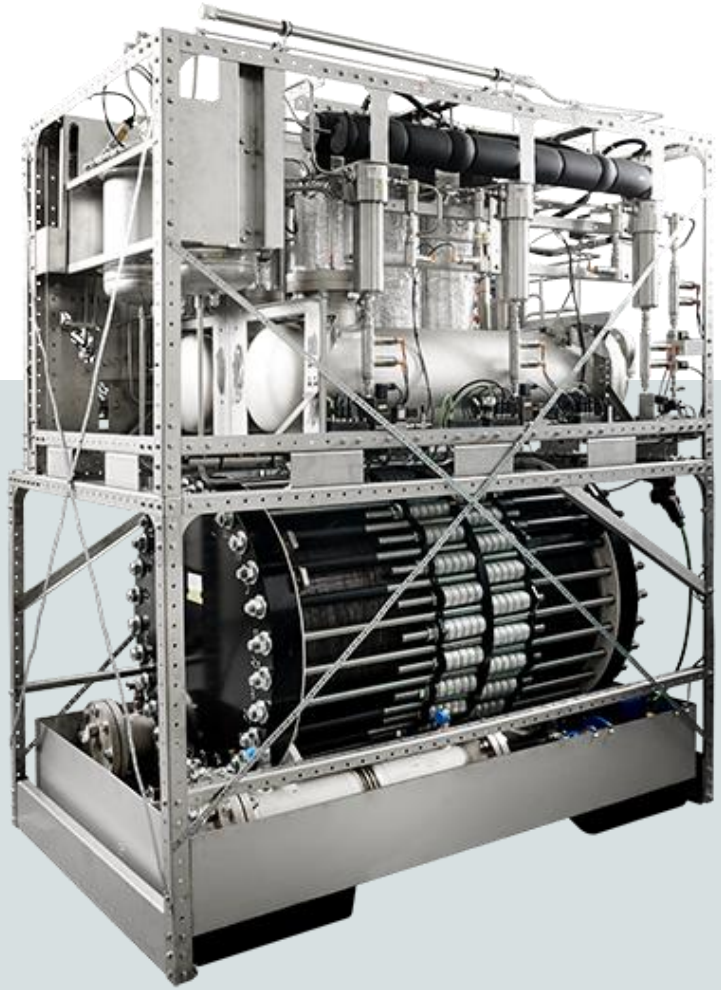
SYSTEMS

Advantages Pressurized Alkaline Water Electrolysis



	AWE	**PAWE**	PEM
Abundant Materials		■	
Low CAPEX		■	
High Pressure		■	
Quick Ramping		■	
Low Footprint		■	
Solid Electrolyte			

GREEN HYDROGEN SYSTEMS

Current

HyProvide® A - Series

For projects
up to 4.5 MW

Upcoming

HyProvide® X - Series

For projects
above 4.5 MW
and beyond
100 MW

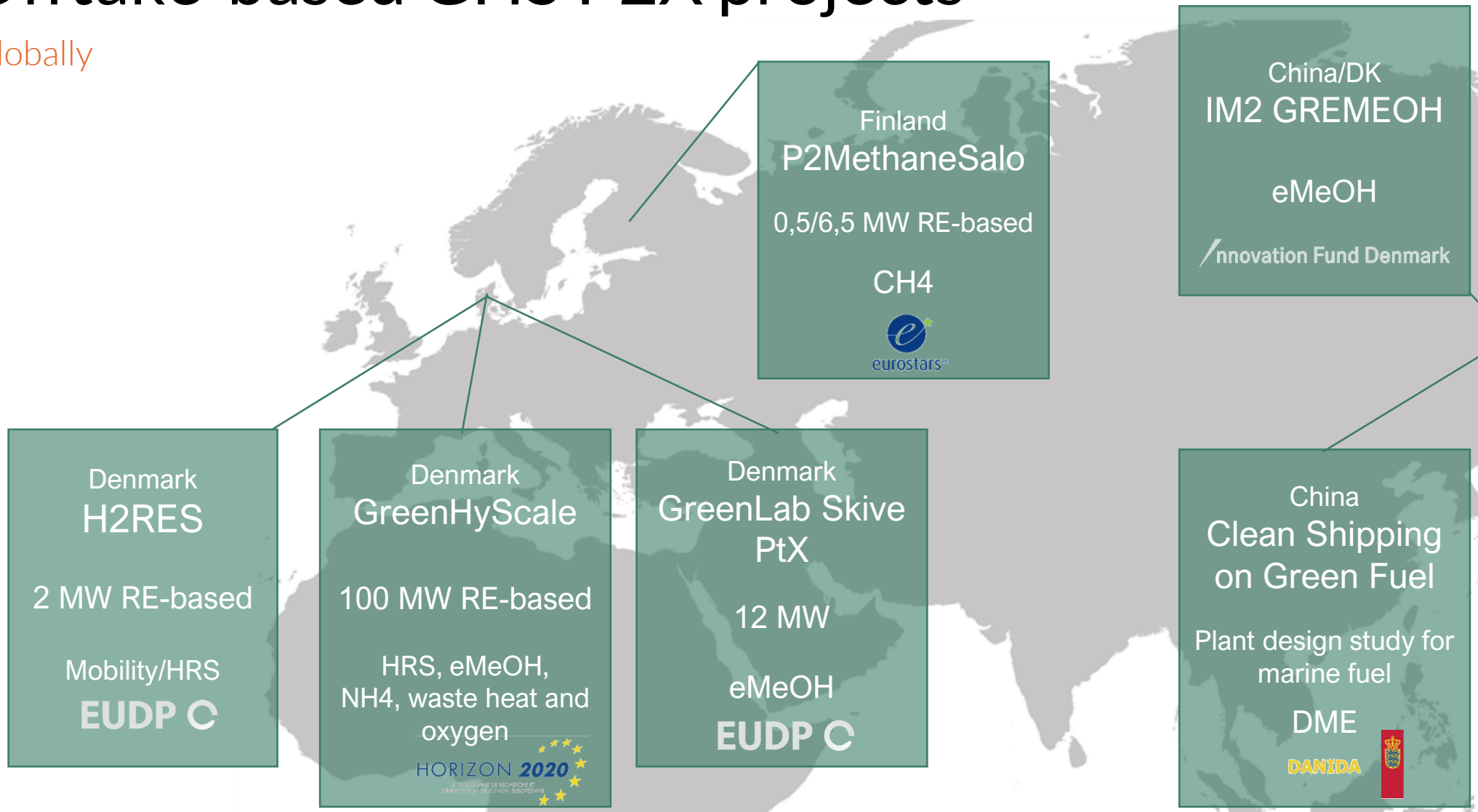
GHS HyProvide

	A90	X1200
Capacity (Nm^3/hr)	90	1200
Energy requirement (kWh/kg H2)	57,0*	54,7**
Output pressure (barg)	30	35
Ramp rates (s)	<15	<45
Footprint (m^2/MW)	33 - 111	13 - 45
Launch	2018	2024

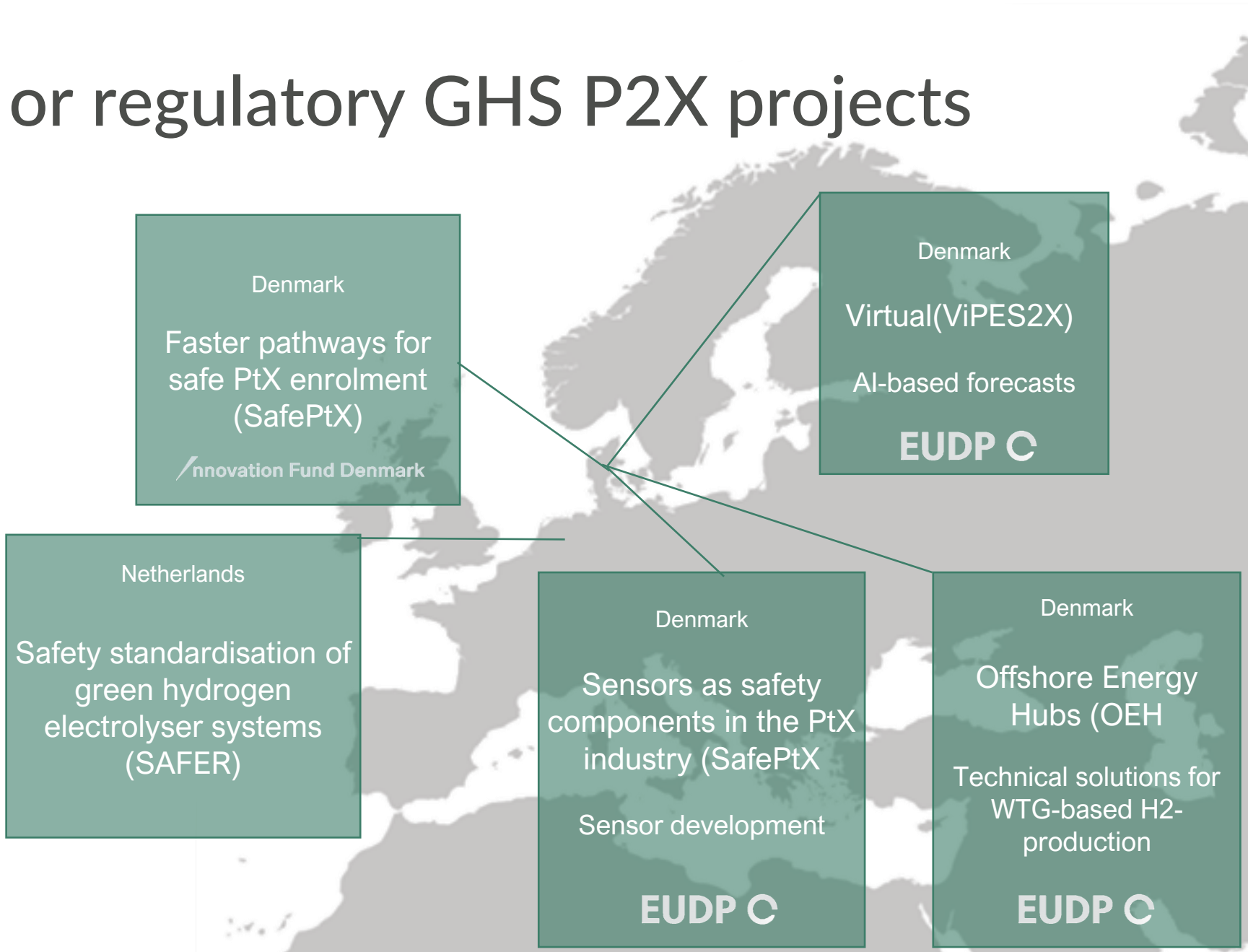
* stack and power supply; **expected, stacks, process module and power supply

Offtake-based GHS P2X projects

Globally



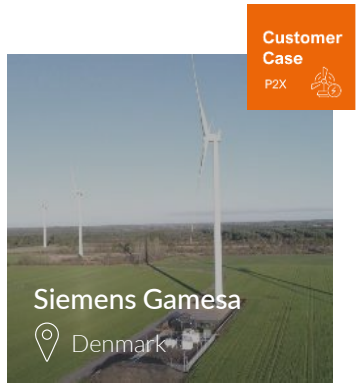
Technical or regulatory GHS P2X projects

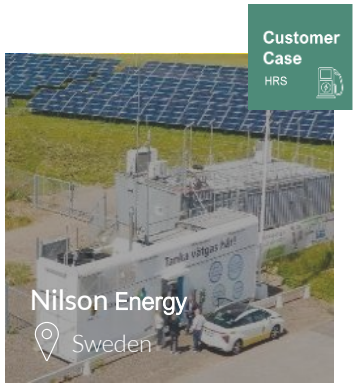


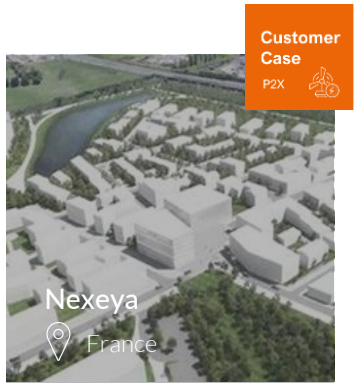
GREEN HYDROGEN SYSTEMS

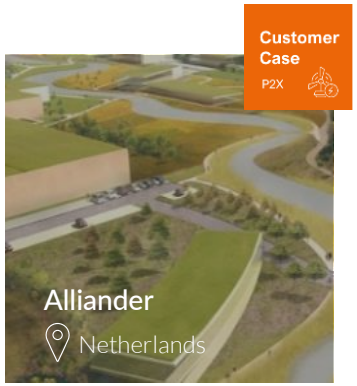
Selected customer cases

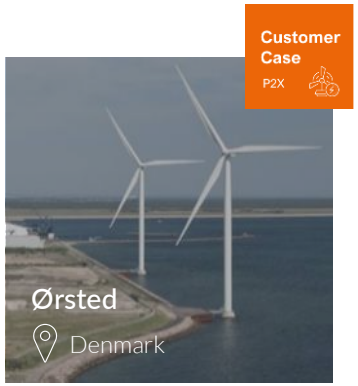
in Europe

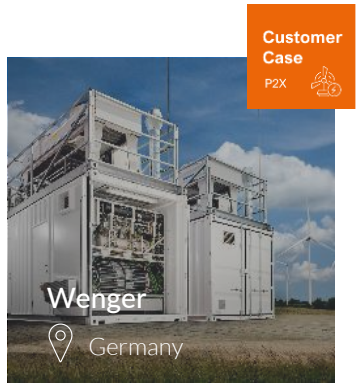


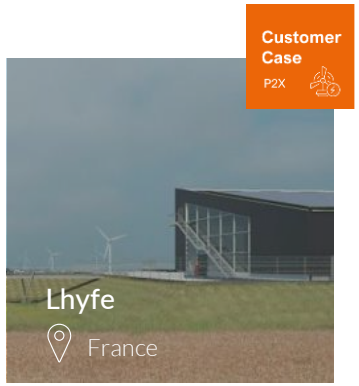


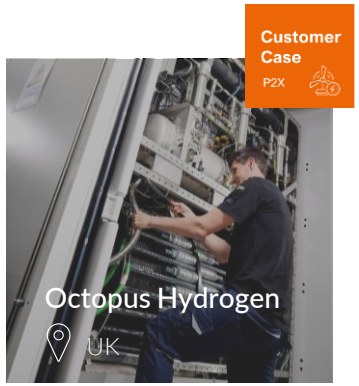


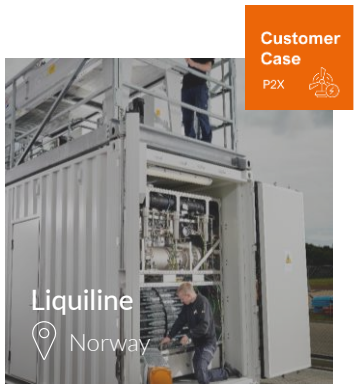


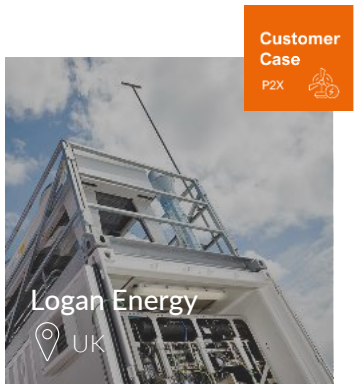












GREEN HYDROGEN SYSTEMS

Ørsted: H2RES

Demonstration of large-scale offshore RE-production

The aim of project, known as H2RES, is to produce renewable hydrogen fuel for heavy-duty road transport. A plant will be built around 5 HyProvide™ A90 electrolysers powered by two offshore wind turbines. Complete turnkey delivery and commissioning by GHS.

- Production: 975 kg H_2/day
- Outlet pressure: 28 bar
- Distribution to the transport sector in Greater Copenhagen and Sealand

Customer Case

P2X

GreenHyScale

Denmark's first 100 MW P2X facility

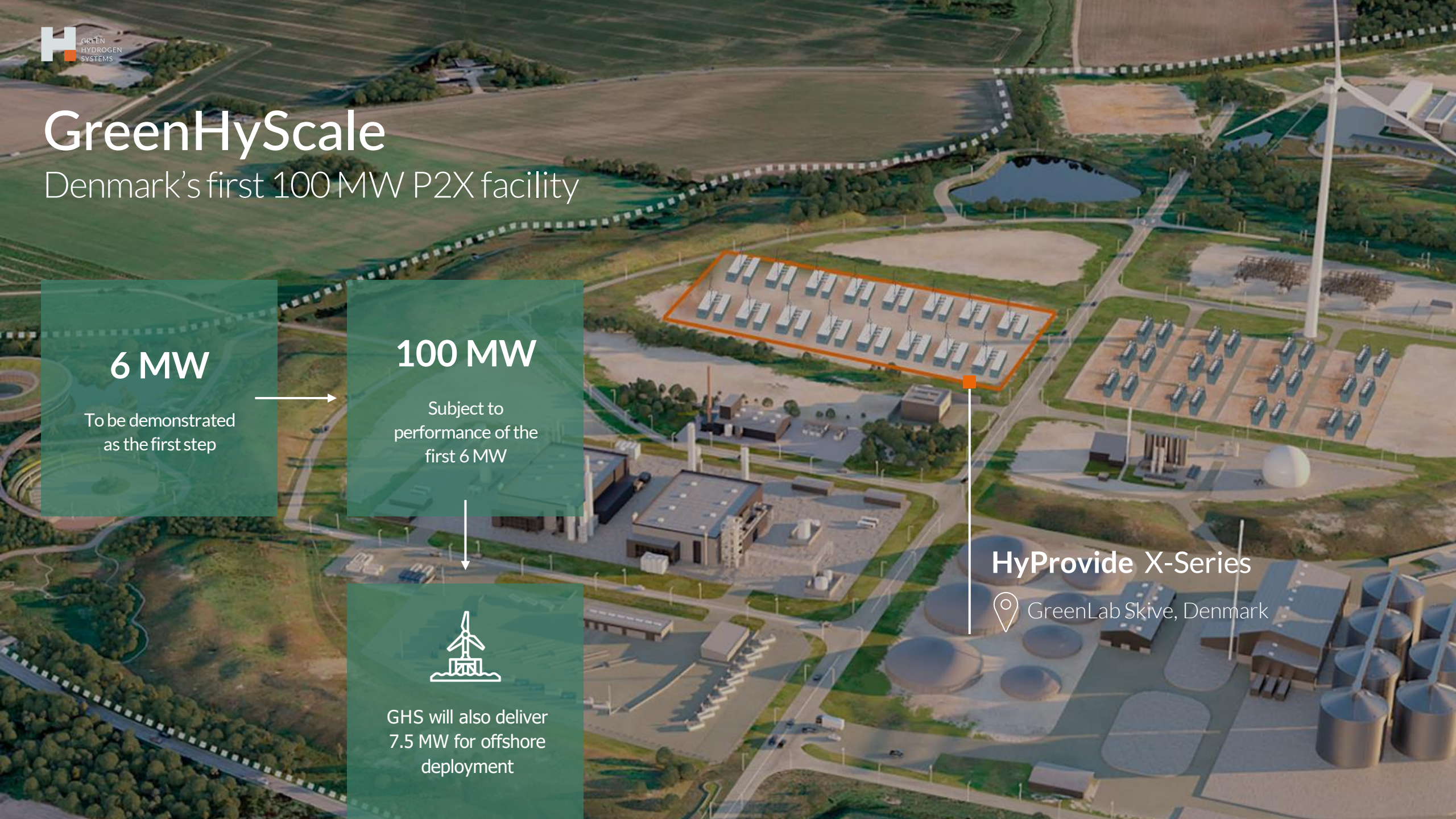
6 MW

To be demonstrated as the first step

100 MW

Subject to performance of the first 6 MW

GHS will also deliver 7.5 MW for offshore deployment



HyProvide X-Series

GreenLab Skive, Denmark

GREEN
HYDROGEN
SYSTEMS

Current production facility

From 75 MW to 400 MW

GREEN
HYDROGEN
SYSTEMS

Thank you for watching!