

Large-scale Deployment of Modular Pressurized Alkaline Electrolysers

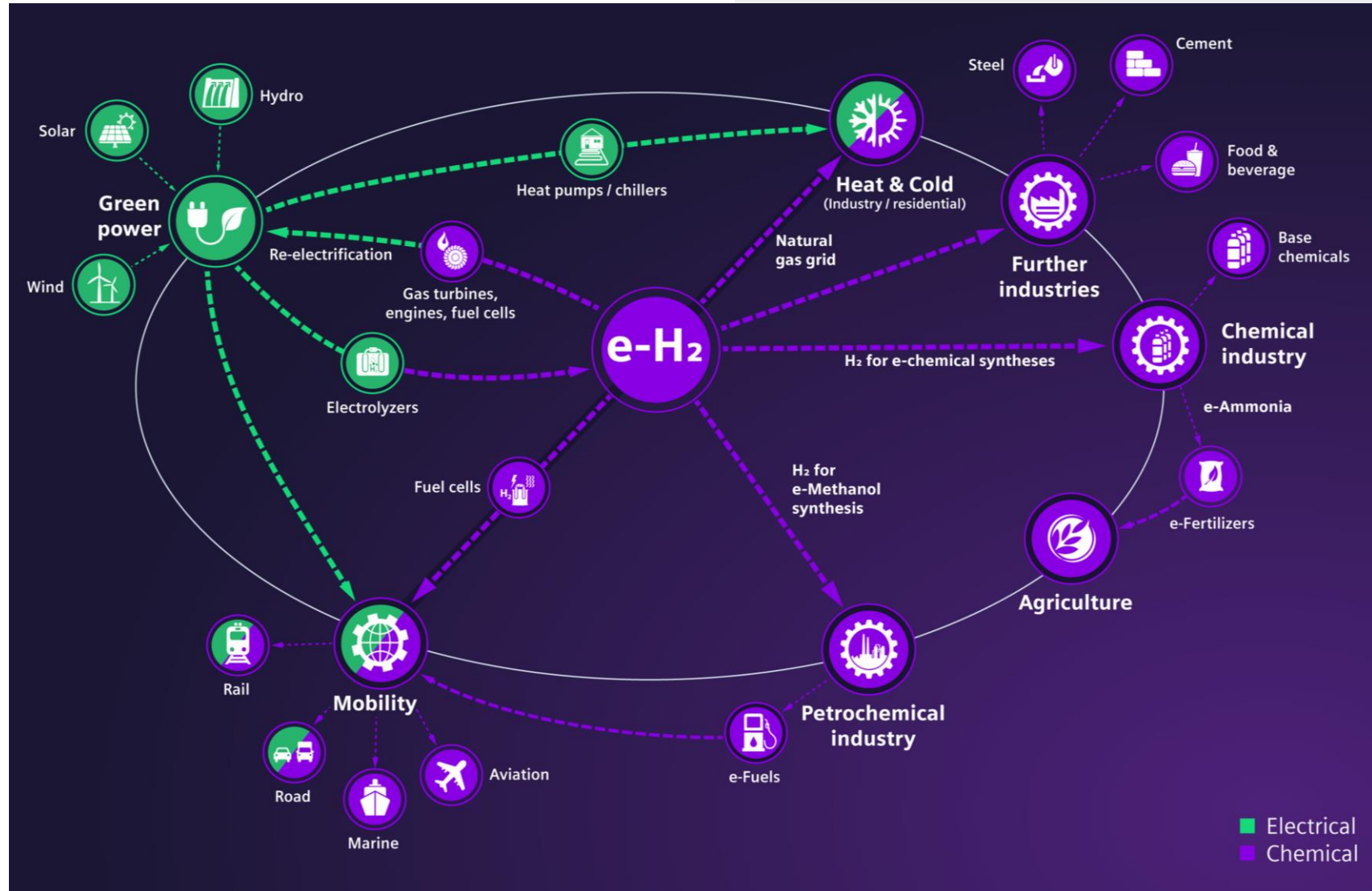
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■ Kasper Tipsmark Therkildsen

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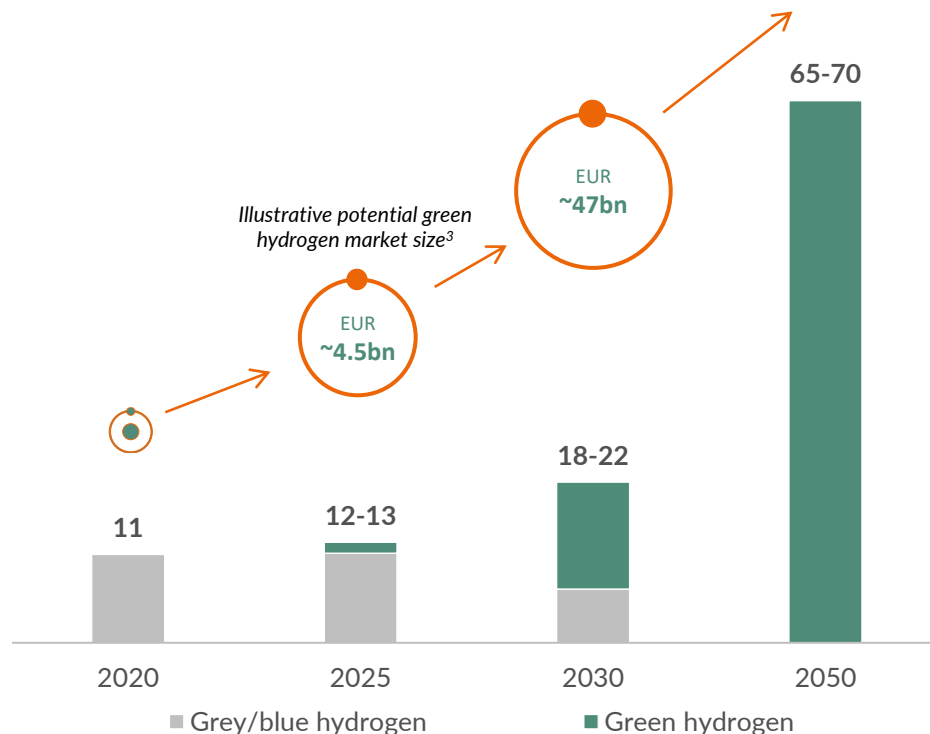
Path to a fossil free society



Demand for green hydrogen is surging, requiring significant scale-up of electrolysis capacity

Estimated future demand for hydrogen in the EU¹

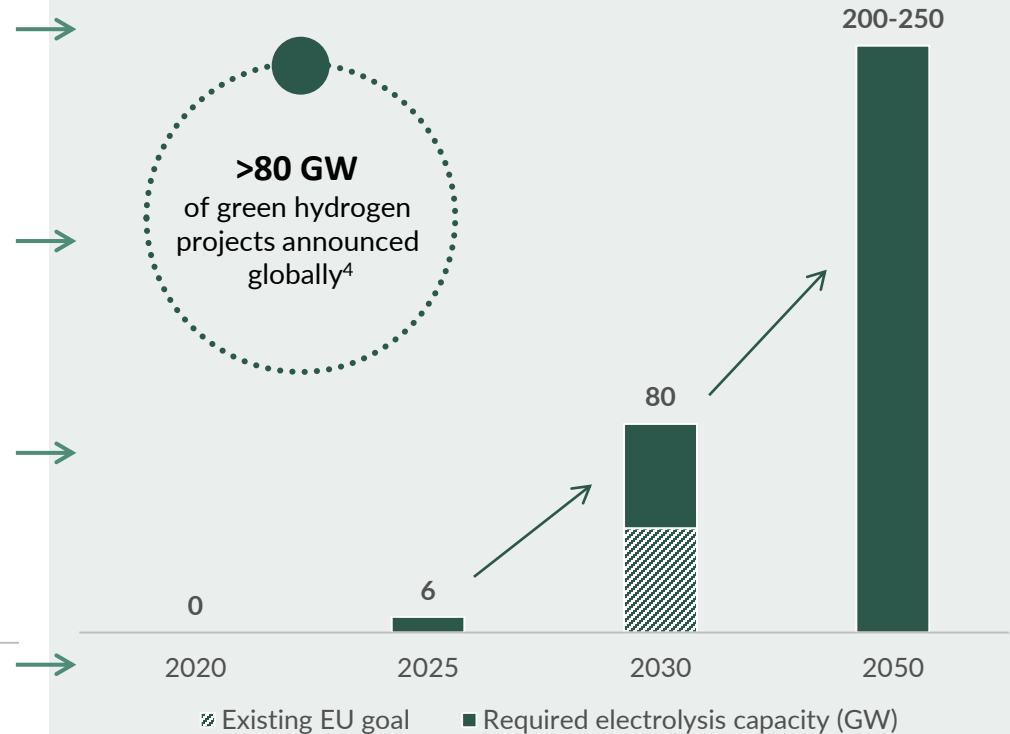
From Dansk Energi. Hydrogen demand in million tonnes H₂



Demand for hydrogen in Europe is expected to expand significantly

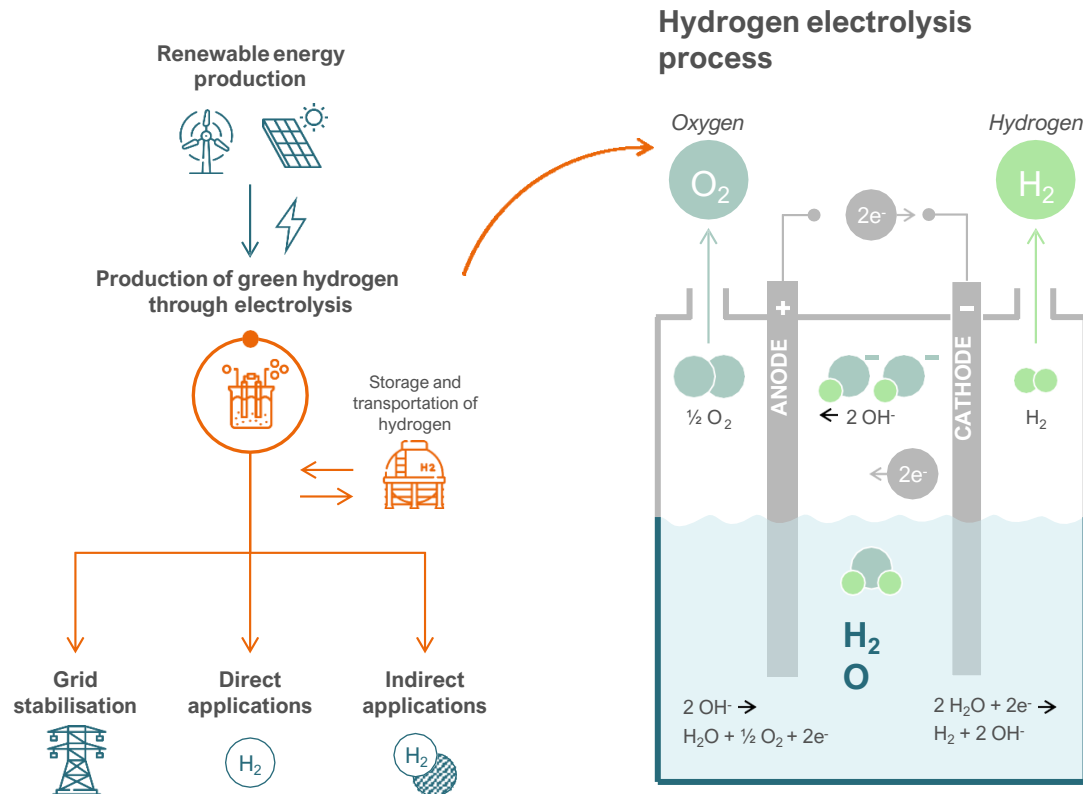
Required electrolysis capacity to meet EU demand¹

From Dansk Energi. Electrolysis capacity in GW



To meet demand, supply must increase considerably from highly limited current capacity

Hydrogen electrolysis splits water into hydrogen and oxygen

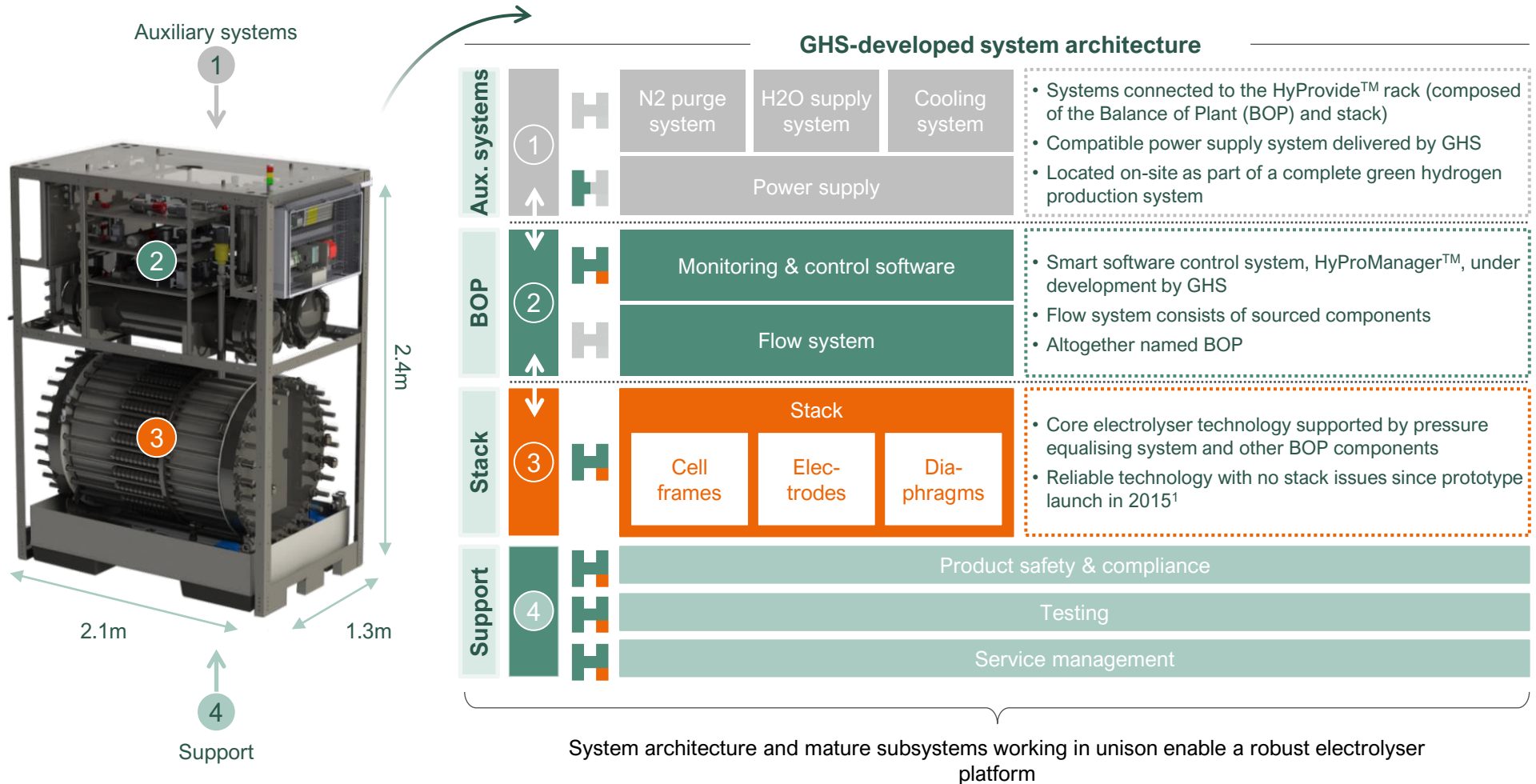


Hydrogen electrolysis is a process that splits water into hydrogen and oxygen using electricity.

If the electricity is derived from renewable energy sources, the produced hydrogen is considered green.

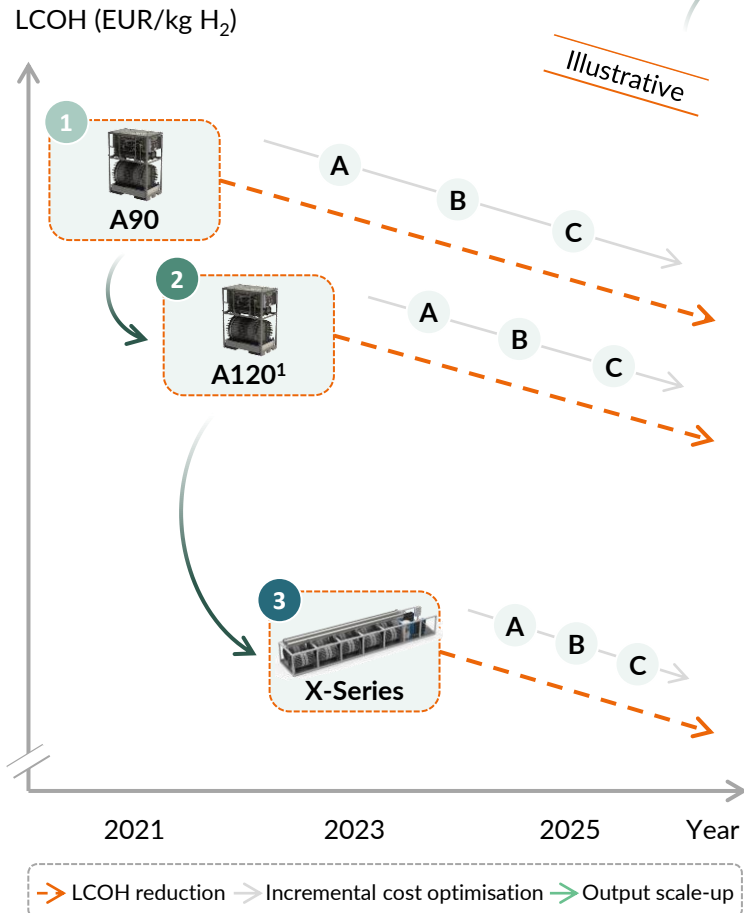
The process of green hydrogen electrolysis is completely fossil-free, as the only by-product is oxygen and the power used in electrolysis is generated from renewable sources.

Platform system architecture and sub-systems



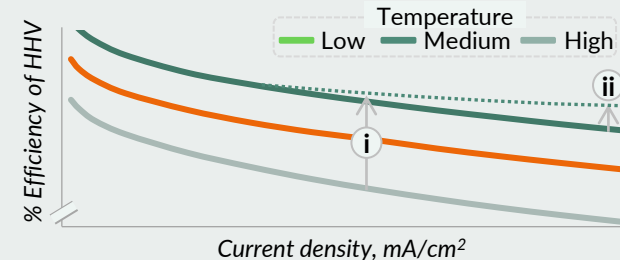
GHS will realise LCOH reduction through initiatives across key cost factors focused on cost optimisation and output scale-up

GHS' LCOH reduction over time



LCOH reduction initiatives across key cost factors

Initiatives	Cost-out actions	LCOH impact
A Cost-out programme	<ul style="list-style-type: none"> Should-cost analysis, sourcing optimisation and design to cost 	All cost factors
B Serial production	<ul style="list-style-type: none"> Optimisation of technology, design and processes to increase system suitability for serial production 	CAPEX, other OPEX
1 C Increased system energy efficiency	<ul style="list-style-type: none"> R&D to achieve higher system energy efficiency <ol style="list-style-type: none"> System design for higher temperatures (higher efficiency per electric current density) Cell resistance reduction (reducing slope of linear part of efficiency curve) 	Electricity
2 Model version upgrade	<ul style="list-style-type: none"> Increased system current density, enabling higher output at marginally lower efficiency and costs 	CAPEX, other OPEX
3 System platform development	<ul style="list-style-type: none"> Optimisation of BOP and stack through new platform development, enabling greater scale economics 	All cost factors

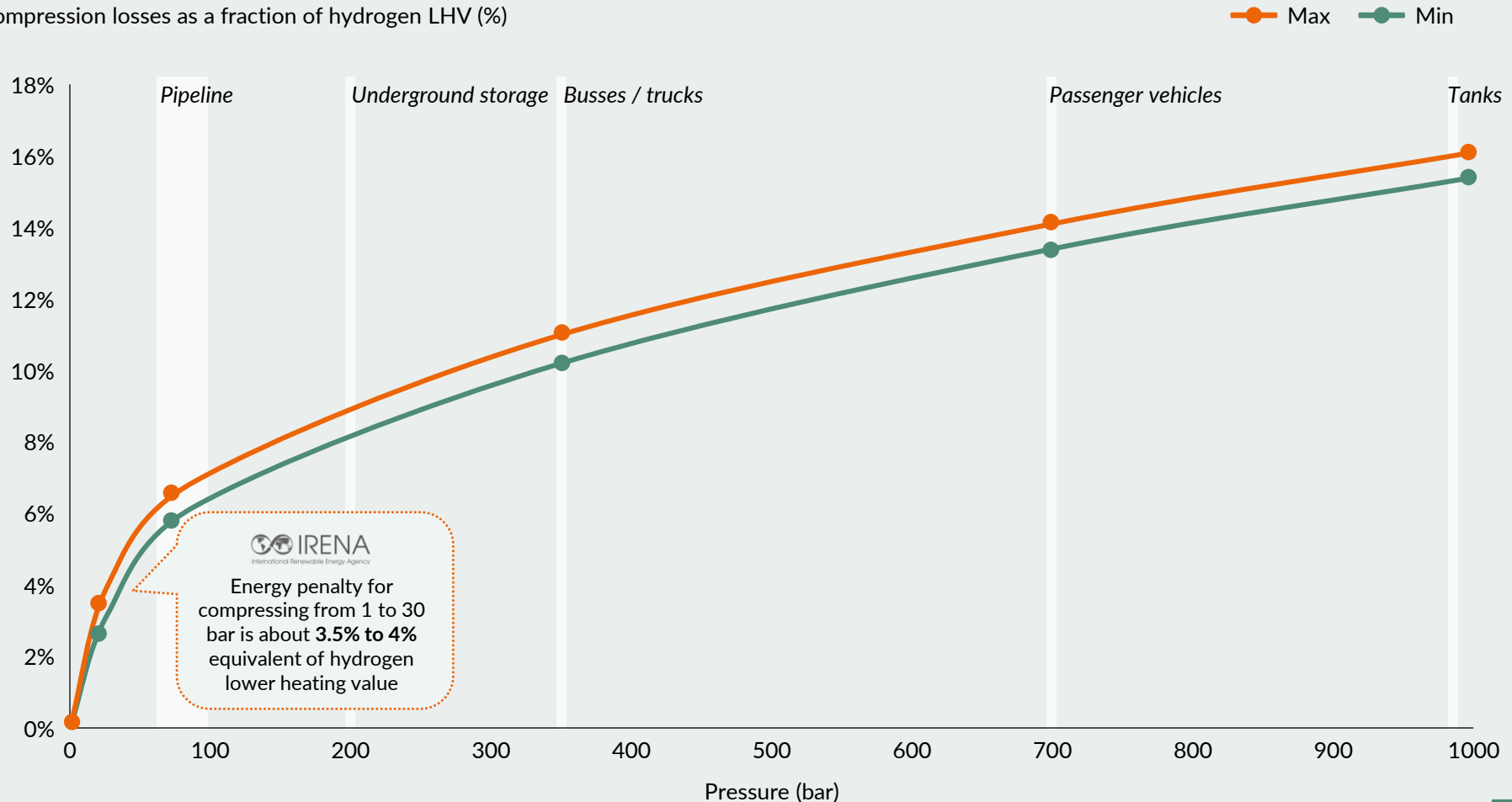


High system delivery pressure is an advantage as it affects versatility through efficiency and LCOH

Energy losses for the multi-stage mechanical compression of hydrogen






Illustrative

Compression losses as a fraction of hydrogen LHV (%)



Modular system design enables targeting of increasingly large projects

Modular system design

-  Standardised and pre-tested “plug-and-play” electrolyser modules
-  Quick and easy addition/ installation of new modules on-site like building blocks
-  Fully automated operation with minimal manpower requirements¹
-  Modular in-a-box design allowing for clustered solutions and incremental project build-out
-  Small footprint/MW consumption increasing number of applications

Scalable and footprint efficient offering

Multi-MW projects

GreenLab
skive

To be announced 2021

30 x A90

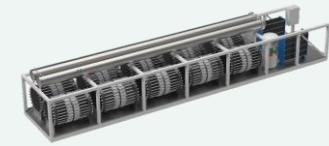


12
MW

GHS electrolyzers

Electrolysis capacity²

Future GW-scale projects



X-Series ready for commercialisation in 2023

Beyond 2025

~133 x 7.5MW⁵



GHS electrolyzers



Electrolysis capacity

Increasingly large projects over time, delivering solutions with high efficiency per sqm.

HyProvide X-series in a clustered version



Dynamic utilisation

Load balancing to achieve specified production output is critical when energy source is variable



Automated redundancy

Secure stable production if one unit is temporarily down



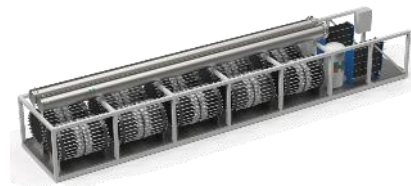
Easy service and maintenance

Production can continue during service and maintenance on specific parts



Rapid system diagnostics

Precise system diagnostics and problem-solving enabled by monitoring of individual units

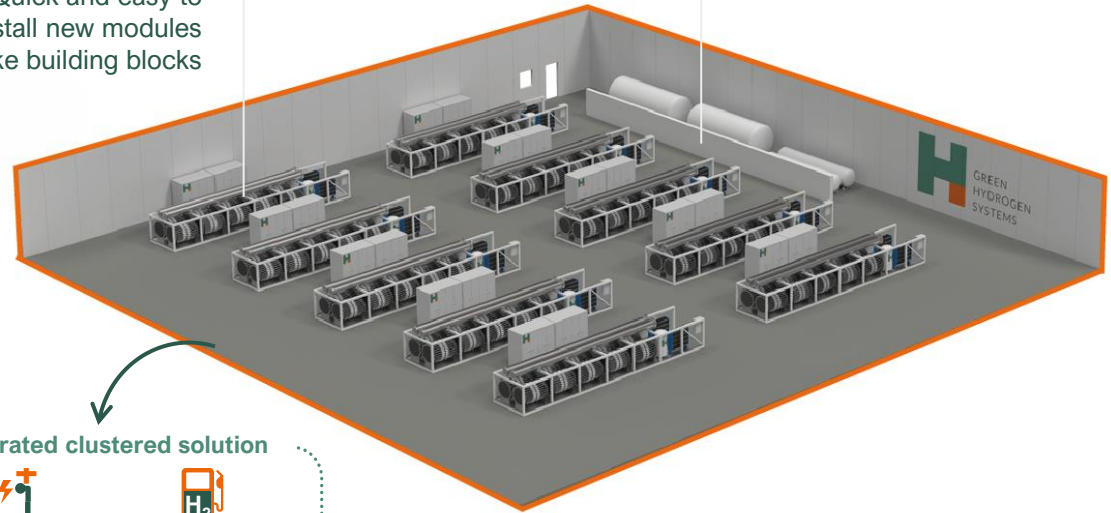
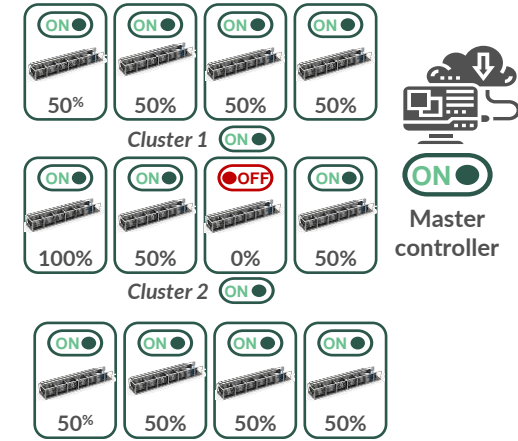


Standardised & pre-tested modules

Quick and easy to add/install new modules on-site like building blocks



HyProManager™ software enables control of individual units, clustered units and all units as a group, bringing ultimate flexibility



Illustrated clustered solution



~?

max module power
consumption



~?

daily hydrogen
production

GreenHyScale



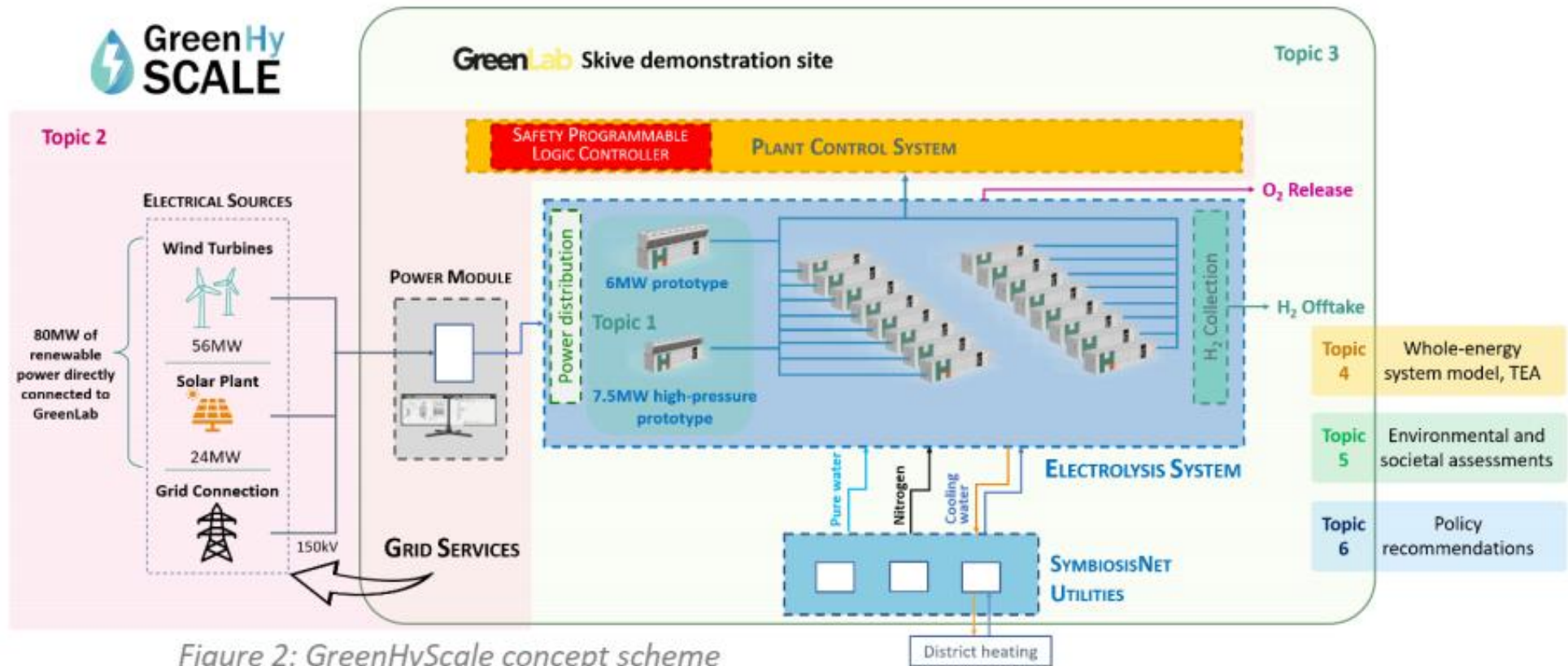
100 MW installation at GreenLab Skive

Project start: Oct. 2021 duration 5 years
Total budget: 53M€
Funding: 30M€

Key milestones

Nov 22: Prototype operational at GreenLab Skive
Oct 23: Go/No Go milestone
Oct 24: 100 MW fully operational At GreenLab Skive
Nov 25: First operation of high-pressure 7.5 MW electrolyser at GreenLab Skive

GreenHyScale concept

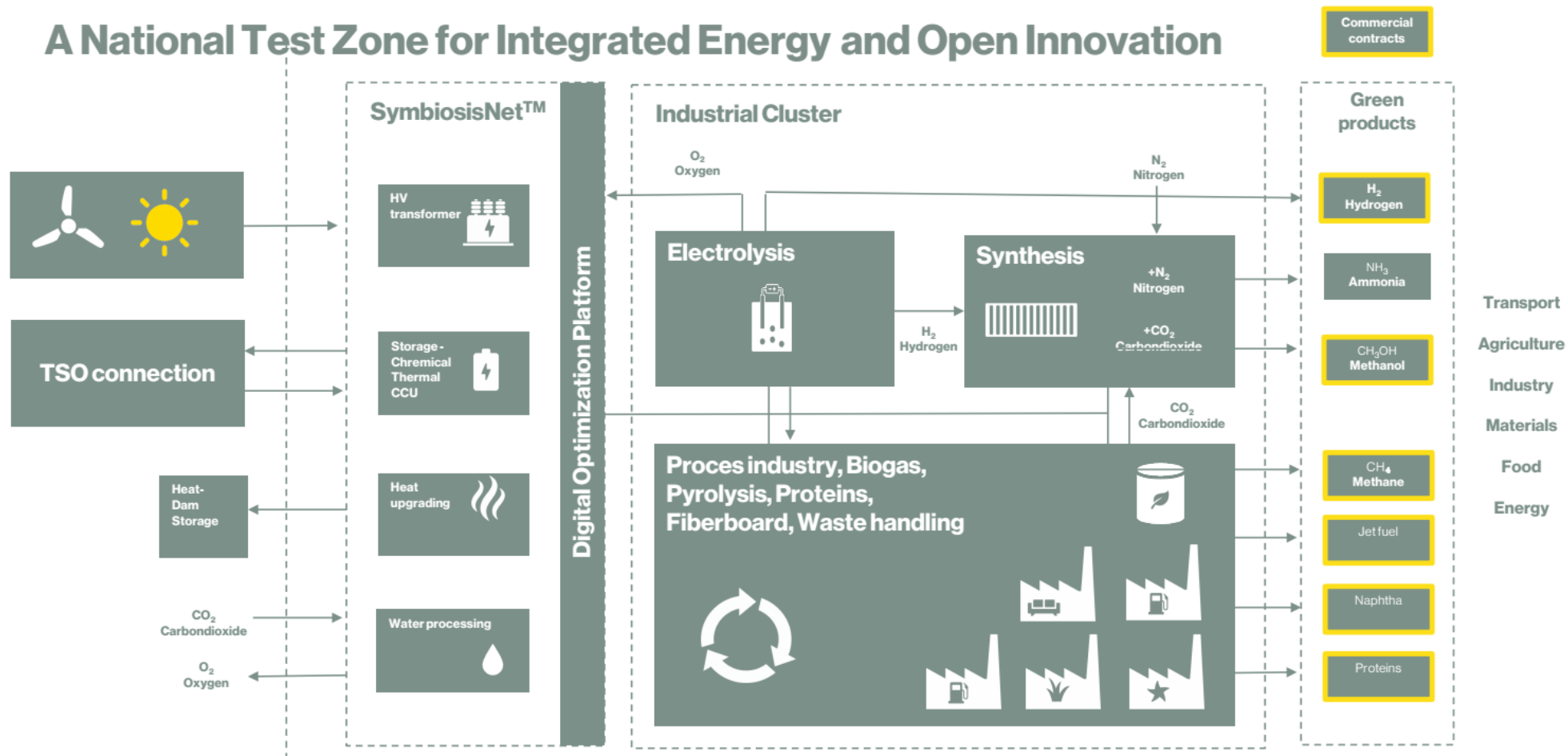


GreenLab Skive



GreenLab Skive Energy Park – SymbiosisNet™

A National Test Zone for Integrated Energy and Open Innovation



Local infrastructure

Unique location

We are close to national gas and electricity grids as well as Batum Salt Cavern for potential seasonal storage.

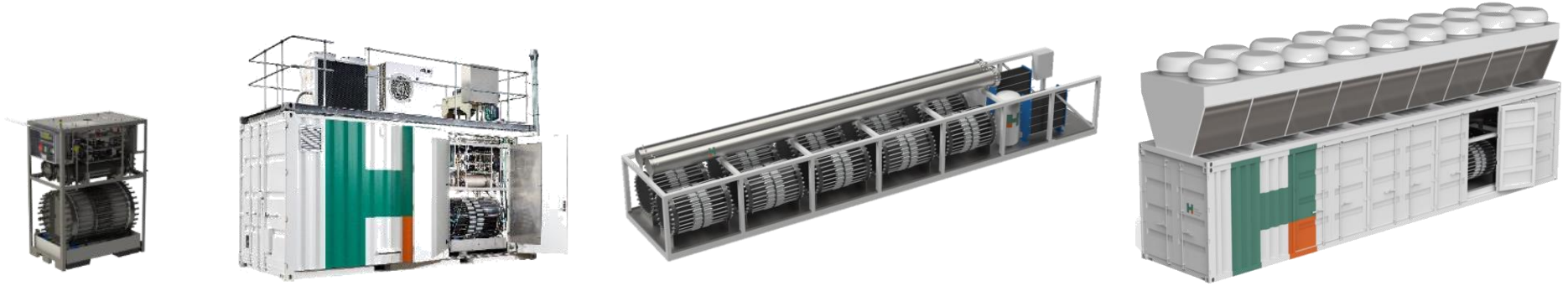
- GreenLab areas
- District heating pipeline
- 40 bar gas distribution pipeline
- 4 bar gas distribution pipeline
- Pipeline Balling - Bostrup Biogas
- High voltage cable - 150 kV

Thank you



GREEN
HYDROGEN
SYSTEMS

Why choose our electrolyzers?



Selected technological benefits



Builds on mature and commercially proven pressurised alkaline technology



Flexible with ability to handle variable loads suitable for renewable energy



High efficiency (HHV) and system delivery pressure (bar)



Modular and versatile solutions that are suited for scale-up and serial production



Significant cost-out potential

Selected commercial benefits



“Plug-and-play” units with modular in-a-box design allowing for clustered solutions



Small footprint due to compact modular design increasing number of applications



Fully automated operation with minimal manpower requirements¹



Standardised and pre-tested components and design for lower S&M costs



High durability (10+ year stack durability) and system uptime

One of the most efficient pressurised alkaline electrolyzers on the market

HyProvide™ A-Series

HyProvide™ X-Series

Current offering

Under development

A30

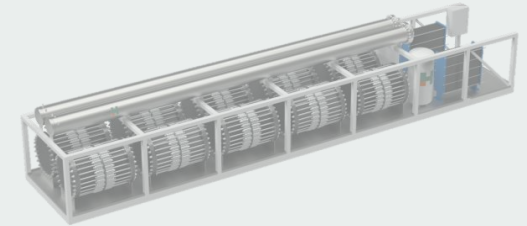
A60

A90

A120

A150

X-versions



Power consumption (kW)

Power consumption (kW)

150

300

450

600

750

5 – 7,500

Ancillary solutions and supporting services



Containerised solutions
for rapid installation and
deployment



Installation and engineering
services



Global Service and
Maintenance for installed
units

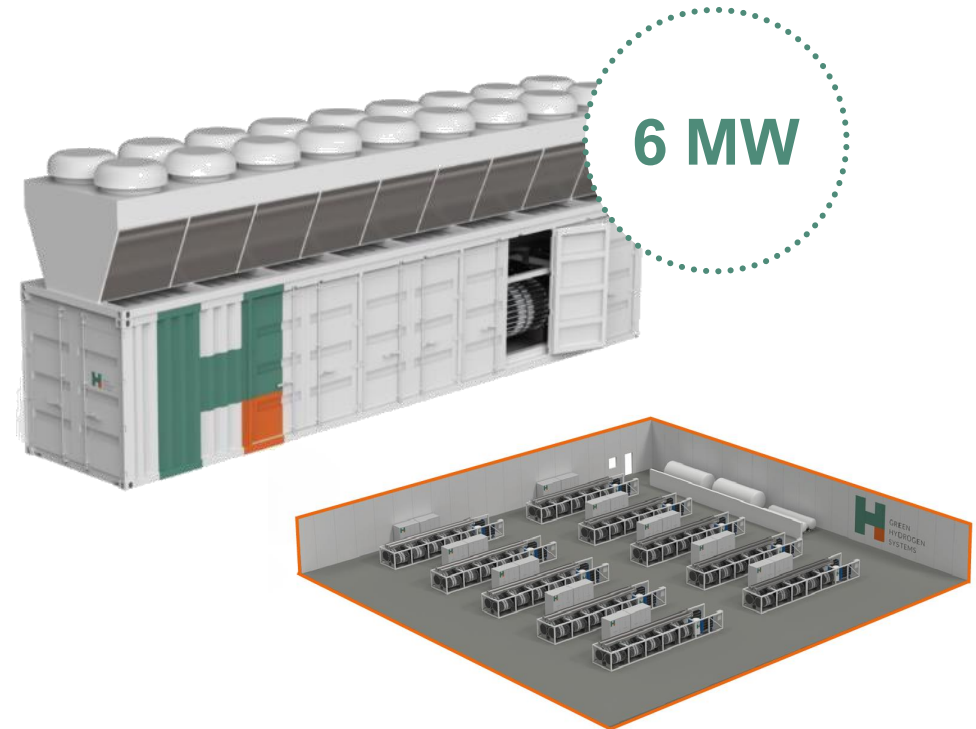
Solution for every scale

HyProvide™ A-Series Containerised solution



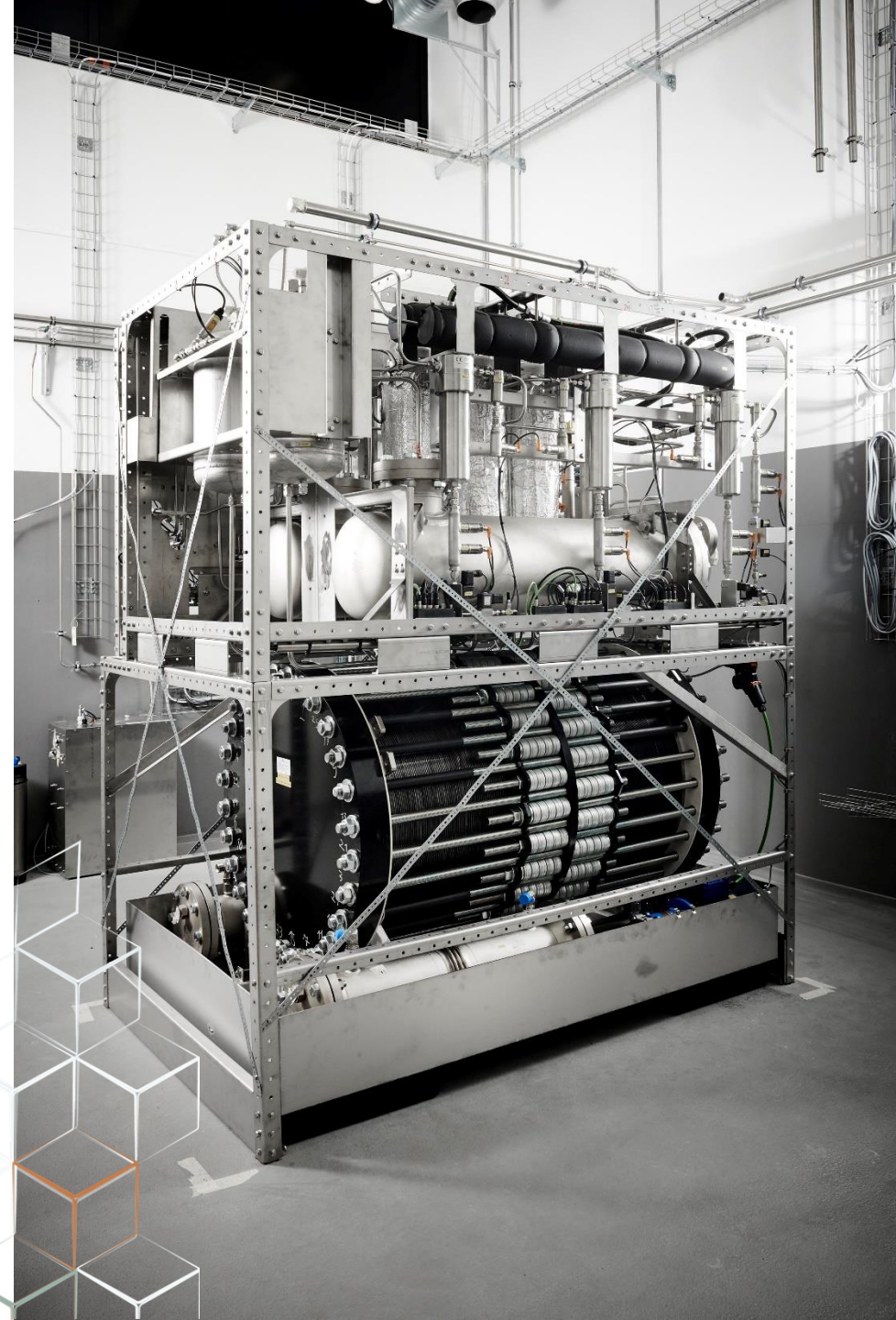
20-foot or 40-foot containers comprising 1-2x A90
(includes auxiliary systems) **or factory floor solution**

HyProvide™ X-Series Containerised solution



Upcoming 40-foot container comprising 1x X-Series
(excludes auxiliary systems) **or factory floor solution**

Green Hydrogen Systems is a leading provider of **alkaline electrolyzers**. Our technology is required to build an energy supply system solely based on renewable energy - and we are committed to help our customers **decarbonise their operations** and increase their independence from fossil-fuels through onsite production of green hydrogen



Ongoing scale-up of production expansion



Nordager (Kolding) production site



Nordager site

1 2

4,500 m²
(of which ~2,000m² admin)

1

2021 year-end run-rate capacity could triple by introducing additional production shifts

2

Introduction of production processes and efficiencies could further double the capacity

75 MW p.a. >>> 150 MW p.a.

The Company expects to expand its facilities ahead of reaching maximum capacity, making it unlikely that production output will be limited by the above estimates

Expansion potential

2+

30,000 m²
(acreage availability)

+1,000 MW p.a.
(estimated potential based on full expansion of facilities)³



New production facilities
Kolding, Denmark

The Nordager production site is designed to be a **standardised factory blueprint** for establishing potential additional production sites

New production sites to be considered **if commercially substantiated by order pipeline**

The versatile design of our solutions allows for application across **many different market segments** for green hydrogen production. Below selected customer cases.

Customer Case
P2X



Customer Case
HRS



Customer Case
P2X



Customer Case
HRS



Customer Case
P2X



Customer Case
P2X



Customer Case
P2X



Customer Case
P2X

