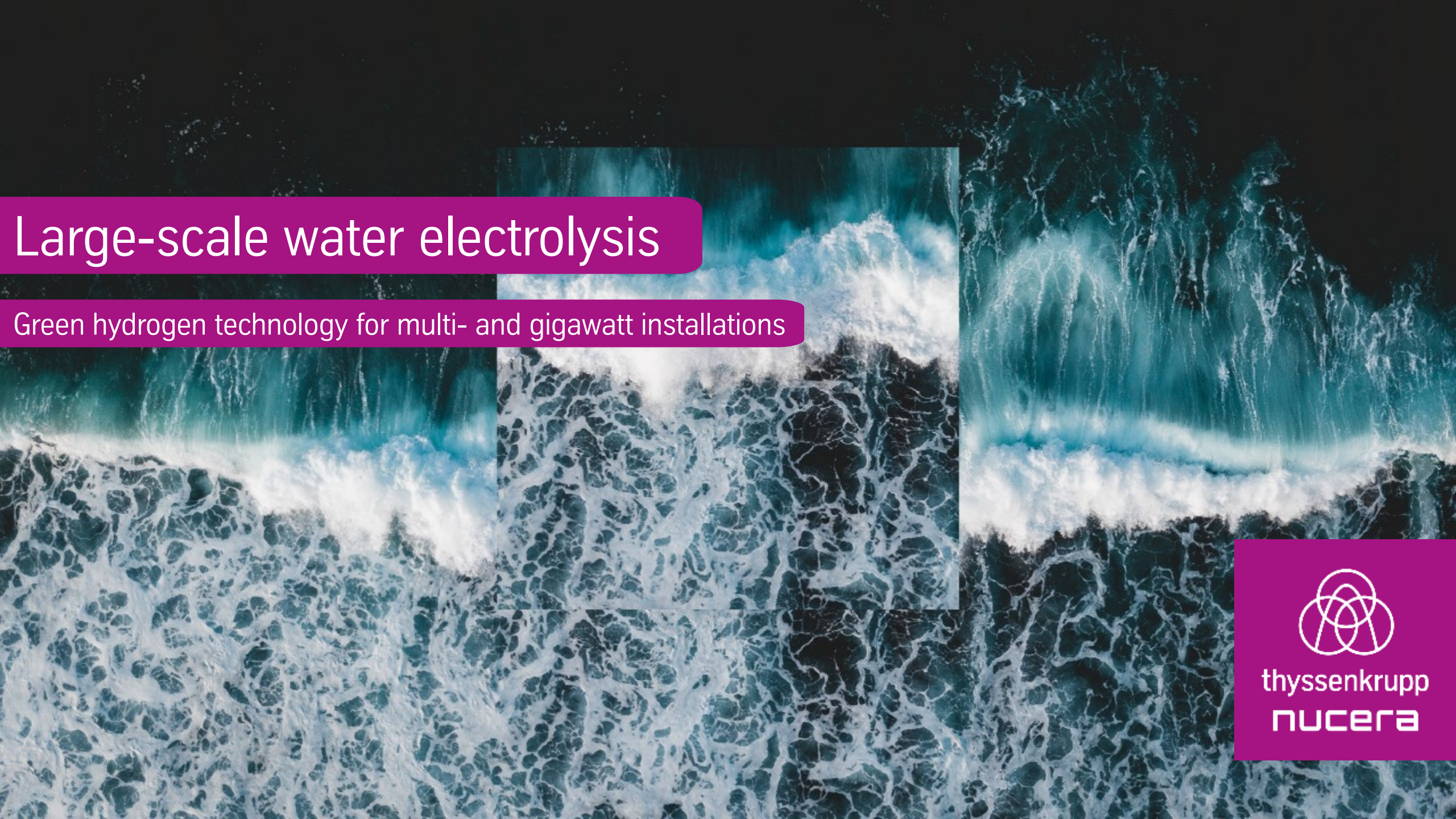
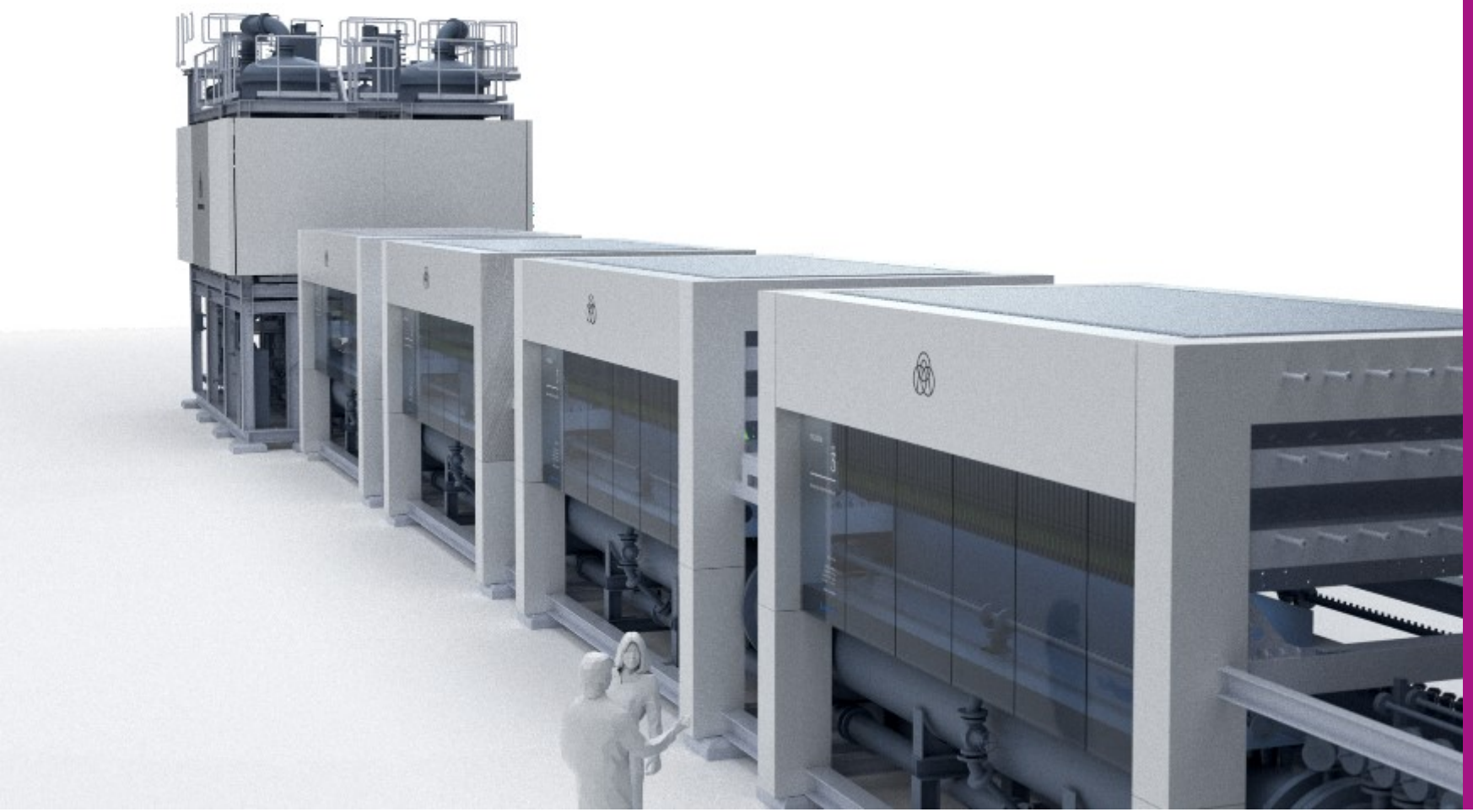


Large-scale water electrolysis

Green hydrogen technology for multi- and gigawatt installations

thyssenkrupp nucera



Who we are

Purpose:
We shape the new era.

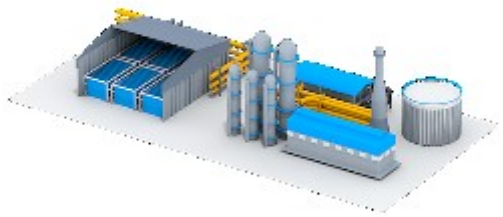
Vision:
#1 provider of hydrogen and chlorine technologies.

Mission:
With passion for innovation,
we enable our customers to make superior electrolysis products and minimize the CO_2 footprint.

thyssenkrupp nucera

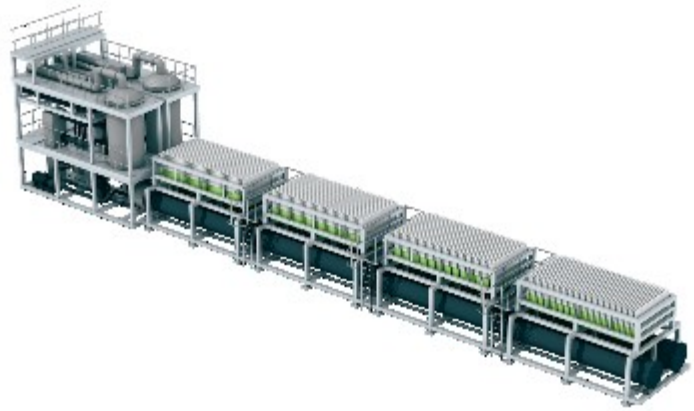
We are the leading Alkaline Water Electrolysis (AWE) and Chlor-Alkali (CA) technology provider globally and have strong partners at our side

thyssenkrupp — 66%[1] → thyssenkrupp nucera ← 34% — DE NORA our research - your future



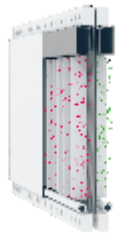
EPC contractor for green chemicals

- thyssenkrupp Uhde is one of the world's leading engineering companies in the design and construction of chemical plants
- Joint offering for integrated solutions like green NH_3 or MeOH



Supplier of electrolyzer modules

Advisory	IP and R&D	Engineering
Procurement	Construction	Service

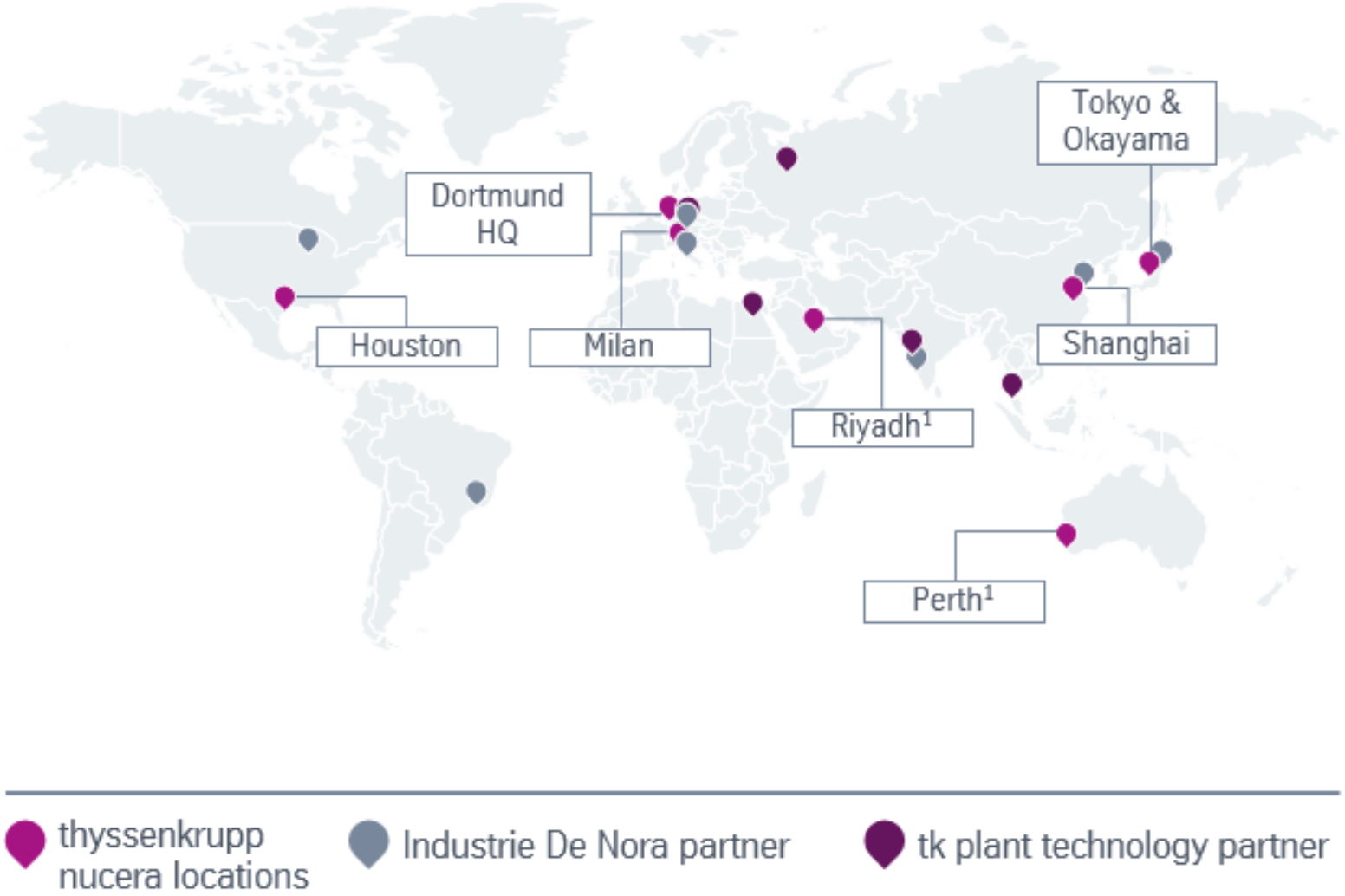


Manufacturer of the electrolysis cells

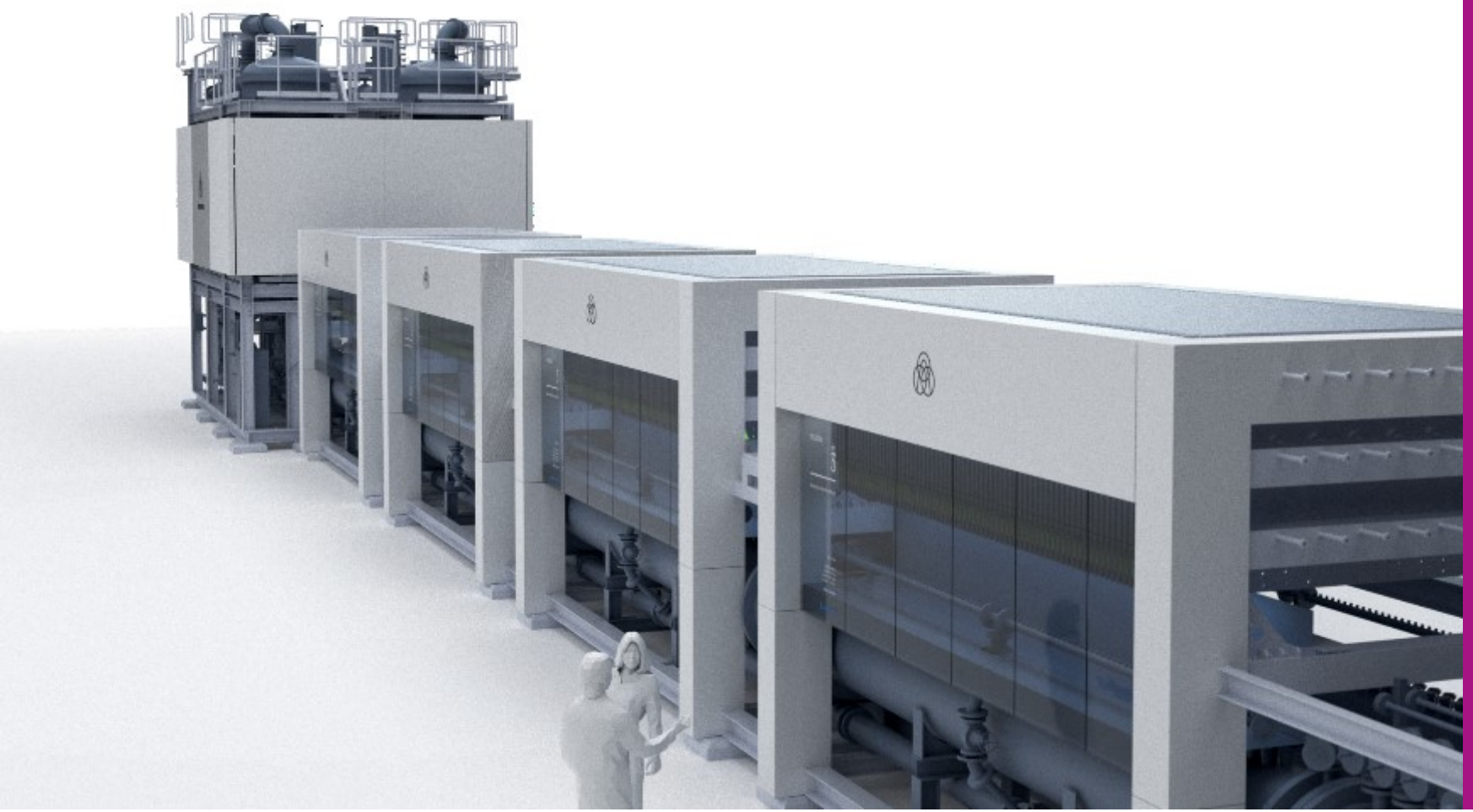
- 20-year partnership with Industrie De Nora, dedicated to unique technical solutions
- Joint development of coatings and electrolyzer cells for thyssenkrupp nucera

1 Shares of thyssenkrupp and Industrie De Nora in thyssenkrupp nucera

Building on a leading global organization with a network close to customers



1 Newly established office

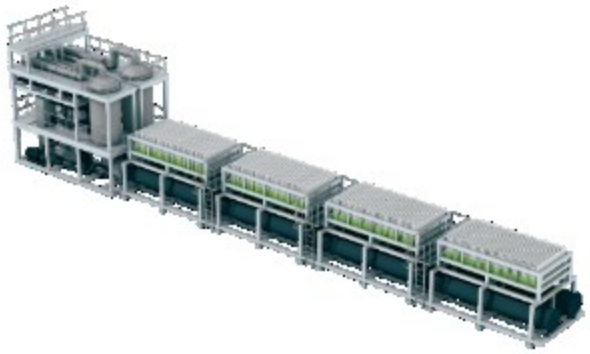


Our product

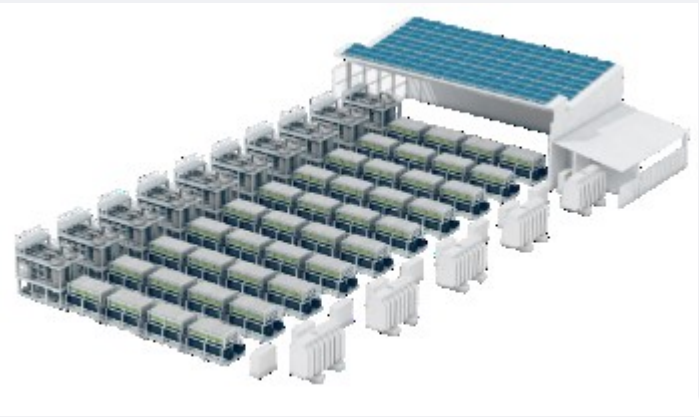
We offer an efficient and highly scalable concept

AWE single element

20 MW electrolyzer unit



Highly scalable GW plants



Our unique 20 MW electrolyzer module – the basis for bankable projects

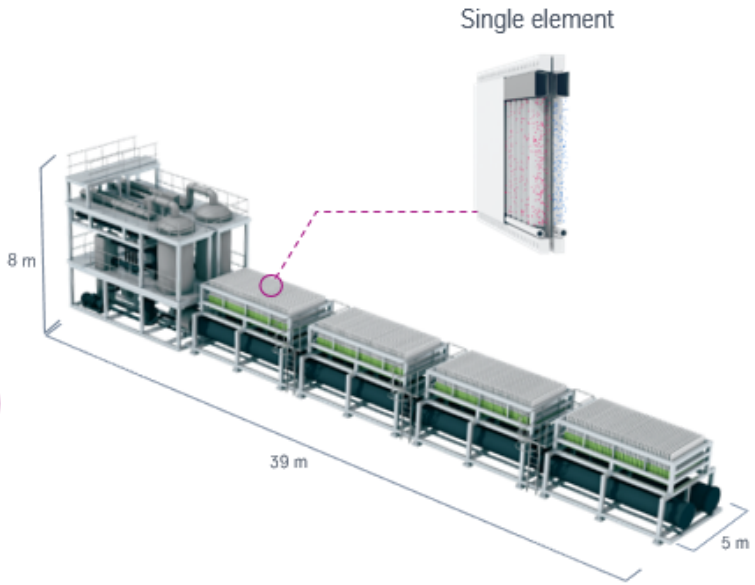
10 Gigawatt
installed Power[1]
(incl. Chlor-Alkali electrolysis)

50 years
expertise in design, construction and operation

> 1 Gigawatt
manufacturing capacity for water electrolysis equipment in Germany

> 600
electrochemical projects realised worldwide[1)]

[1] 1 incl. Chlor-alkali electrolysis



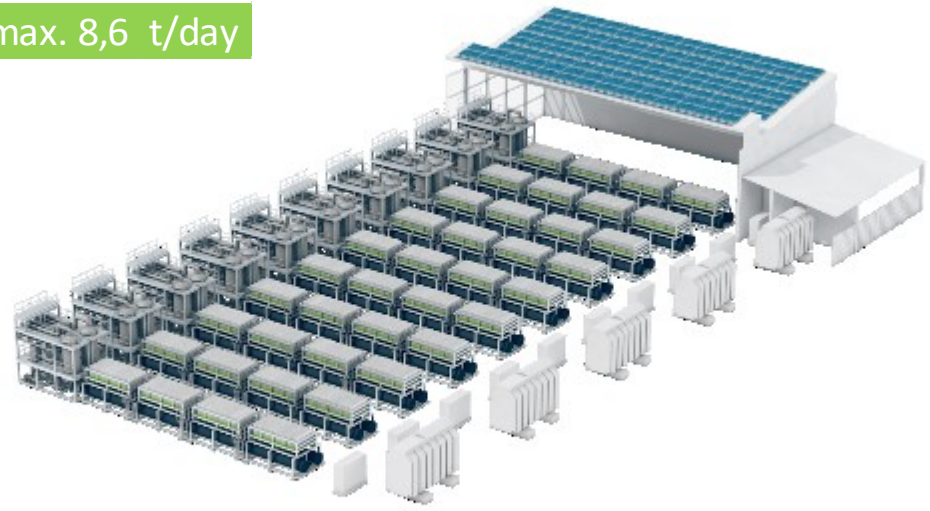
- ✓ **Safety** | Non-pressurized design | single element monitoring
- ✓ **Longevity** | Fit for circular economy and refurbishments Single element exchange instead of stacks
- ✓ **High Performance** | Leading in total cost of ownership
- ✓ **Compact Design** | High current density | small footprint
- ✓ **Service** | Existing service network
- ✓ **Financing** | Well referenced cell design and expertise in electrolysis support a viable banking case

Our standardized high performance product and its key features

Output from a 20 MW_{el} module

Hydrogen production rate	4,000 Nm^3/h^*
Hydrogen pressure at AWE module	0.300 barg
Hydrogen purity, saturated with H_2O at 40 °C	99.9 % (v/v)
Oxygen production rate	2,000 Nm^3/h^*
Oxygen pressure at AWE module	0.200 barg
Oxygen purity, saturated with H_2O at 40 °C	99.5 % (v/v)

360 kg/h max. 8,6 t/day



Operability

The turn down ratio of the electrolysis modules	10 %
The turn up ratio of the electrolysis modules	100 %
Ramp-speed (up and down, hot system)	Suitable to renewable energy sources
Start-up times: Cold to 100 % load	40 – 60 min.
Availability	up to 98 %

Power consumption at start of life (DC)

Electrolyzer, at max. capacity	4.5 kWh/Nm^3 (DC)

50,1 kWh/kg
78,7% efficiency (HHV)

Power consumption at start of life (AC)

System at nominal capacity:

- incl. transformation / rectifying
- incl. hydrogen compression to 30 bar_g
- incl. all other electrical consumers within battery limits (purification of 99,999 %)

4.9 kWh/Nm^3 (AC)

* Nm^3 is defined as 1 m^3 of gas (100%) at 273.15 K and 1.013 bar

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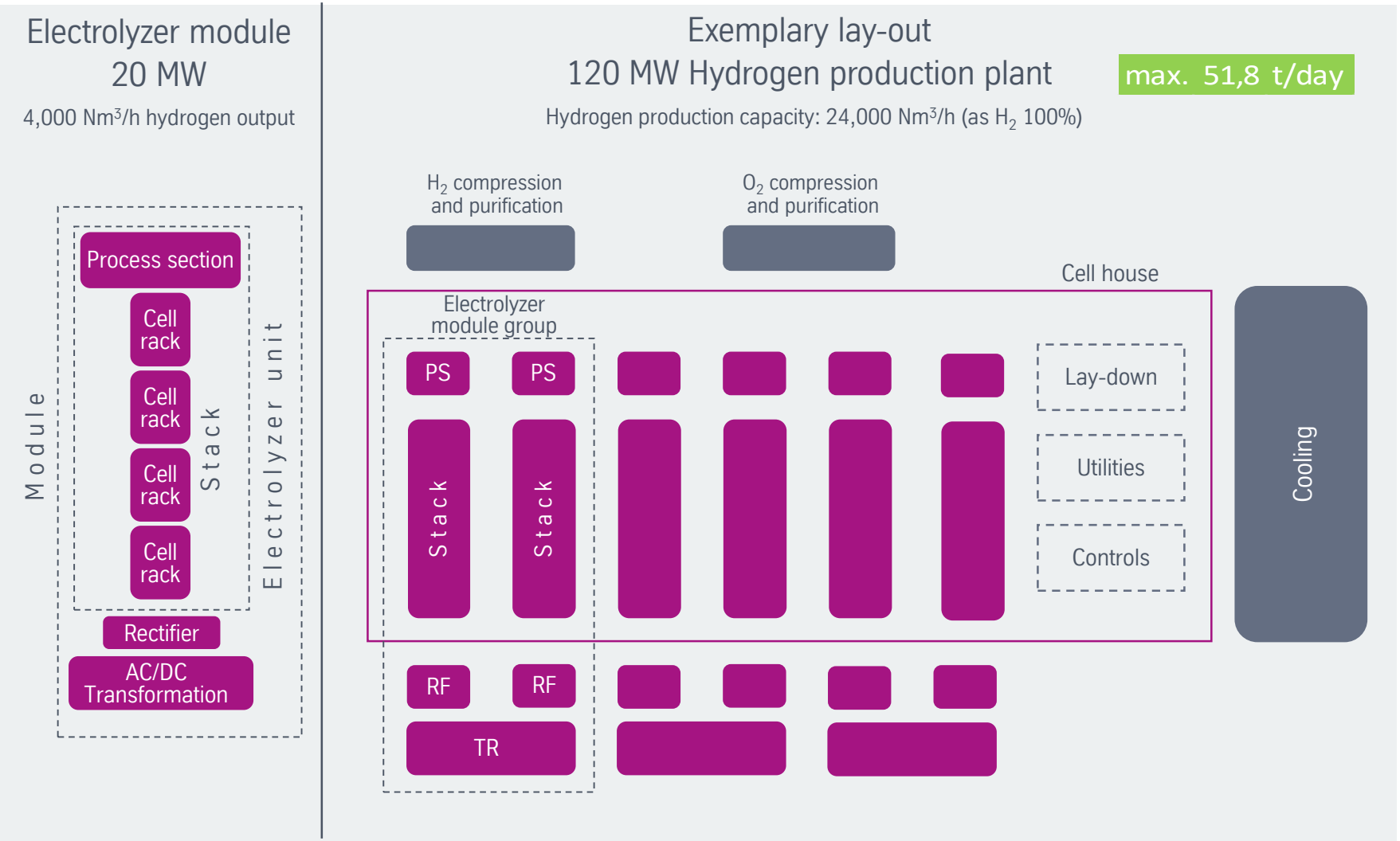
Exemplary Layout 120 MW



thyssenkrupp nucera

20MW AWE master module is a

TÜV Rheinland certified product in accordance with ISO 22734:2019

-

AS 22734:2020

Hydrogen generators using water electrolysis - Industrial, commercial, and residential applications (ISO 22734:2019, modified adoption)

Certificate

Hydrogen Generator

based on ISO 22734:2019

Certificate No.: 268505376

Certificate Holder: **thyssenkrupp nucera AG & Co. KGaA**
Vosskuhle 38
44141 Dortmund
Germany

Scope of application: This is to certify that, based on a documentation review, the design of the hydrogen generator "**tkn 20 MW AWE Master Module**" meets the requirements of chapter 4 of ISO 22734:2019.

Examination: The issued certificate is based on the results of the examination

Date: 07.06.2022

Report No.: 268505376-001

Cologne, 08.06.2022

TÜV Rheinland Industrie Service GmbH
Geschäftsfeld Deutschland
Druckgeräte & Anlagentechnik

www.tuv.com

TÜVRheinland®
Precisely Right.

thyssenkrupp nucera

360° service - we deliver solutions along the entire plant lifecycle

Customer support & competence development

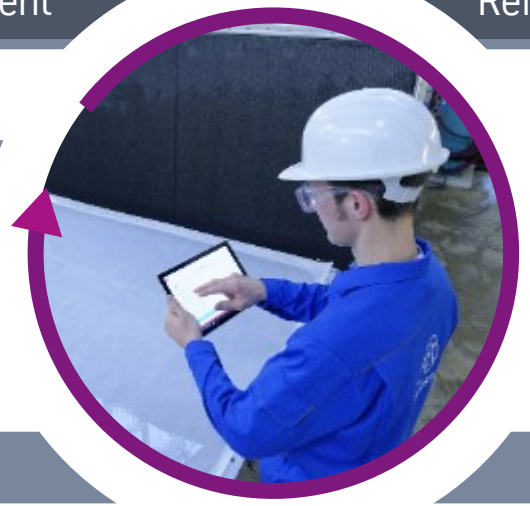
Continuous support | Consulting, audits & risk analysis | Benchmarking | Technical guidance | Training courses

Maximum effectiveness of the plant

Refurbishment & revamps

Full Service | Cell refurbishments | Element upgrades & replacements | Process improvements

Local service solutions to avoid & solve faults



Parts & supply management

OEM & other spare parts | Capital, two years of operational & strategical spare parts | Cell elements

Parts supply with know-how

Selected services

Engineering studies | Technical inspections | Service contracts | Shutdown management | Cell element leasing

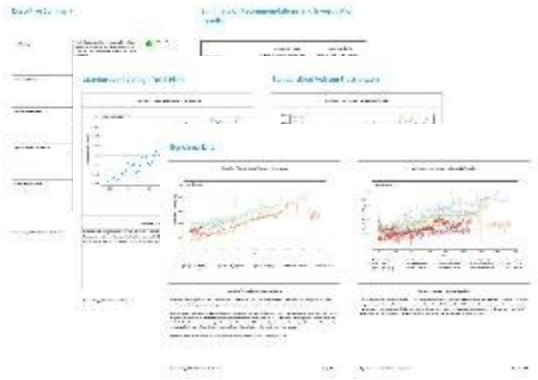
Customized solutions for the assets

Digital solutions

Predictive Maintenance | Predictive Operation | Data Analytics & Consultancy | Performance optimization

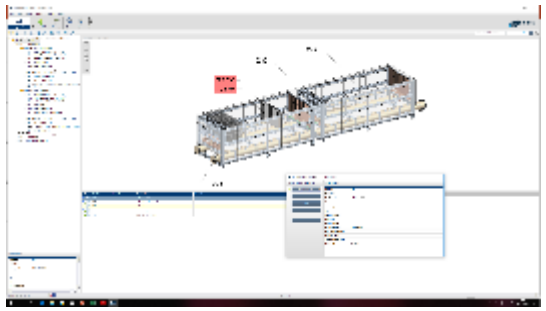
Local and remote digital services for optimum plant performance

Smart products & services



Remote condition monitoring – reporting and consulting packages

- Analysis of plant, electrolyzers and elements
- Management overview and details
- KPIs and analytics results
- Benchmarking
- Online dashboard



Online parts catalogue

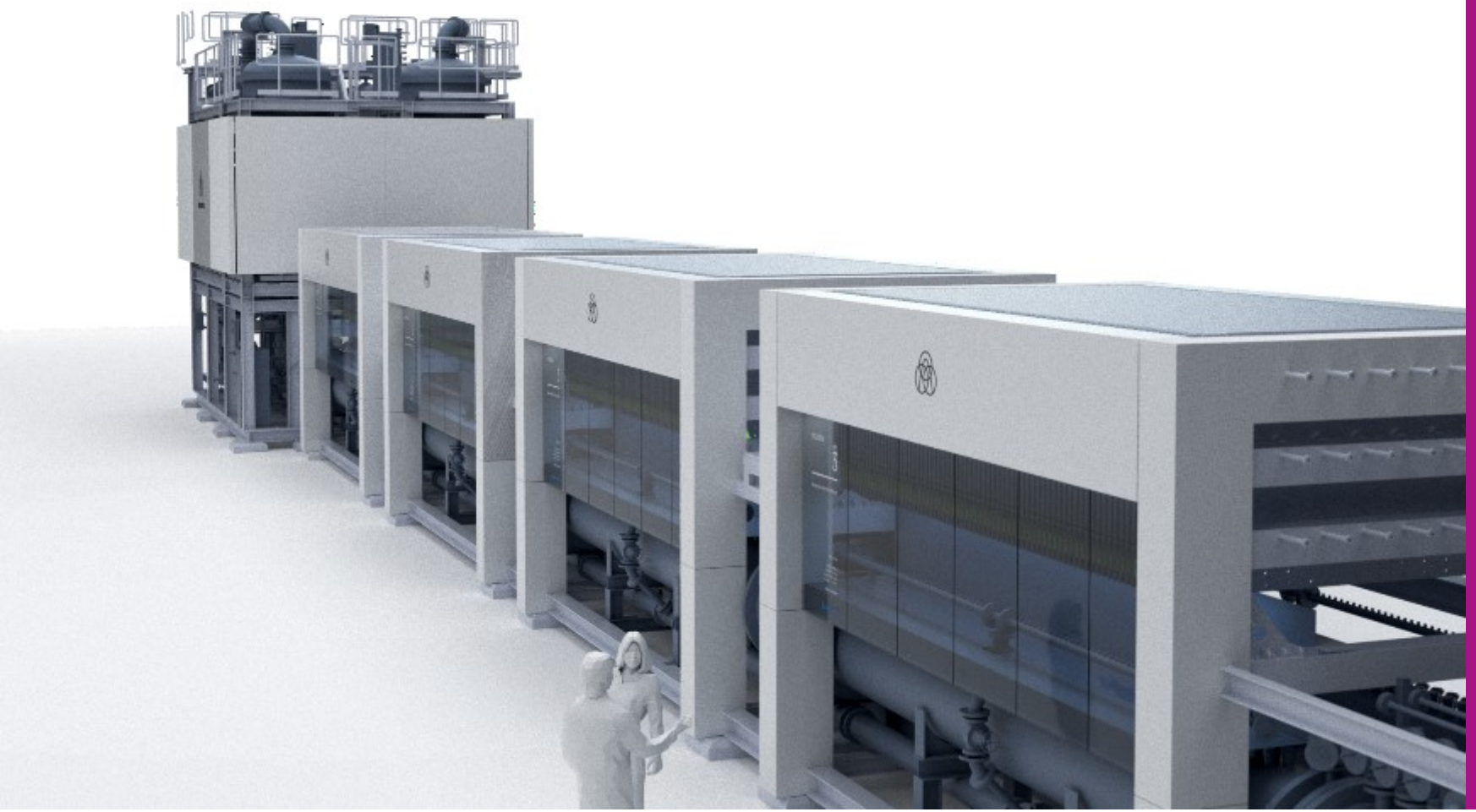
- Illustrated parts catalogue
- Structured representation all relevant spare parts
- Easy and quick identification of correct parts
- Editable, printable, savable and exportable shopping basket

Remote expert support

- Expert knowledge on site, worldwide
- Fast assistance – tailored to your needs
- Easy and cost-efficient

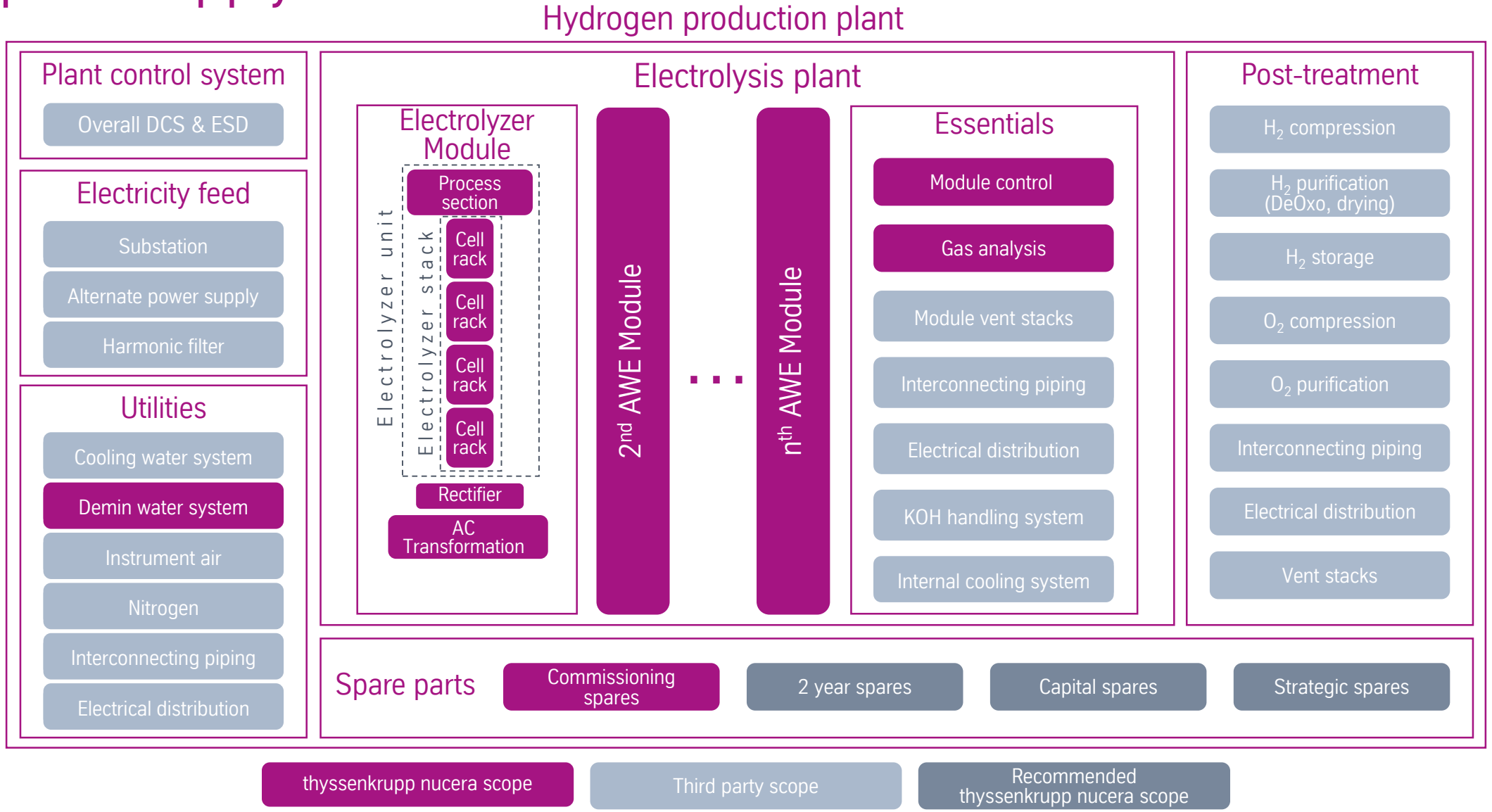
Advanced process control

- Application of dynamic models to provide close loop plant controls.
- Maximum production at a given amount of electrical energy
- Minimum power consumption at a given production rate

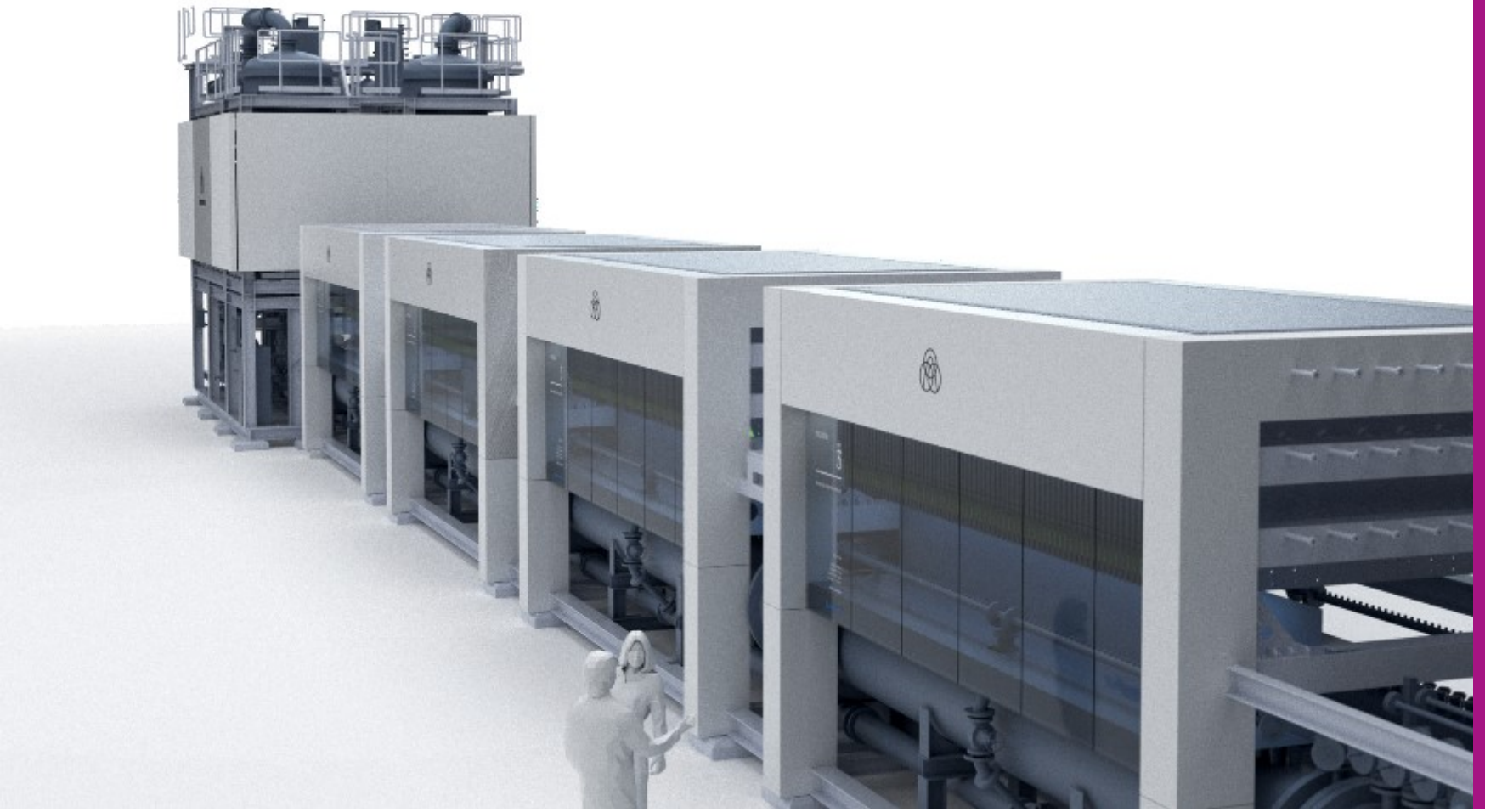


Our services

Scope of supply



thyssenkrupp nucera



thyssenkrupp nucera today and tomorrow

Currently over 2 GW total capacity under realization

Carbon2Chem®
2 MW

Our downscaled demonstrator hydrogen plant in Duisburg, Germany – a green world premiere.

2018

CF Industries
20 MW

Awarded supply contract by CF Industries to deliver a green hydrogen plant for the production of green ammonia.

2023

Element One
20 MW

Awarded contract by NEOM to deliver green hydrogen as a feedstock for green ammonia.

2023

Air Products
10 metric tons per day

Supply of modules and accessories to Air Products to produce green liquid hydrogen in Casa Grande, Arizona.

2023

Shell
200 MW

Engineering, procurement and fabrication of Shell's 200 MW hydrogen facility in the port of Rotterdam.

2024

NEOM
> 2 GW

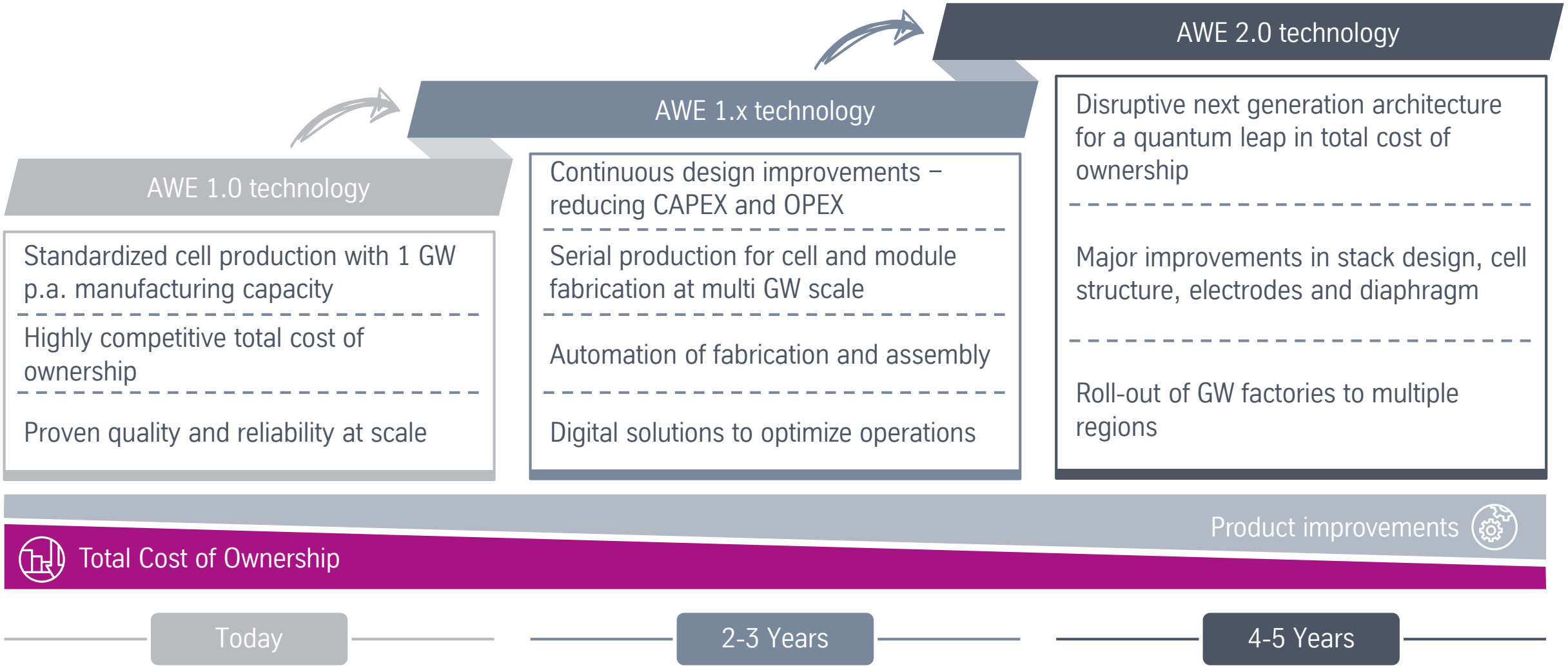
thyssenkrupp nucera signs one of the largest green hydrogen projects in the world to install over 2 GW electrolysis plant for Air Products in NEOM.

2026

more to come

For water electrolysis technology as of Dec. 31, 2021 | Years under the references indicate the targeted start-up of the individual project

Strategic roadmap for disruptive next generation architecture will deliver superior performance



thyssenkrupp nucera's AWE technology is most suitable for large scale rollout of green hydrogen production capacity globally

Technology		Alkaline Water Electrolysis (AWE)	Polymer Electrolyte Membrane (PEM) Electrolysis	Solid Oxide Electrolyzer Cell (SOEC)
Development stage[1]		Mature and commercial	Commercial under development	Early stage development
Application[1]		Centralized	Decentralized	To be determined
Typical plant size (MW)[2]		Multiple of 100	Multiple of 10	To be determined
Response time[3]		Fast	Very fast	Very slow
Efficiency[4,5] (LHV)[6]	*Today*	thyssenkrupp nucera[1]:  Industry average: 		
	2030E			
Pressure (bar)[4]		thyssenkrupp nucera[1]: Atmosphere	Industry average: 1 – 30	30 – 80	1 *If steam at a high temperature is available*
Use of precious metals[1]		Limited	Significant	n/a

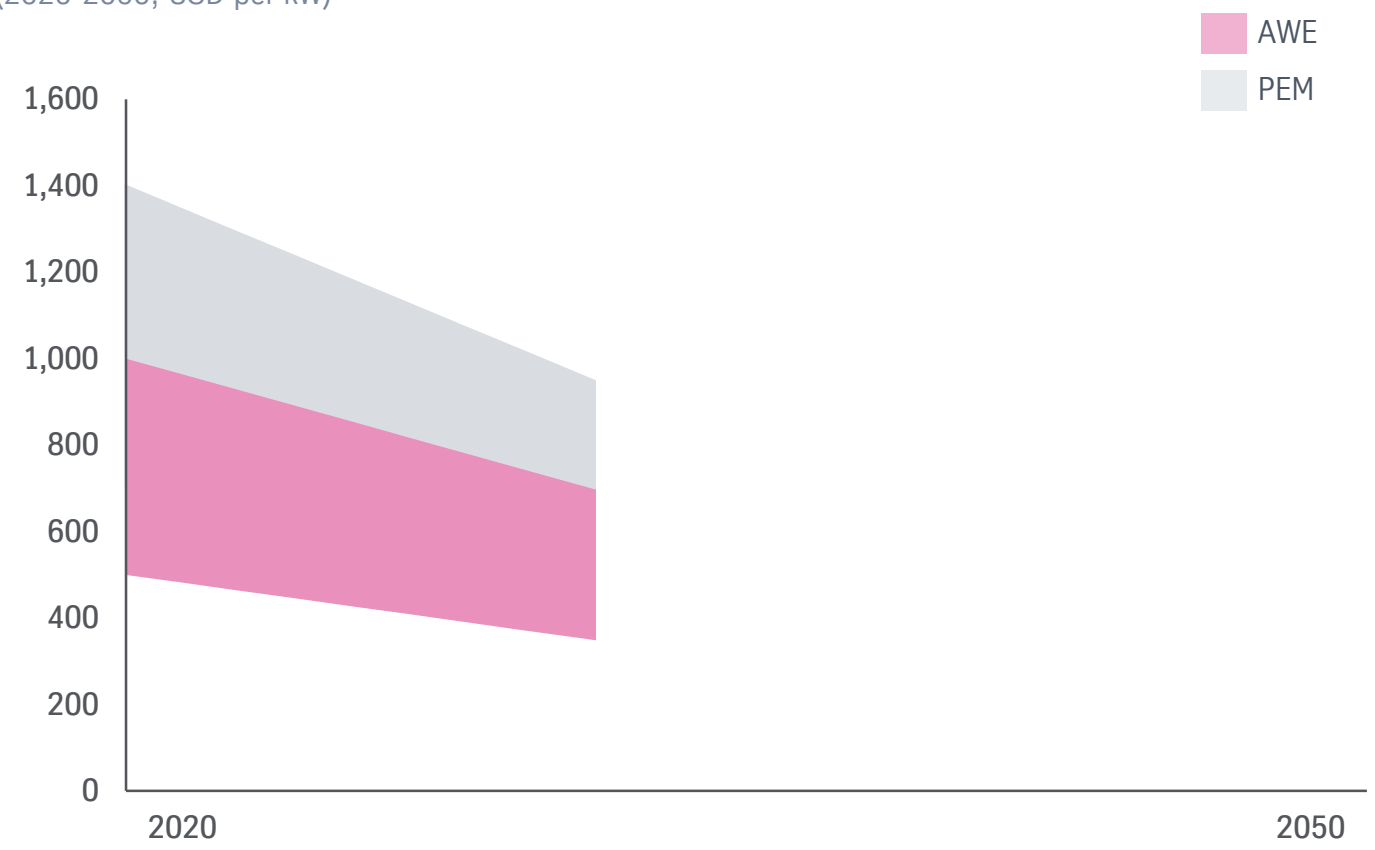
 High  Low

Illustrative table 1. Company estimates 2. Typical size of plants tendered in the green hydrogen market 3. Source: IRENA (2020), Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5ºC Climate Goal, International Renewable Energy Agency, Abu Dhabi 4. Source: Source IEA (2019), The Future of Hydrogen, IEA, Paris https://www.iea.org/reports/the-future-of-hydrogen 5. Harvey balls represent a relative metric and not actual efficiency 6. Lower heating value

thyssenkrupp nucera's AWE leads technology development & represents most competitive green H_2 production solution

AWE and PEM cost evolution[1,2]

(2020-2050, USD per kW)



- Also independent sources confirm the current and expected long-term cost leadership of AWE over PEM
- thyssenkrupp nucera has already proven successfully related long-term cost-down efforts for the Chlor Alkali electrolysis

1. Includes Global NZE by 2050 for Alkaline and PEM 2. Source: IRENA (2020), Green Hydrogen Cost Reduction: Scaling up Electrolysers to Meet the 1.5ºC Climate Goal, International Renewable Energy Agency, Abu Dhabi

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