

Large-scale water electrolysis for green hydrogen production



thyssenkrupp



#1
supplier for electrolysis
plants & equipment

600
electrochemical
projects worldwide

> 10 GW
of power
installed

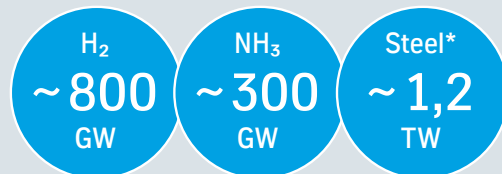
1 GW/year
supply chain
established

Our business case: Climate neutral with green hydrogen. Industrial scale.

Scale up technology for efficient operations

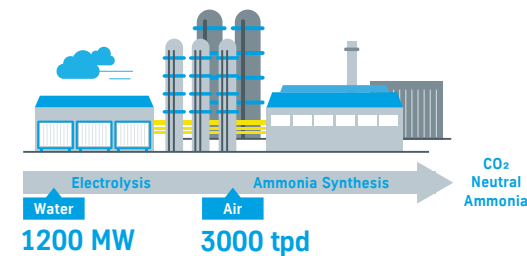
1

Substitution of grey hydrogen in existing value chains already requires **gigawatt scale**



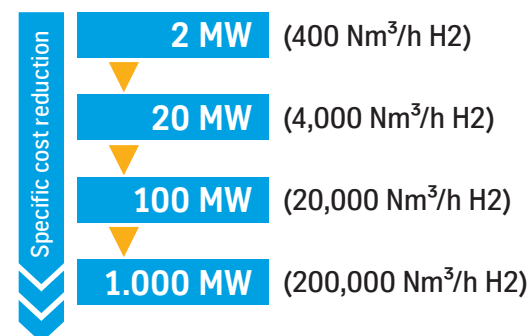
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Power-to-X applications require **scale** to compete against grey commodity prices



3

Scaling up electrolysis plants shows **significant cost reduction**



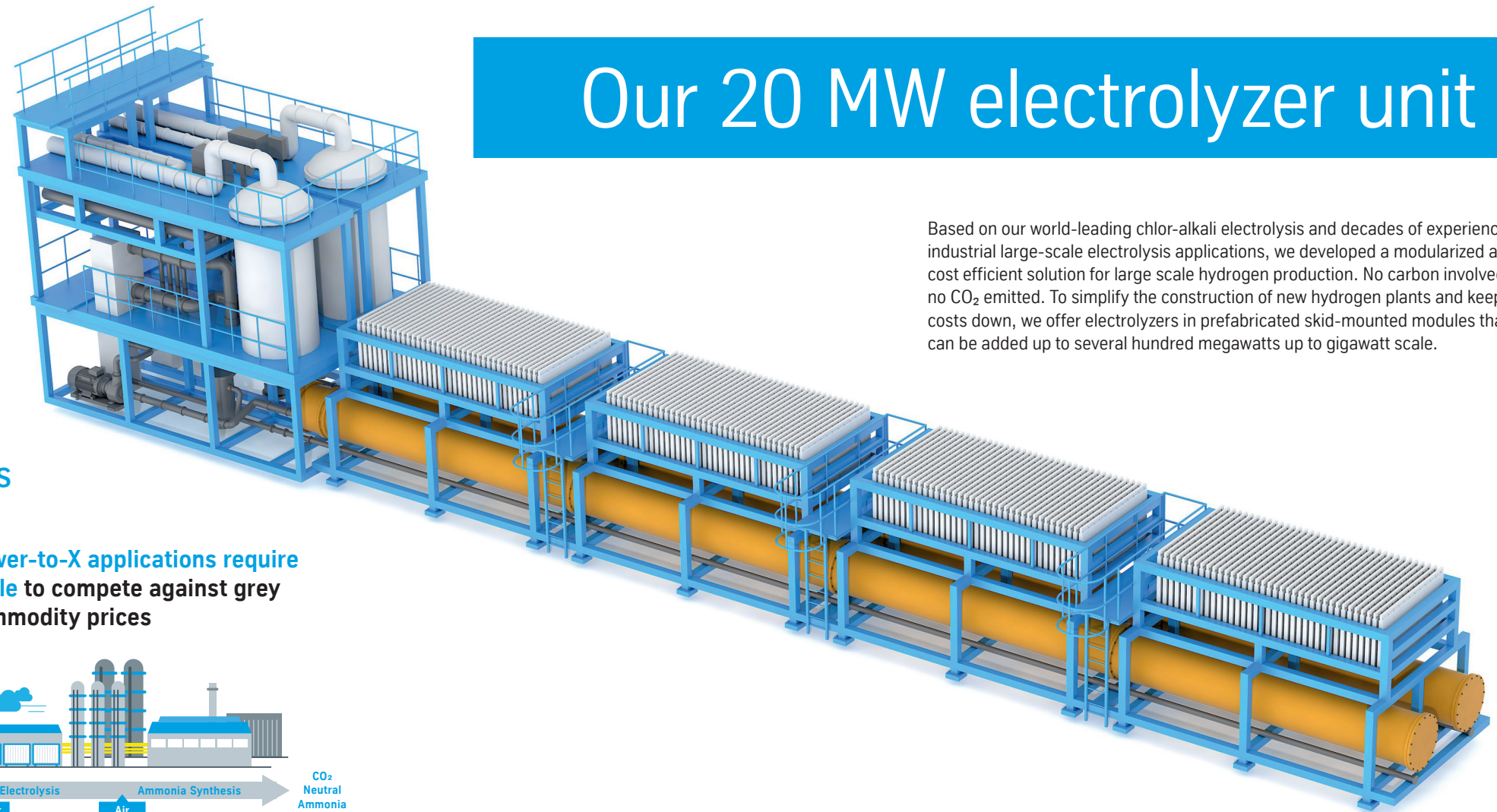
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Only at gigawatt scale **global transport chains** operate efficiently



Our 20 MW electrolyzer unit

Based on our world-leading chlor-alkali electrolysis and decades of experience in industrial large-scale electrolysis applications, we developed a modularized and cost efficient solution for large scale hydrogen production. No carbon involved, no CO_2 emitted. To simplify the construction of new hydrogen plants and keep costs down, we offer electrolyzers in prefabricated skid-mounted modules that can be added up to several hundred megawatts up to gigawatt scale.



20 MW module

Design capacity H_2	4000 Nm^3/h
Power consumption (DC) at start up	4.5 kWh/Nm^3
Water (demineralized) consumption	<1l/ $\text{Nm}^3 \text{H}_2$
Standard operation window	10% - 100%
H_2 product quality at electrolyzer outlet	> 99.9% purity (dry basis)
H_2 product quality after treatment (optional)	as required by customer, up to 99.999%
H_2 product pressure at electrolyzer outlet	~300 mbar
Operating temperature	up to 90 °C

All figures above are to be understood as "expected values" and may vary depending on operating conditions

Key benefits

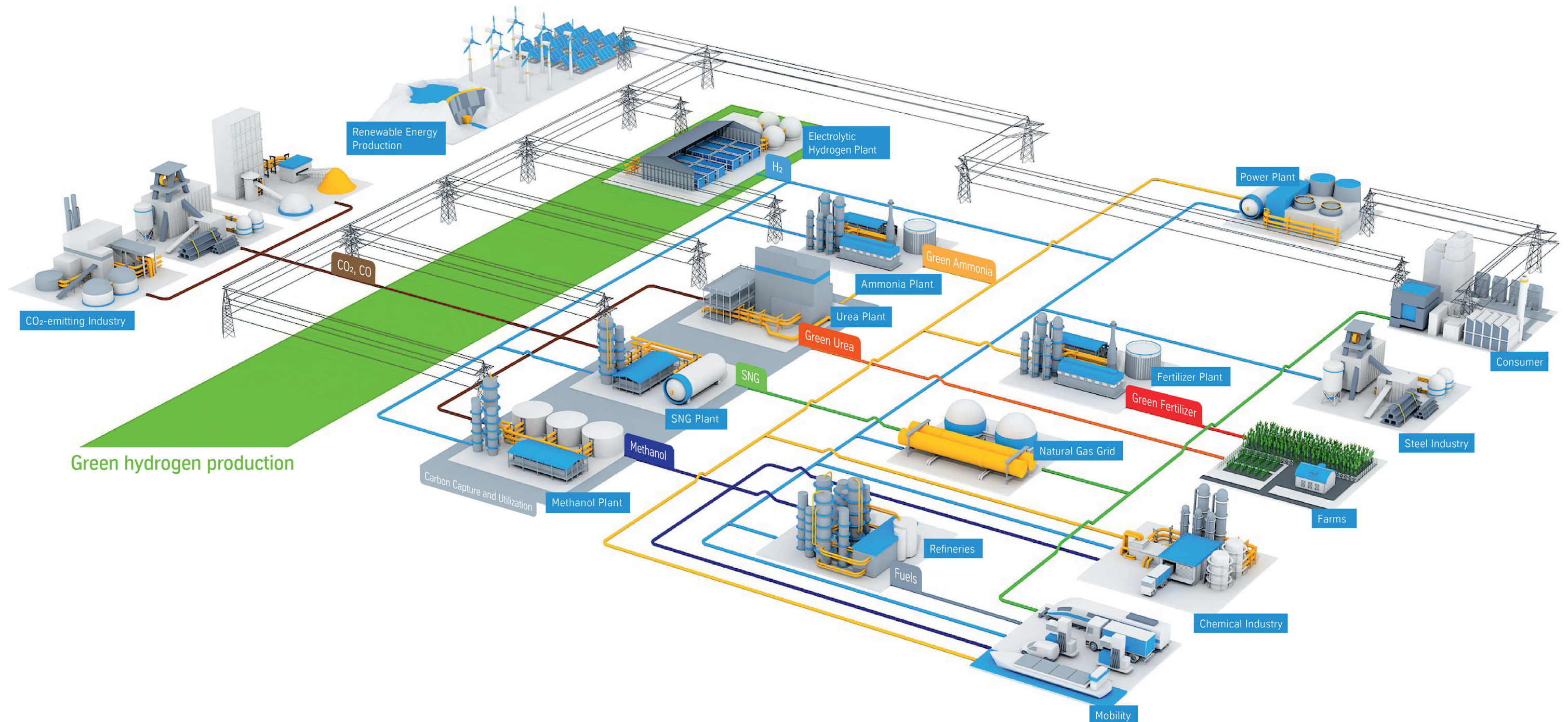
- Modular, skid mounted design
- Low power consumption
- Fully automated operation
- Fast dynamics suitable to renewable power sources
- Mass production & supply chain at scale
- Production capacity of total 1 GW electrolysis cells per year
- EPC turnkey execution worldwide
- Global service

* Direct reduction of iron ore.

Green hydrogen enables a comprehensive sector coupling

Industrial decarbonization and new green value chains from scratch

As a globally renowned specialist in chemical processes and plant construction, thyssenkrupp offers turnkey power-to-gas solutions for the needs of grid-scale renewable integration, and for industrial usage of hydrogen and its subsequent downstream applications. Fully integrated plant concepts harness synergies and enable high-efficiency production of e.g. green ammonia and via carbon capture technology green methanol. The heart of this new and interconnected net-zero industry is green hydrogen.



360 degree solutions for green hydrogen applications

Building your business case with concept modeling & optimization

1

The key question in any project development process is the economic viability of the project. Especially at the early stages, many decisions have to be taken which later have a huge impact on CAPEX, OPEX and project execution. The aim is to identify the best opportunity for the lowest cost and to avoid late concept changes which incur costly rework as well as schedule delays. With our techno-economic studies we investigate and evaluate end-to-end configuration of hydrogen Power-to-X value chains and select the most appropriate concept for our clients based on our proprietary know-how and suite of integrated green technologies for any type of end applications and sector coupling.

Key features

- Identify the most attractive hydrogen value chain concept flowsheets
- Identify material and energy sector coupling opportunities
- Green hydrogen, uhde® green ammonia, uhde® green methanol, uhde® green SNG, green steel
- Develop strategies for energy monetization
- Estimate carbon emission intensity for the PtX concepts
- Identify risks and opportunities
- Assist in engagement with potential partners and financiers
- Develop ideas sufficiently to estimate capital cost and quantify preliminary economics
- Develop the selected concepts in sufficient detail to obtain funding
- Develop a project road map



Global EPC footprint

2

We have planned, built and commissioned over 600 of electrolysis plants and installations with a total capacity of 10 GW all over the world – experience you can rely on. As a globally renowned EPC specialist for electrochemical plants, we are a leading supplier of electrolysis equipment, solutions and services. You benefit from our proven competence in realizing complete plants which operate smoothly and safely over decades.

Service throughout the entire plant life-cycle

3



With our know-how we assist you throughout the plant's life cycle – from start-up to on-site support by thyssenkrupp engineers, specialists and trainers for your personnel. We are your single point of responsibility for all maintenance inspections, spare parts or capacity increases.



Reliability, availability, maintainability analyses
Operation & maintenance strategy & execution, personnel training



Predictive, preventive & corrective maintenance support & execution



Support for operation & optimization – digitally & on site



Electrolyzer stack refurbishment

1 GW supply chain – – – – – On the road to 5 GW

Through continuous improvements and dedicated research and development, we deliver cutting-edge technologies for high-efficiency and maximum revenue.

With our trusted joint venture shareholder De Nora, we have a globally renowned specialist in electrochemistry for cell manufacturing, coatings and repairs at our side. Together, we deliver fast and efficient value to our clients all over the world from over 20 De Nora locations and over 70 thyssenkrupp sites. Thanks to our long cooperation for our chlor-alkali electrolyzers, we can rely on a fully set-up supply chain for our water electrolysis cells. Today, we can deliver a total of 1 GW electrolysis cells per year and have already set the course for expanding to a 5 GW supply chain.

In the upcoming years we will research to optimize the cell and stack design even further, in order to enable fully automated series production on the one hand and thus reduce the overall target costs of alkaline water electrolysis on the other. Also the full automation of manufacturing and assembly processes is at the center of our considerations in order to realize efficient supply chains in the gigawatt range in the long term. We are convinced that we can also significantly strengthen the competitiveness of hydrogen technology as a whole. We increase the availability of hydrogen, reduce costs – and establish a new market standard as well as a valuable contribution to a fully automated and integrated gigawatt supply chain.



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