



Large scale Power to X technologies

For Industry decarbonisation

thyssenkrupp Uhde  
GIZ|30.01.22| T.M.QUANG

engineering. tomorrow. together.



thyssenkrupp – a global corporation with  
~ €34 bn sales, over 100,000 employees &  
presence in 56 countries with ~1,100 locations



# thyssenkrupp's portfolio

## “Group of companies”

Materials Services



Industrial Components



Automotive Technology



Steel Europe



Marine Systems



## “Multi Tracks”

CEM <sup>1</sup>	Springs & Stabilizers <sup>3</sup>
UHD <sup>1</sup>	Powertrain Solutions <sup>3</sup>
MIN <sup>1</sup>	Battery Solutions <sup>3</sup>
AST <sup>2</sup>	Grobblech <sup>4</sup>
Infrastructure <sup>2</sup>	CC <sup>5</sup>
TKE <sup>6</sup>	

UHD = Uhde  
(Chemical and Process Technologies)

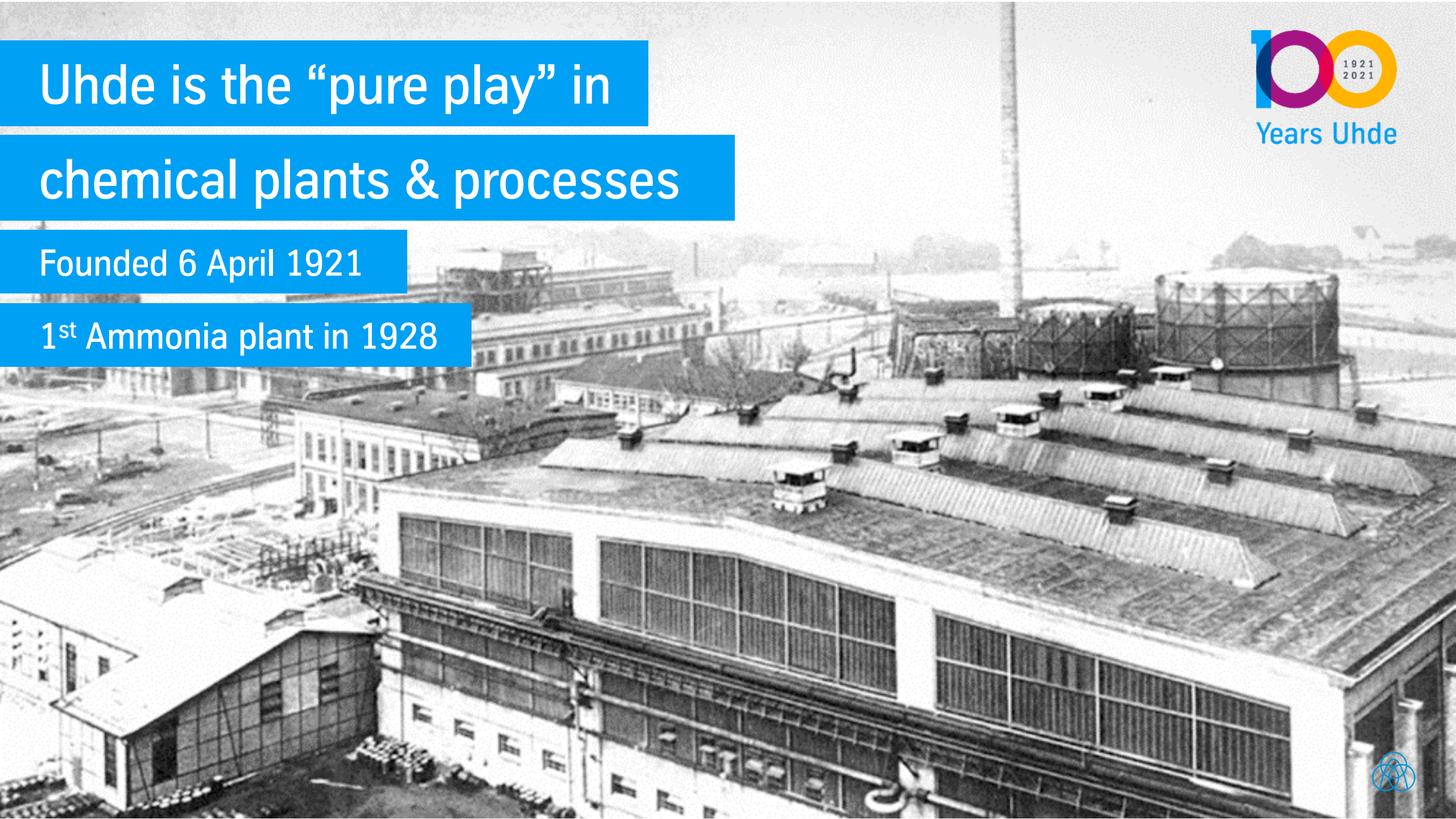
- 1. Business Units from former Plant Technology: Cement Technologies, Uhde (Chemical & Process Technologies) and Mining Technologies | 2. Transfer from Materials Services segment | 3. Transfer from Automotive Technology segment | 4. Transfer from Steel Europe segment | 5. thyssenkrupp Carbon Components | 6. Reinvestment TK Elevator



# Uhde is the “pure play” in chemical plants & processes

Founded 6 April 1921

1<sup>st</sup> Ammonia plant in 1928



# Serving a broad spectrum of industries

with an international footprint of around 4,500 employees

Customer industry



Units

	UCE <sup>1</sup>	FER	PP	UHPT	UIF	CP
	thyssenkrupp nucera	Fertilizer & Methanol	Petrochemicals & Polymers	High Pressure Technologies	Polycondensation Technologies	Coke Plant & Inorganic Acids
Products	Chlor-Alkali, HCl, Green hydrogen (H <sub>2</sub> O electrolysis)	Ammonia & Urea, Nitric acid, Methanol, Urea Granulation	H <sub>2</sub> O <sub>2</sub> , Vinyls Propylene Oxide, PG, Polyols and Oleochemistry, PDH/BDH, PE/PP, Refineries, Reformer H <sub>2</sub>	LDPE, High Pressure Pr., Sup. Critical Fluids, Water Jet Cutting	PET, Polyamides, Polylactic acids	Coke plants, H <sub>2</sub> SO <sub>4</sub> , Phosphoric acid

Scope and  
Footprint

Project Management, Engineering, Procurement, Construction, Service, Digital Products etc.

<sup>1</sup> Separate entity but close cooperation



# Thyssenkrupp: Two missions in the energy transition

Transition path to  
green steel

-30% CO2 reduction  
by 2030



Green hydrogen and  
chemicals

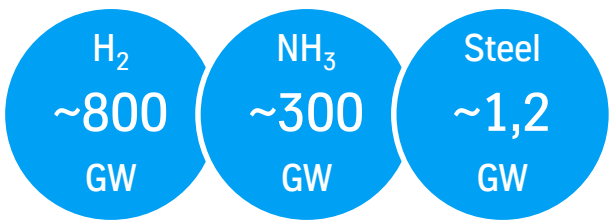
1 GW electrolysis  
manufacturing

10 GW installed in the  
chemical industry

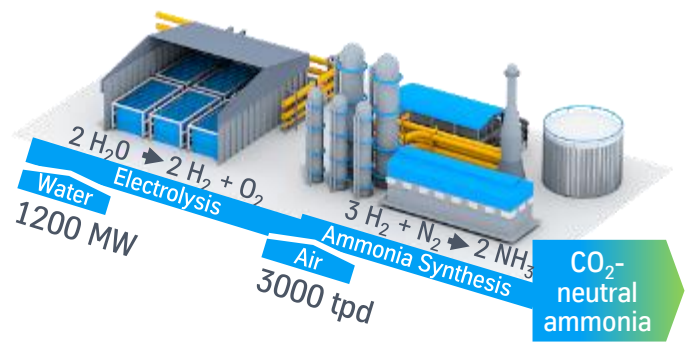


# Drivers for Green Hydrogen: Scale up technology for efficient operations

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

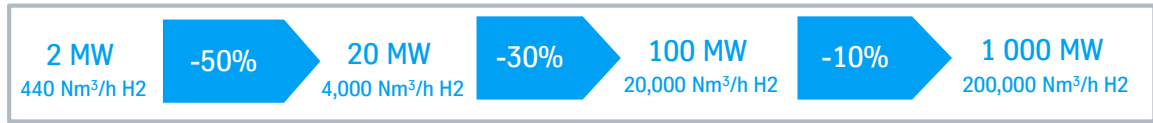


Power-to-X applications require scale to compete against grey commodity prices

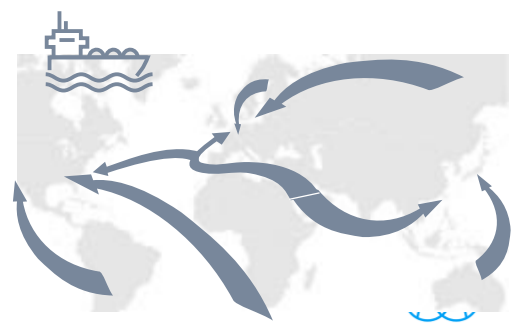


Scaling up electrolysis plants shows **significant cost reduction**

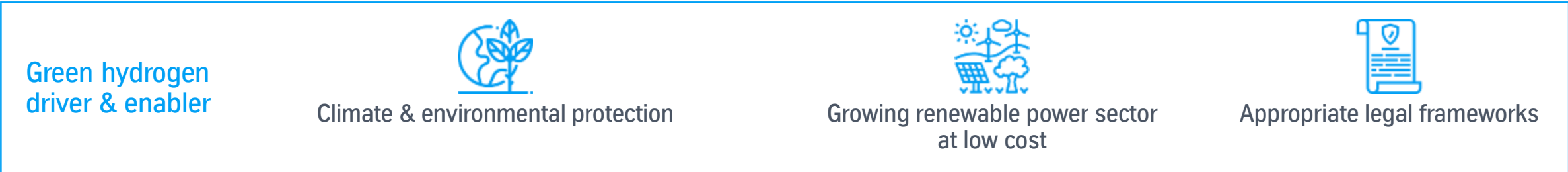
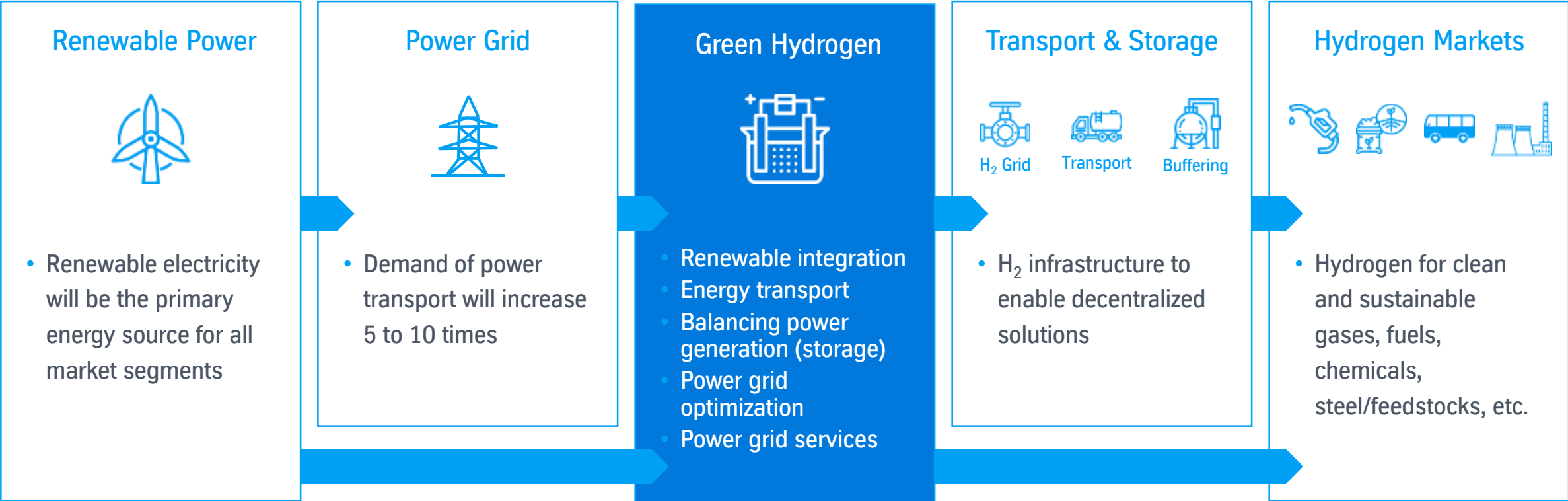
Typical cost down opportunities



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

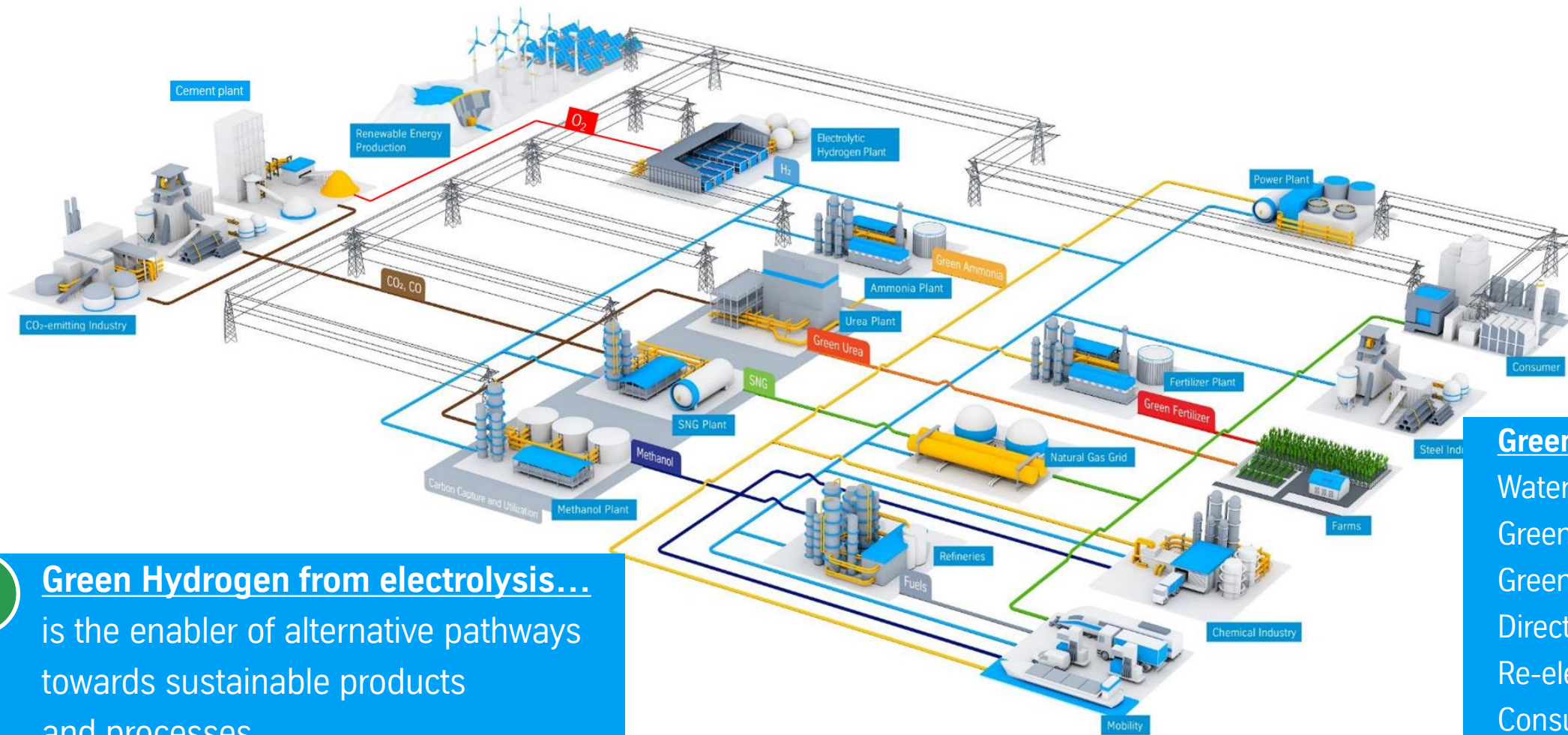


# Electrolysis connects power sector with fuels and gases markets providing benefit to both





# ... for realizing large-scale sustainable green value chains



H<sub>2</sub>

**Green Hydrogen from electrolysis...** is the enabler of alternative pathways towards sustainable products and processes.

## **Green chemicals route:**

Water Electrolysis  
Green Ammonia  
Green Methanol  
Direct Reduced Iron  
Re-electrification  
Consumer markets



# Our standardized high performance product and its key features

## Output from a 20 MW<sub>el</sub> module

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

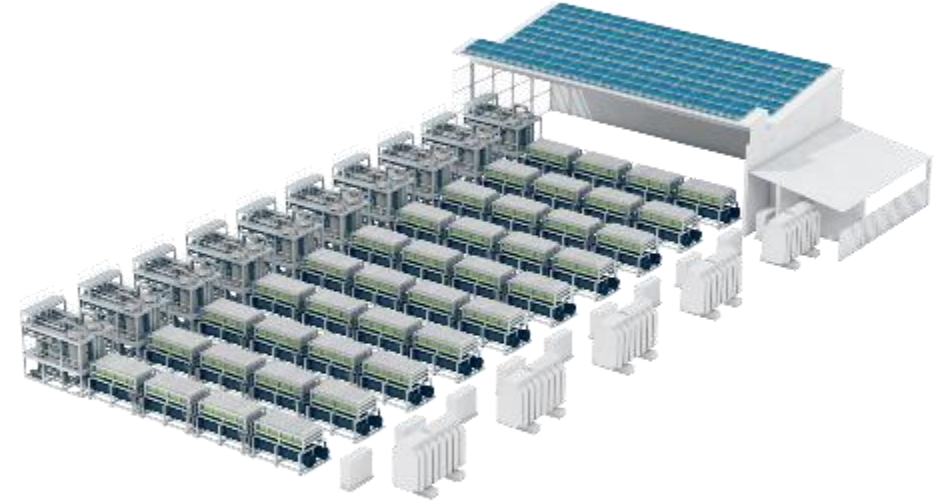
## Operability

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 <sup>3</sup> (DC)
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\* Nm<sup>3</sup> is defined as 1 m<sup>3</sup> of gas (100%) at 273.15 K and 1.013 bar



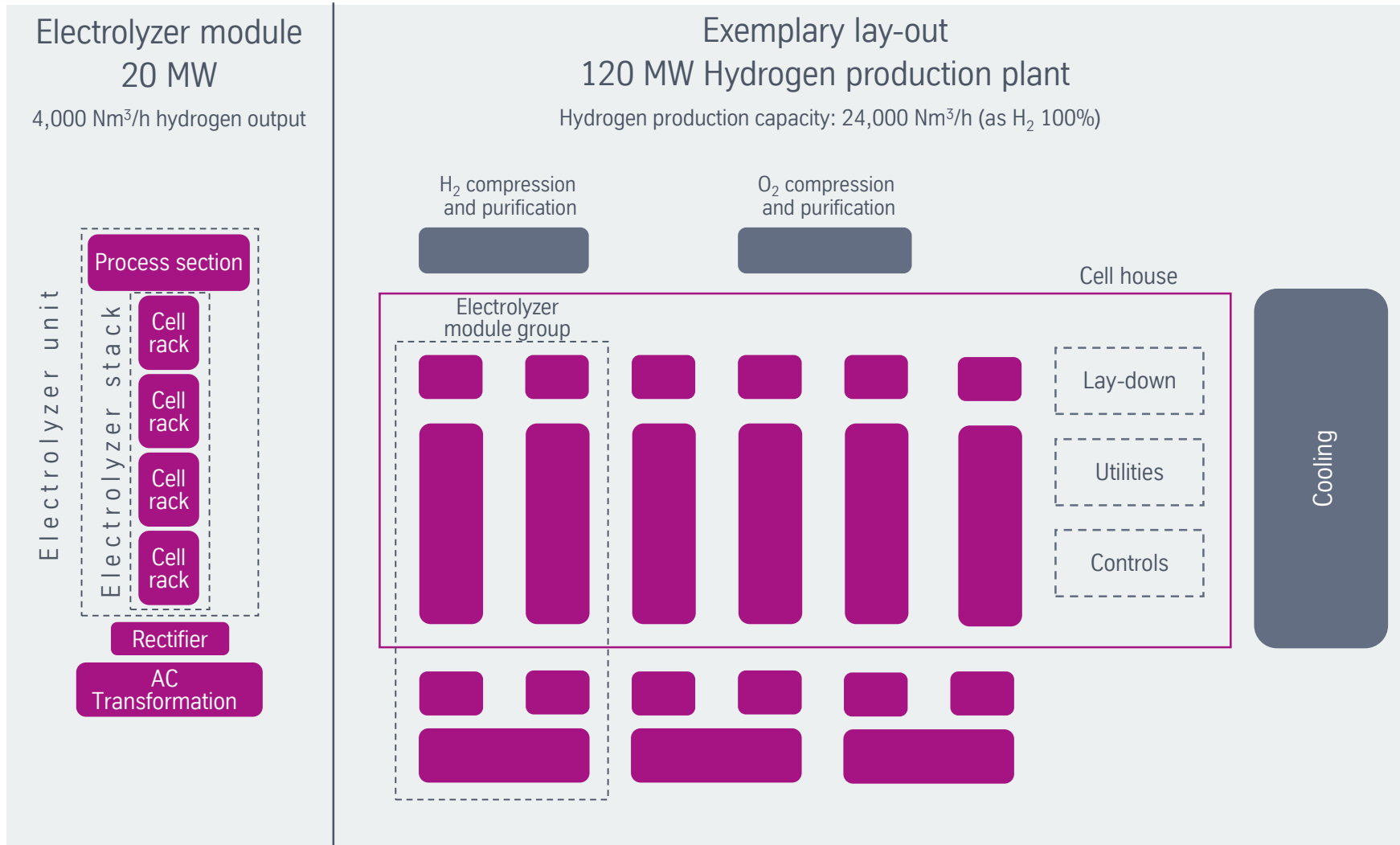
## Power consumption at start of life (AC)

System at nominal capacity:

- › incl. transformation / rectifying
- › incl. hydrogen compression to 30 bar<sub>g</sub>
- › incl. all other electrical consumers within battery limits (purification of 99,999 %)

4.9 kWh/Nm<sup>3</sup> (AC)

# Harmonized and specific nomenclature



# Select Thyssenkrupp nucera green hydrogen milestones timeline solidifies position as an industry leader



Carbon2Chem

thyssenkrupp nucera's Duisburg demonstrator hydrogen plant started operations, a green world premiere



20 MW installation

thyssenkrupp nucera awarded supply contract by CF Industries to deliver a green hydrogen plant for the production of green ammonia



NEOM

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



Shell

thyssenkrupp nucera to engineer, procure and fabricate Shell's 200 MW hydrogen facility in the port of Rotterdam



Air Products

thyssenkrupp nucera to deliver two 20 MW modules for a 10 metric ton per day facility to produce liquid hydrogen in Casa Grande, Arizona.



Unigel

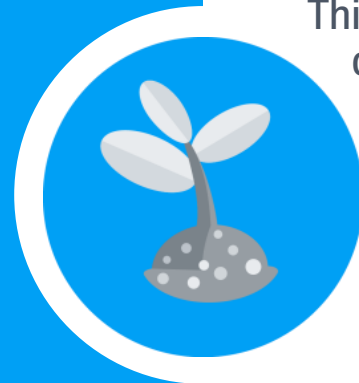
thyssenkrupp nucera to deliver three 20 MW modules for Unigel's industrial scale green hydrogen facility in Camaçari Industrial Complex, Brazil.



# Ammonia industry

# 100 years

experience in the  
construction of ammonia plants



## We offer

- Outstanding management expertise for large-scale projects
- Modern global purchasing strategies
- Best-in-class processes such as uhde® dual pressure process fostered by continuous R&D efforts
- Fully integrated and standardized green ammonia plants
- Technology and EP(C) + S

This enables us to supply you with optimum solutions offering maximum cost efficiency around the globe – **reliable, sustainable and eco-friendly.**



# Latest track records 2017-2020

our experience goes back to 1921 with more than 130 plants built and about 50mln tpa ammonia capacity

# since 2000'

5



Ma'aden 3, KSA (EP), 2018

3,300 mtpd Ammonia (uhde®)



6



BFI, Brunei (EPC), 2017

2,200 mtpd Ammonia (uhde®)



9



NCIC, Egypt (EPC), 2019

1,200 mtpd Ammonia (uhde®)



# Ammonia market development

Fossil-fuel based

Fossil-fuel based with CCS

Renewable energy based

2 mln tons p.a.

installed ammonia capacity add-on

Fossil fuel based

for ammonia primarily used for fertilizers production (80%)

180 mln tpa

ammonia capacity

<2% global CO<sub>2</sub>

Emission contribution



>8 mln tons p.a.

installed ammonia capacity add-on expected

RE based

for ammonia for fertilizers, but primarily as maritime fuel and as energy carrier

> 400 mln tpa

ammonia capacity in 2050

0 CO<sub>2</sub>

Emission contribution



# Ammonia plant development and our contribution

Fossil-fuel based

Fossil-fuel based with CCS

Renewable energy based

130

ammonia plants primarily as one-stop-shop

600 to 3,300mtpd

ammonia capacity range

Tailor-made

600

electrolysis plants primarily as one-stop-shop

1 GW

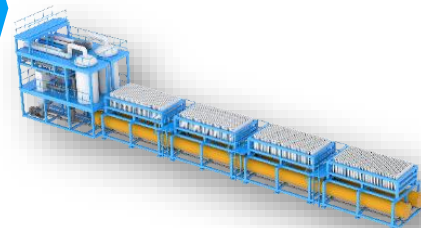
manufacturing capacity

Standardized



## A Market Ready Solution:

- Fully modularized and standardized
- Integrated offering
- RHAMFS© to optimize integration
- Highest flexibility
- Easy scale-up to 5,000 mtpd
- Worldwide supply chain
- One-stop-shop
- World wide foot print and service



9-10MWh/t

Specific consumption

5 GW

manufacturing capacity

50 to 5,000mtpd

ammonia capacity range

Standardized

Design and design requirements

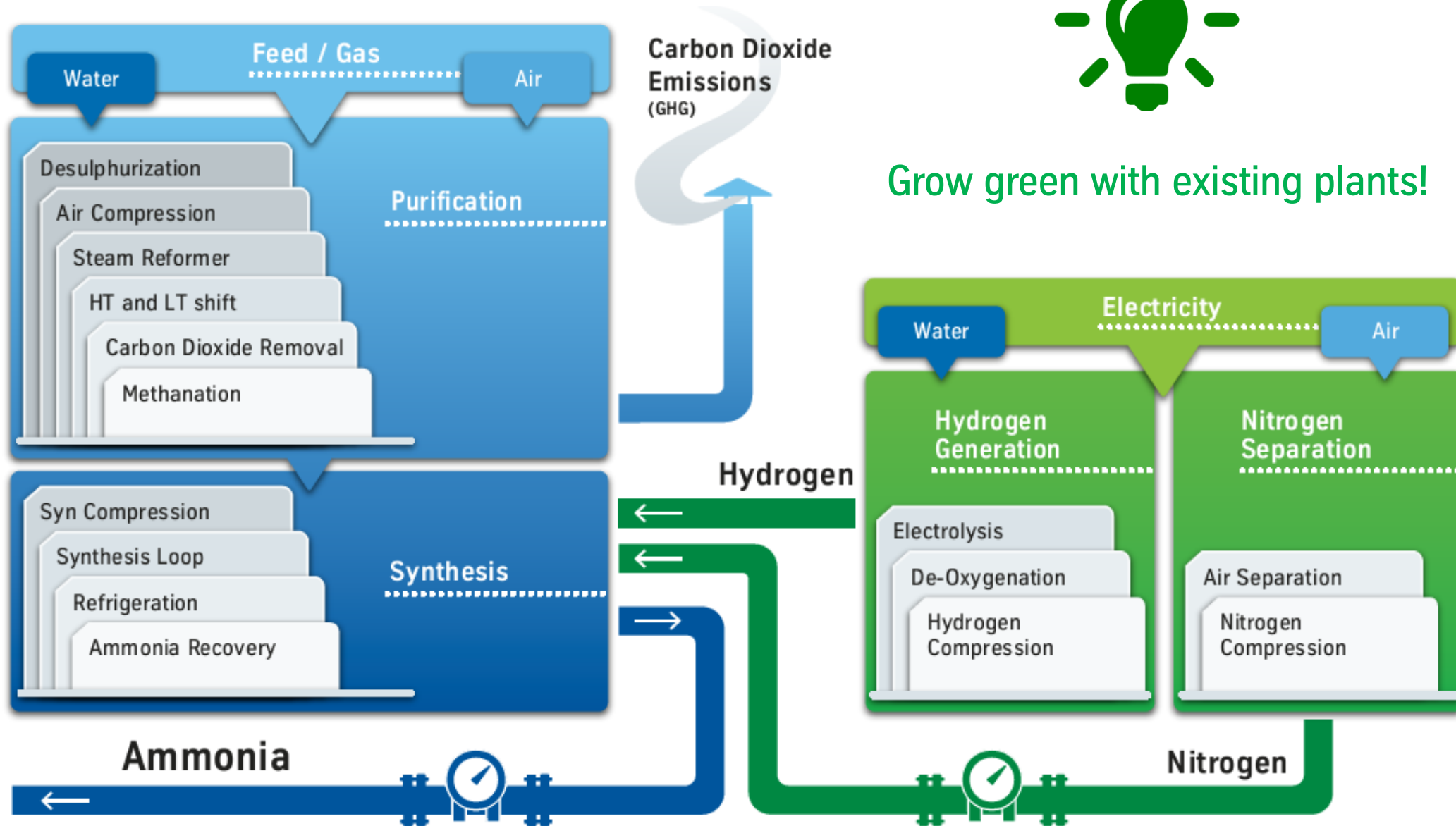




# Green Ammonia Revamp Option



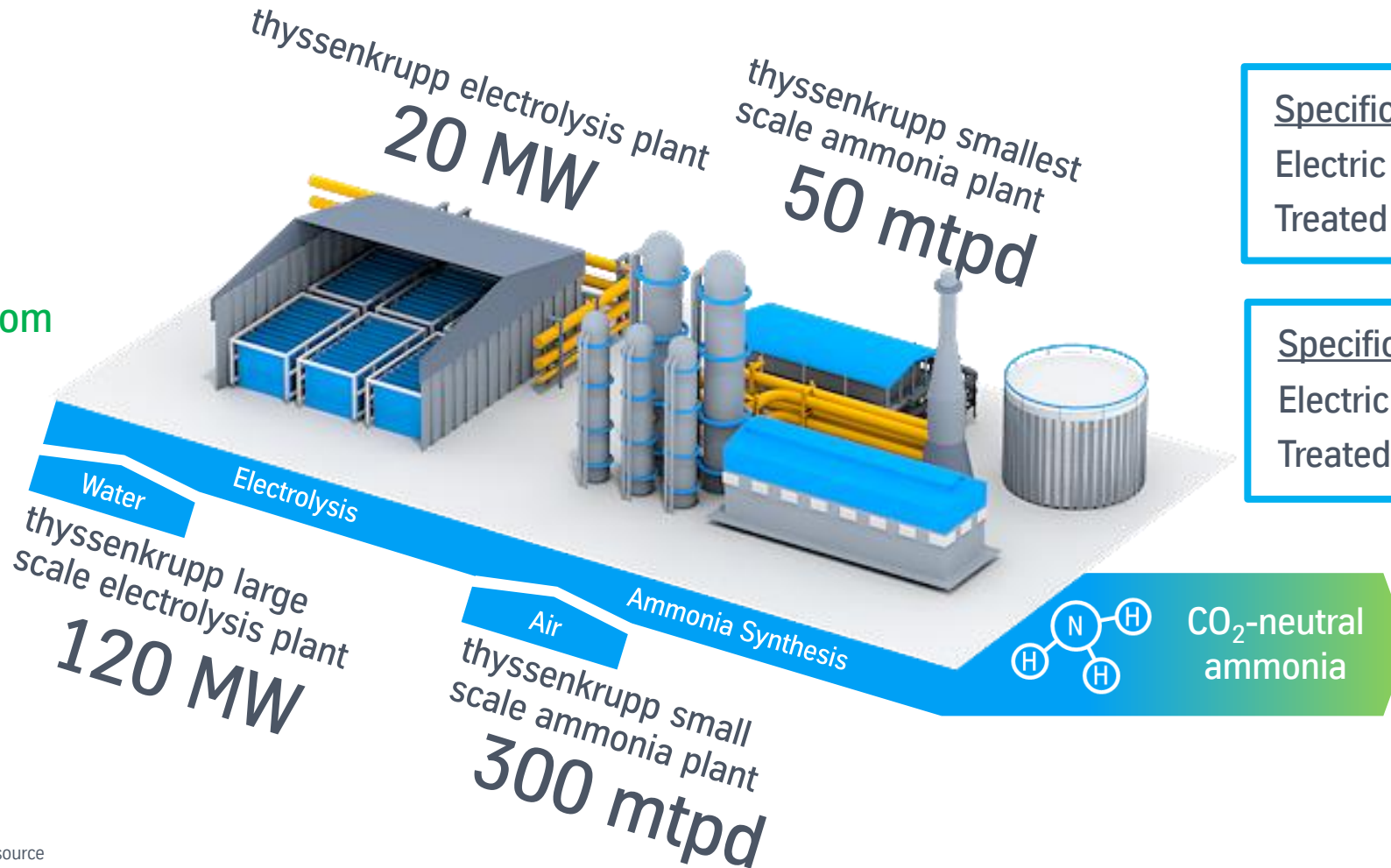
Grow green with existing plants!



# Uhde® green Ammonia



Electricity from renewables



Specific Consumption 50 mtpd plant	
Electric Power:	~ 10 MWh/t <sub>NH3</sub>
Treated Water*:	~ 1.8 tons/t <sub>NH3</sub>

Specific Consumption 300 mtpd plant	
Electric Power:	~ 9.5 MWh/t <sub>NH3</sub>
Treated Water*:	~ 1.8 tons/t <sub>NH3</sub>

\* incl. steam generation

<sup>1</sup> depending on E-power source

20/50 and 120/300 being fully modularized and standardized ready for the market, tailor-made up to 5000mtpd



# Carbon2Chem® in Duisburg/Germany

From idea to commercial implementation

Carbon2Chem® supported by



BMBF funding numbers 03EK3037 to 03EK3043



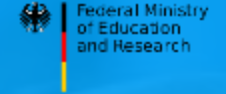
Carbon2Chem®  
Technical Center



# Carbon2Chem<sup>®</sup>, Duisburg/Germany

From idea to commercial implementation

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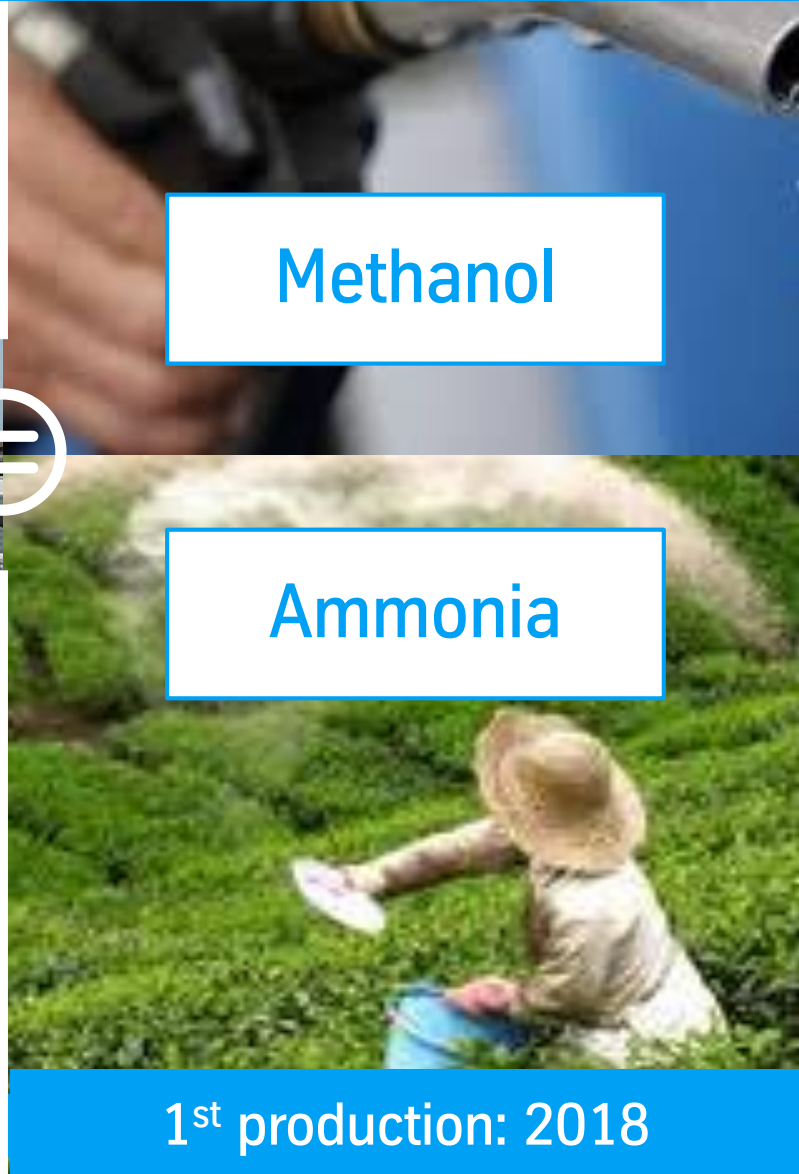
BMBF funding numbers 03EK3037 to 03EK3043



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Syngas



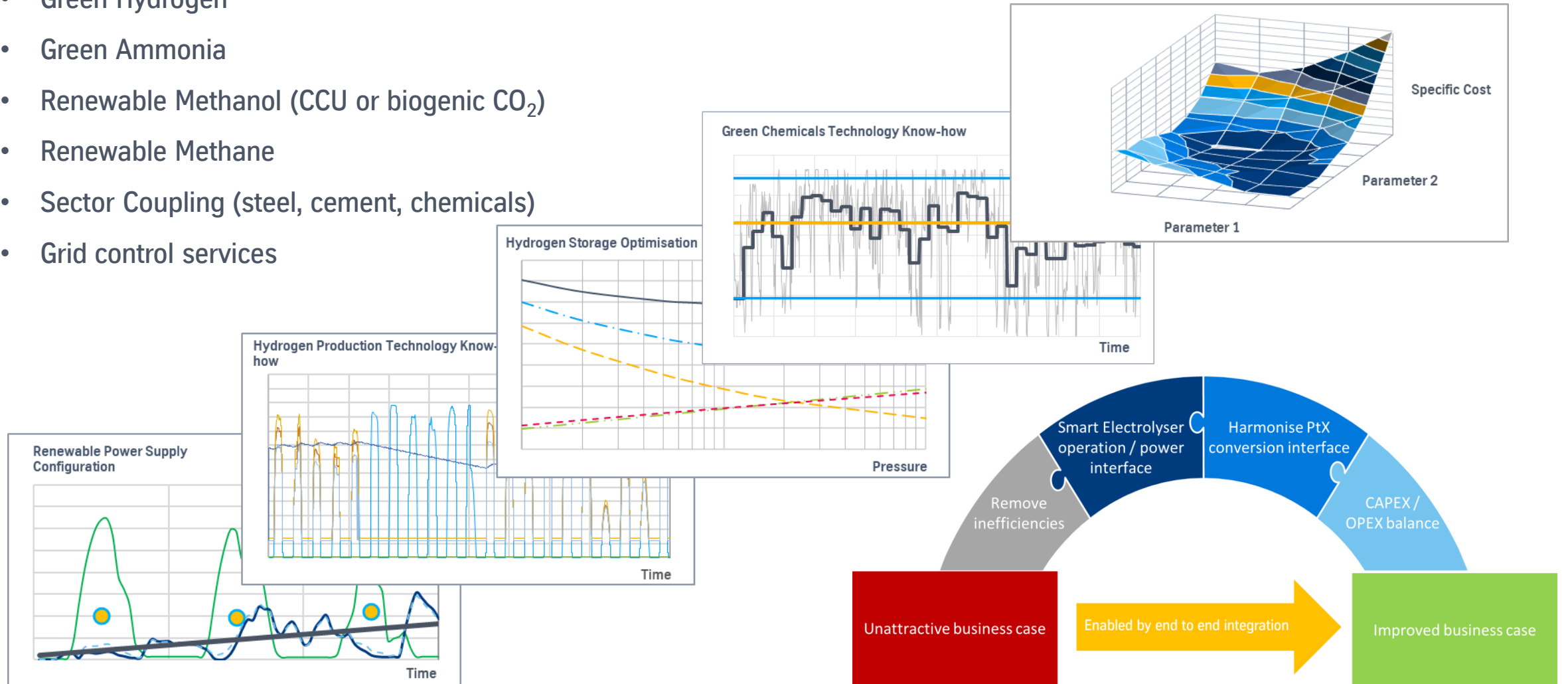
Methanol

Ammonia

1<sup>st</sup> production: 2018

# RHAMFS © - Sustainable PtX solutions founded on technology know-how and further harmonized to master the unique challenges of renewable value chain

- Green Hydrogen
- Green Ammonia
- Renewable Methanol (CCU or biogenic CO<sub>2</sub>)
- Renewable Methane
- Sector Coupling (steel, cement, chemicals)
- Grid control services



engineering.  
tomorrow.  
together.



thyssenkrupp