



thyssenkrupp

engineering. tomorrow. together.

Building a sustainable industrial and energy infrastructure

AEA Conference, November 16th to 18th

thyssenkrupp Industrial Solutions, Tobias Birwe, November 17th



We are a global corporation with

~ €34 bn sales and 109,000 employees &

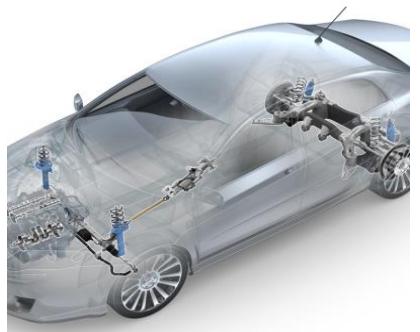
presence in 60 countries with ~1,090 locations



Overview of our businesses

Automotive Technology

Automotive Components



System Engineering



Industrial Components

Forged Technologies



Bearings



Solutions provider

Plant Technology

Chemical & Process Technologies



Mining Technologies



Cement Technologies



Marine Systems

Submarines



Surface Vessels



Naval Electronic Systems



Materials Services

Raw Materials & Trading



Production



Distribution



Supply Chain Services



Applicant

Steel Europe

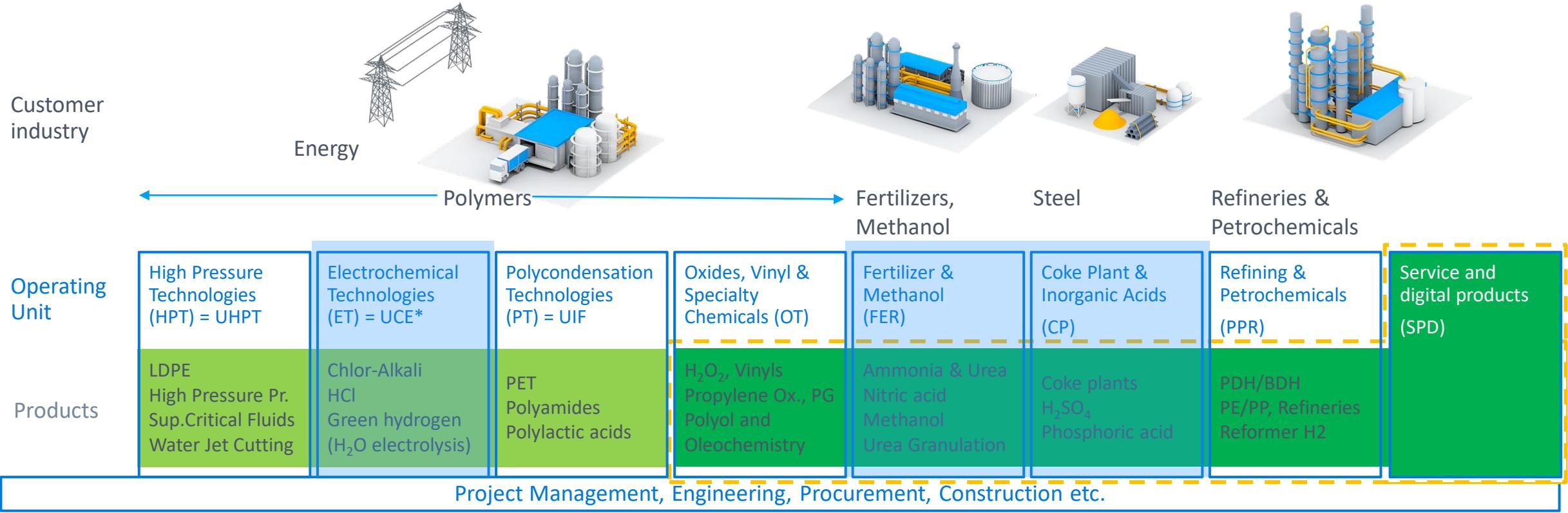
Production & Service



Business Unit Chemical & Process Technologies (formerly Uhde)

Technology Portfolio

Business Unit Chemical and Process Technologies (CPT)



* Joint venture with Denora S.p.A





Location of Carbon2Chem® Technical Center
at thyssenkrupp Steel site in Duisburg

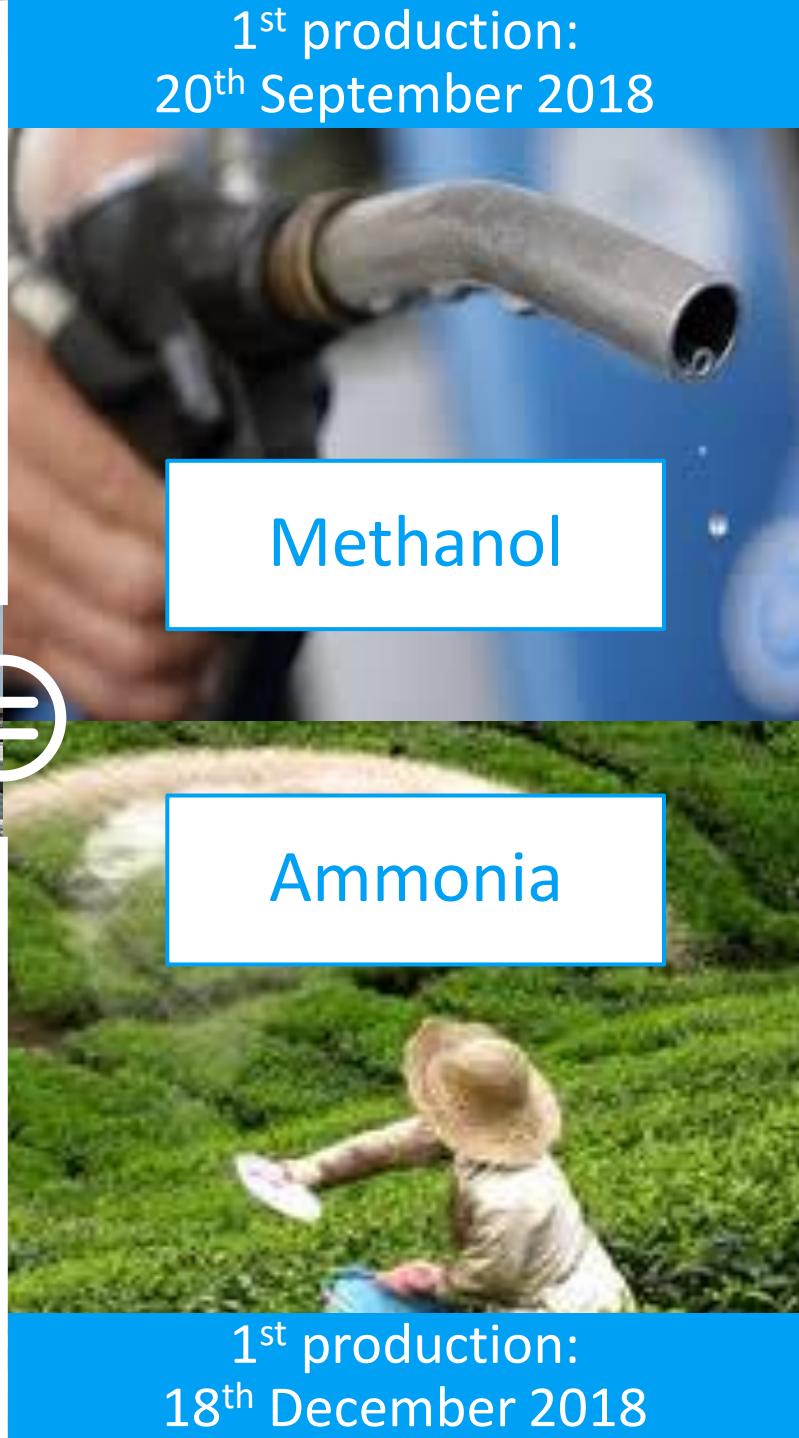
First products



Water electrolysis



Gas cleaning



1st production:
18th December 2018

1st production:
20th September 2018

Carbon2Chem®: Pilot plant is in full operation since April 2018

2 MW water electrolysis



Gas cleaning



	Water electrolysis	Gas cleaning		
Completion	April 2018		April 2018	
Capacity	440 Nm ³ /h H ₂	coke oven gas	100 Nm ³ /h	
		converter gas	70 Nm ³ /h	
		blast furnace gas	70 Nm ³ /h	
Manufacturer	thyssenkrupp Uhde Chlorine Engineers	thyssenkrupp Plant Technology (BU-CPT)		



Smart Solutions for Climate Protection — Alkaline Water Electrolysis

Carbon2Chem in Duisburg



Water Electrolysis

key technology for sustainable hydrogen value chains

Experience cannot be copied.

#1

49% market share
supplier for electrolytic
hydrogen production

600

electrochemical
plants realized
worldwide

over

10 GW

of power installed

Hydrochloric
acid
diaphragm
electrolysis



Hydrochloric
acid ODC¹
membrane
electrolysis



Chlor-alkali
membrane
electrolysis



¹ ODC: Oxygen Depolarized Cathodes

Water Electrolysis by thyssenkrupp - proven technology with established supply chain

>300,000

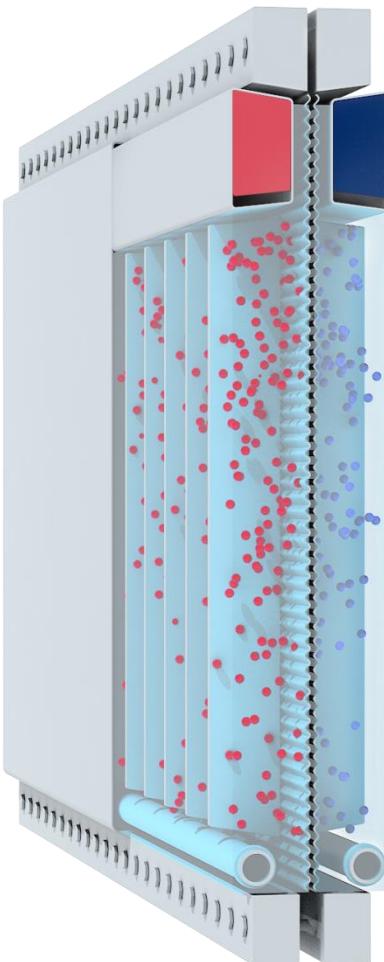
of elements manufactured¹

>1.6 million m²

of electrodes produced¹

>1,000 MW

can be installed each year²



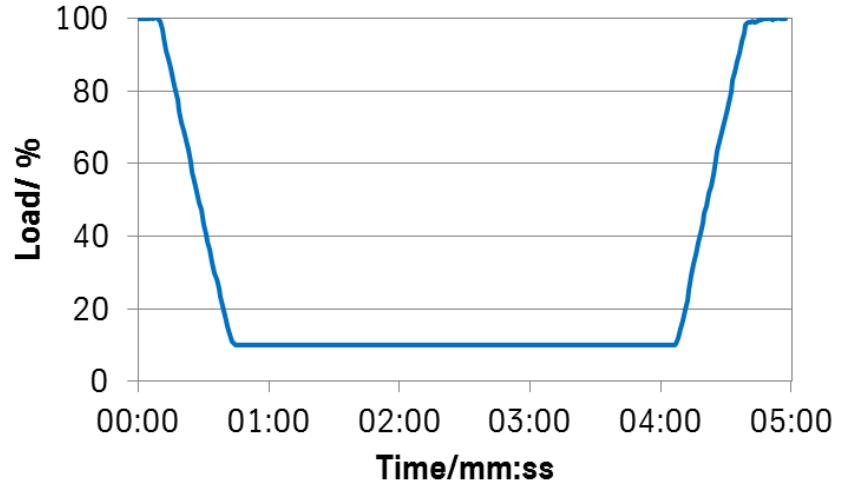
- Proven zero-gap technology
- Introduction of **high efficiency cathode design and coating** (with De Nora) for hydrogen evolution, proven in chlor-alkali technology
- Introduction of **high efficiency anode design and coating** (with De Nora) based on proven chlorine technology
- **Optimized high-performance separators and diaphragms** based on proven design

¹for chlor-alkali plants producing hydrogen as co-product, ²for electrolytic hydrogen production



tkUCE large scale Water Electrolysis

thyssenkrupp Water Electrolysis system is validated at industrial scale for dynamic operation

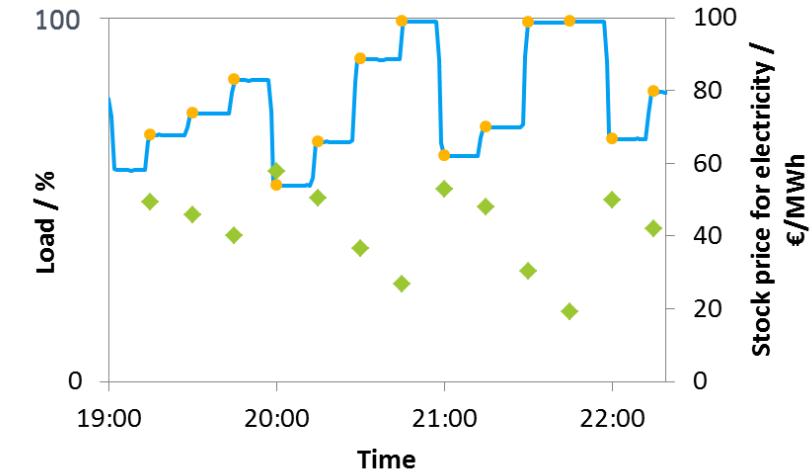


Operation of technical evaluation plant at Carbon2Chem, Duisburg

- Capacity: up to 2 MW
- H₂ production: 440 Nm³/h
- H₂ purity: > 99.95 % (dry basis)

Fast ramping capabilities proven

- Load changes between 10% and 100% in less than 30sec
- Enables utilization for primary control reserve



Power price optimized operation

- Power price based load management established
- Enables optimization of average power price

Carbon2Chem®



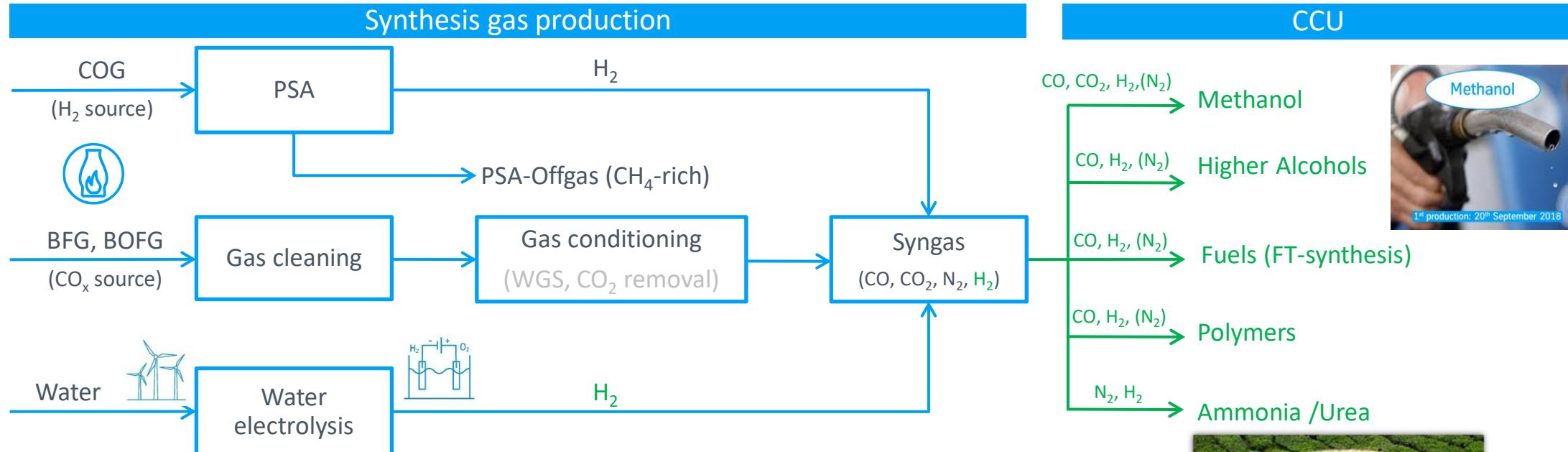
engineering.tomorrow.together.

thyssenkrupp



Introduction to Carbon2Chem®

Production of syngas / chemicals from steel mill gases



COG = Coke oven gas

BFG = Blast furnace gas

BOFG = Basic oxygen furnace gas

PSA = Pressure swing adsorption

Steel mill gases can be used for the production of purified syngas and for the production of chemicals.



Cutting-edge ammonia technology since 1928

uhde® ammonia process

- One of the leading technology providers in ammonia field
- Improved energy efficiency and higher capacities
- Reassuring reliability
- Pioneers in critical plant equipment



Experience cannot be copied.

#1

supplier in EPC
business for ammonia
plants

≈ 130

ammonia plants
realized worldwide

> 90

years of turnkey EPC
solutions



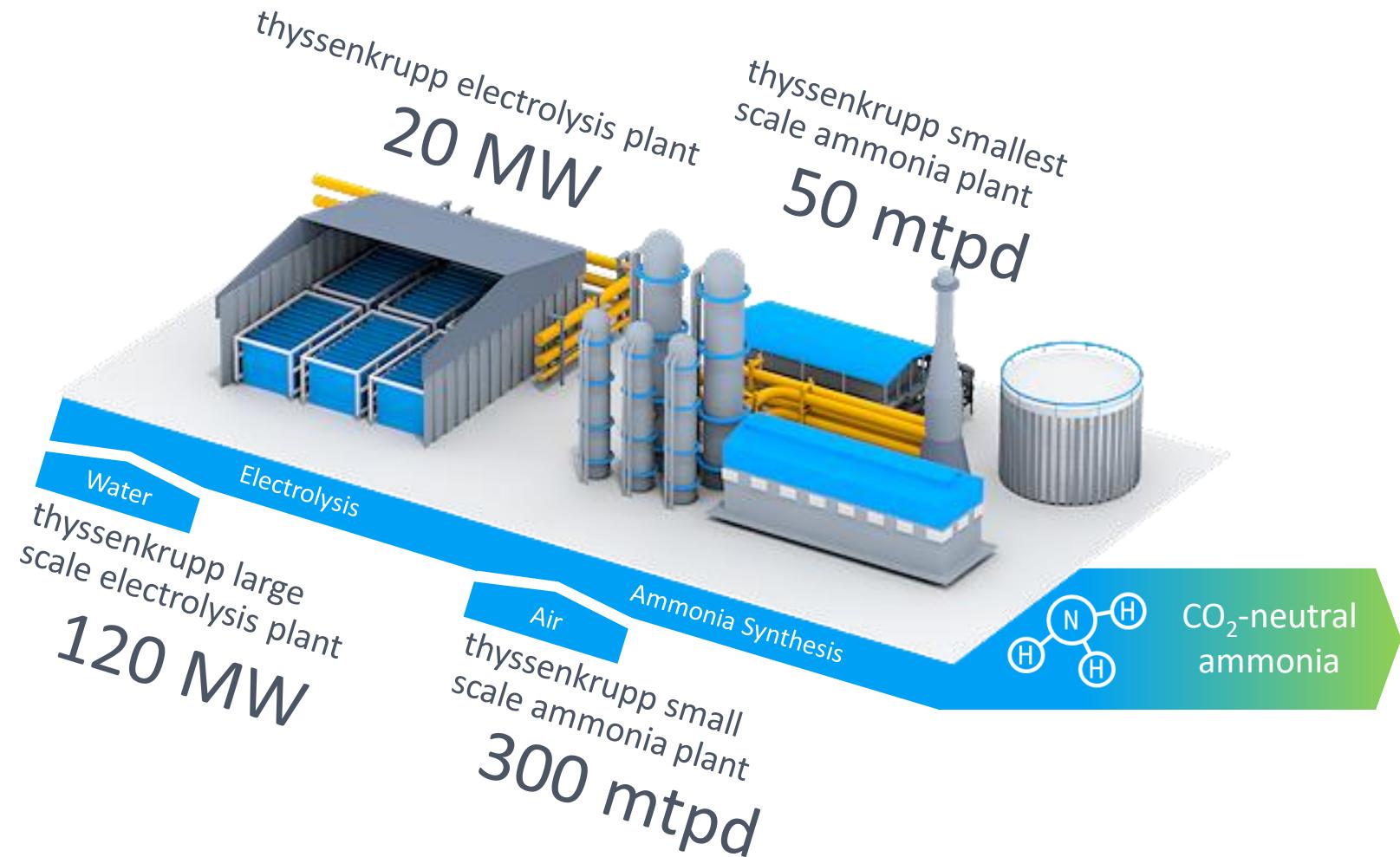
thyssenkrupp

Introducing green ammonia by thyssenkrupp

2 worldwide leading processes

1 holistic solution

0 CO₂ emissions¹



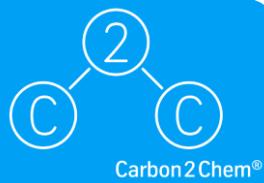
¹ depending on E-power source

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



Introduction to Carbon2Chem®

Results from 1st phase and main objectives for the 2nd phase



Building and operation of C2C technical center

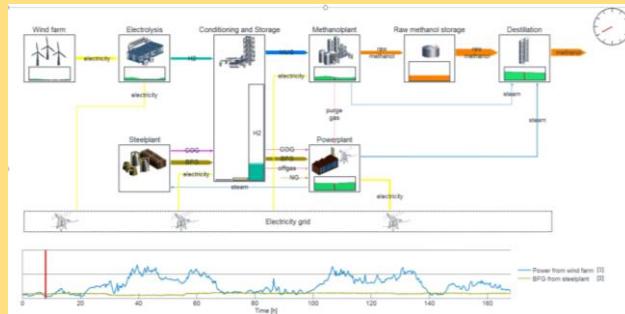
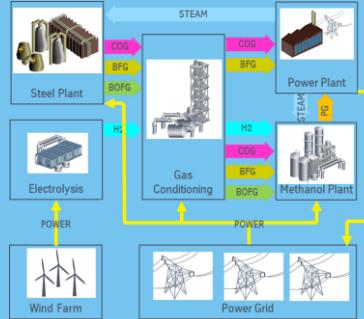
1st phase
2016 - 2020

Production of methanol and ammonia from steel mill gases and hydrogen from alkaline water electrolysis



Carbon2Chem® can reduce the CO₂ emissions of the cross-industrial network if renewable hydrogen is available

Development and simulation of concepts for the cross-industrial network



Demonstration of long-term stability

2nd phase
2020 - 2024

Implementation of the C2C technology into other industries (e.g. cement, lime, waste)



Proof that industrial network is technical feasible

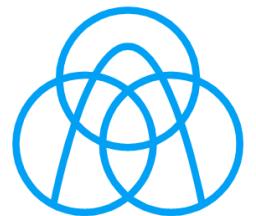


Thank You for Your Attention.



engineering.tomorrow.together.

Tobias Birwe
Head of Sales
Operating Unit Fertilizer &
Methanol
tobias.birwe@thyssenkrupp.com



thyssenkrupp