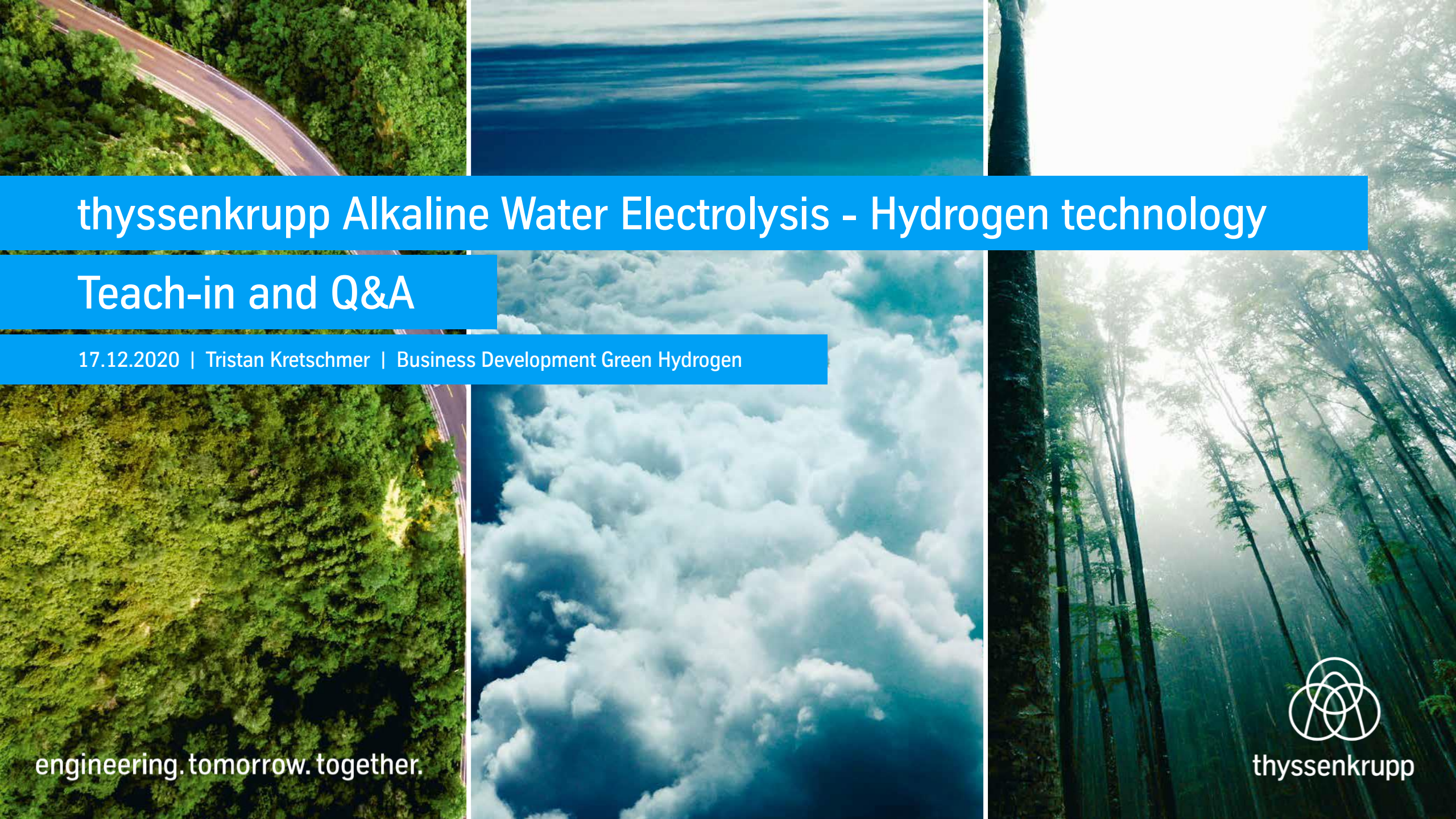
thyssenkrupp Alkaline Water Electrolysis - Hydrogen technology

Teach-in and Q&A

17.12.2020 | Tristan Kretschmer | Business Development Green Hydrogen



thyssenkrupp – target portfolio defined for turnaround and true performance culture

Reporting structure as of October 01, 2020

Group of Companies

	Materials Services	Industrial Components	Automotive Technology	Steel Europe	Marine Systems	Multi Tracks[1]
	MX	Bearings Forged Technologies	AT	SE	MS	AST, SP, CEM, SY PTS, SY BTS, CC, CPT, HP, tkE stake, MIN, Infrastructure
	Stand alone			**Dual Track** Stand alone or industry consolidation		**Multi Tracks** incl. partnership, sell, close
Sales[2]	€9.9 bn	€2.1 bn	€4.1 bn	€7.0 bn	€1.8 bn	€5.5 bn
EBIT adj.[2,3]	€(85) mn	€139 mn	€(166) mn	€(820) mn	€20 mn	€(593) mn

1. HP: Heavy plate (SE); Infrastructure: Technical Services excl. Mill Services & Systems (MX); SP: Springs & Stabilizers (AT); BTS: OU Battery Solutions (SY); PTS: OU Powertrain Solutions (SY); AST: Acciai Speciali Terni, stainless steel production and stainless distribution (MX); CPT: Chemical Plants, MIN: Mining, CEM: Cement (PT), CC: Carbon Components I 2. Prof-forma based on FY 2019/20 I 3. Adjustments according to stricter guideline special items as of October 01, 2020

tk Chemical Process Technologies - global footprint and electrolysis as a core competence

Sales FY 2019/20 ~€1.6 bn

Fertilisers ~130 plants

Nitric acid ~185 plants

Refineries ~380 plants

Aromatics ~75 plants

Hydrogen, ammonia, methanol ~120 plants

Org. Chemicals/petrochemicals ~375 plants

Plastics, synthetic fibres ~115 plants

Polyester / polyamides ~400 plants

Electrolysis / Electrochemical Technologies ~600 plants

Coke Plant Technologies ~500 plants

Tank storage facilities ~105 plants

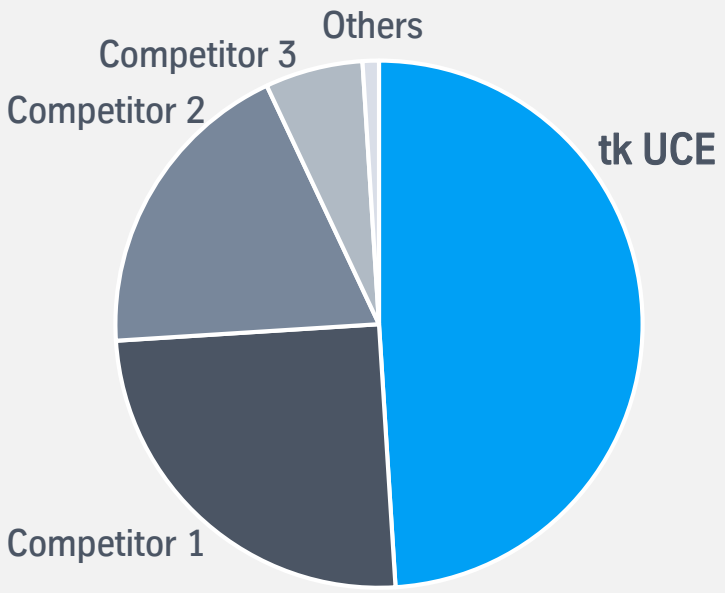
Industrial plants ~150 plants

tk UCE - leverage leading position in Chlor-Alkali electrolysis for Alkaline Water electrolysis (H_2)

History in the water electrolysis process portfolio

- tk Uhde® Chlorine Engineers (JV with DeNora) - established leader in chlor-alkali electrolysis
- In 2016 chlor-alkali technology was basis for alkaline water electrolysis
- First industrial reference (pilot plant) for hydrogen production in 2018 at tk's steel plant in Germany (2 MW capacity at Carbon-to-Chem (C2C) site)

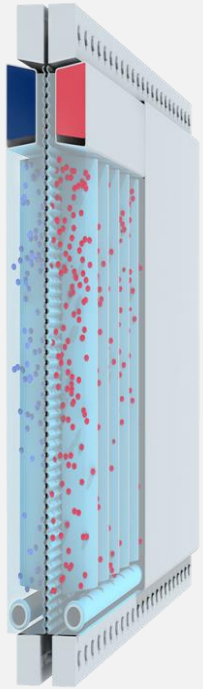
tk UCE – #1 supplier in electrolysis market



Main suppliers of CA membrane technologies
Global IEM CA Market Shares based on installed capacity;
CA = chlor-alkali; free accessible markets only;
Source: tk UCE database (as of 2019)

Technical Highlights

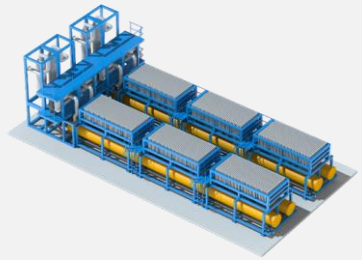
- >300,000 of elements manufactured[1]
- >1.6 million m² of electrodes produced[1]
- Introduction of high efficiency anode/cathode design and coating (with DeNora) for hydrogen evolution, proven in chlor-alkali technology
- Optimized high-performance separators and diaphragms based on proven design



1. For chlor-alkali plants producing hydrogen as co-product

Unique Selling Propositions (overall)

- 10 GW electrolysis cells supplied
- >1 GW p.a. manufacturing capacity
- Fully modularized and automated
- Long lifetime
- Predictive maintenance
- Worldwide service network
- Proven technology for large-scale solutions
- Integrated power-to-X solutions
- One-Stop-Shop



Our technical experience and capabilities: industrial scale EP/EPC Chlor-Alkali electrolysis plants

Products: Chlorine, Caustic Soda, Hydrogen

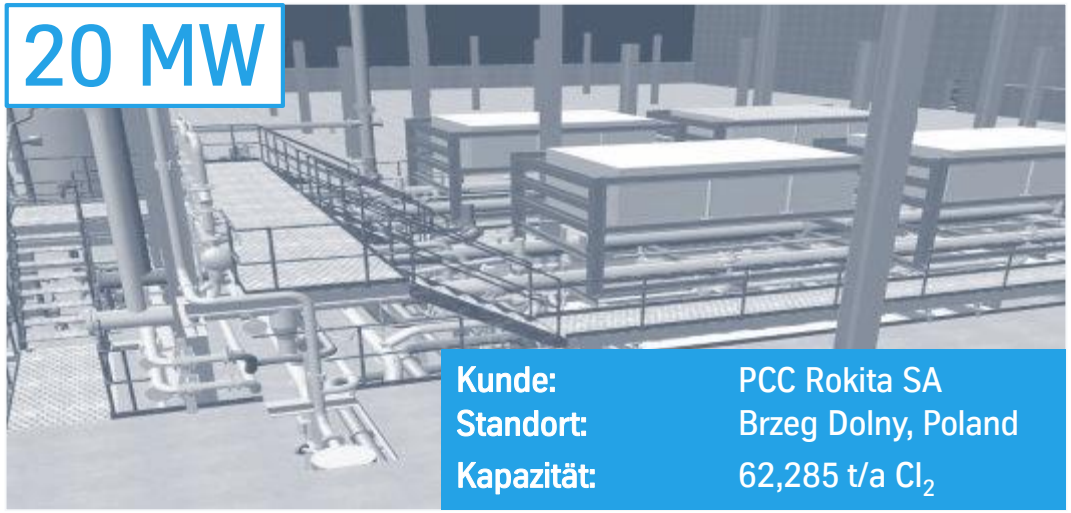
120 MW

Kunde:	KEM ONE
Standort:	Lavera, France
Kapazität:	400,000 t/a Cl_2

100 MW

Kunde:	Tessenderlo
Standort:	Belgium
Kapazität:	306,000 t/a of NaOH 272,000 t/a Cl_2

20 MW

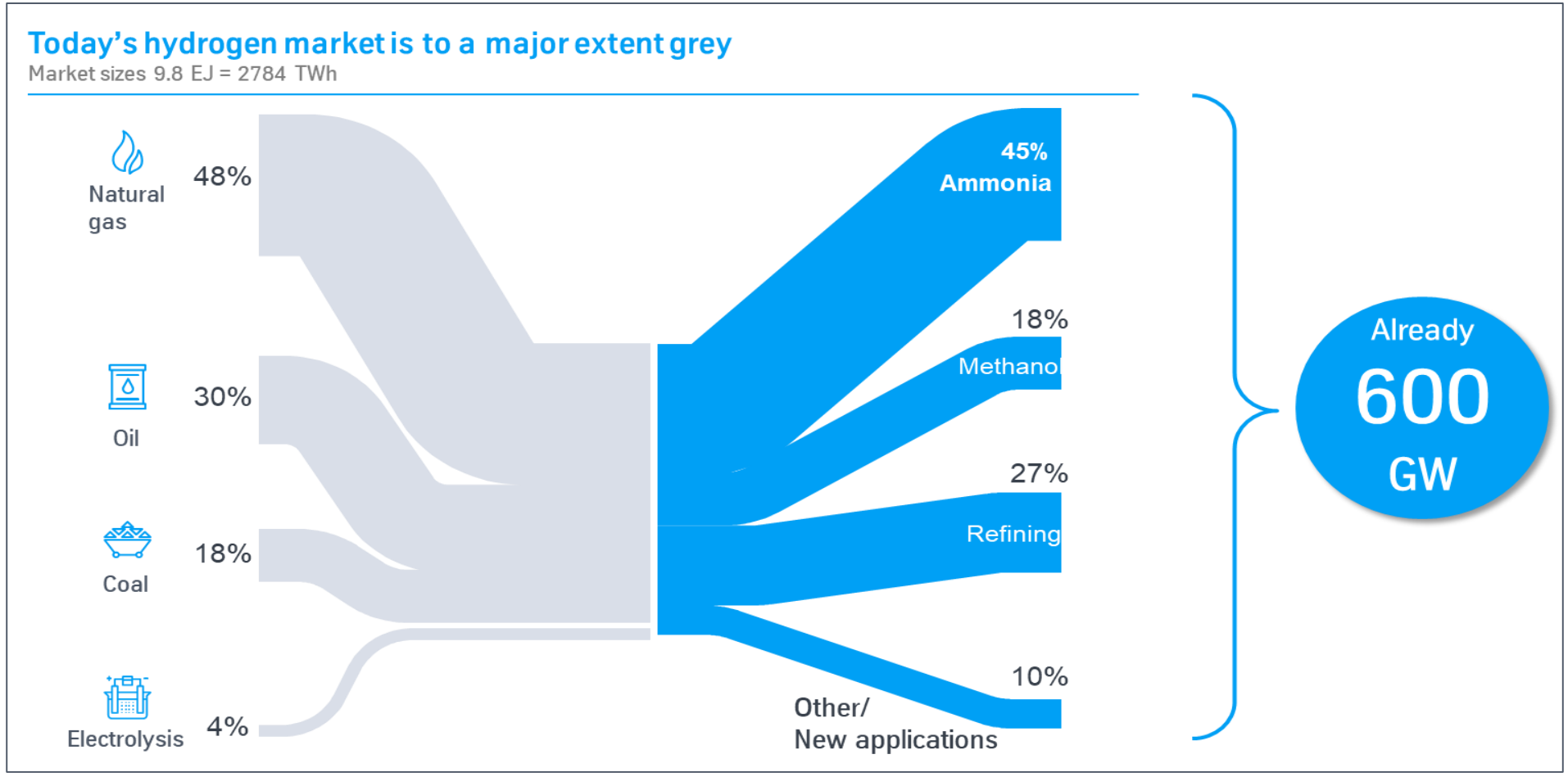


Kunde:	PCC Rokita SA
Standort:	Brzeg Dolny, Poland
Kapazität:	62,285 t/a Cl_2

80 MW

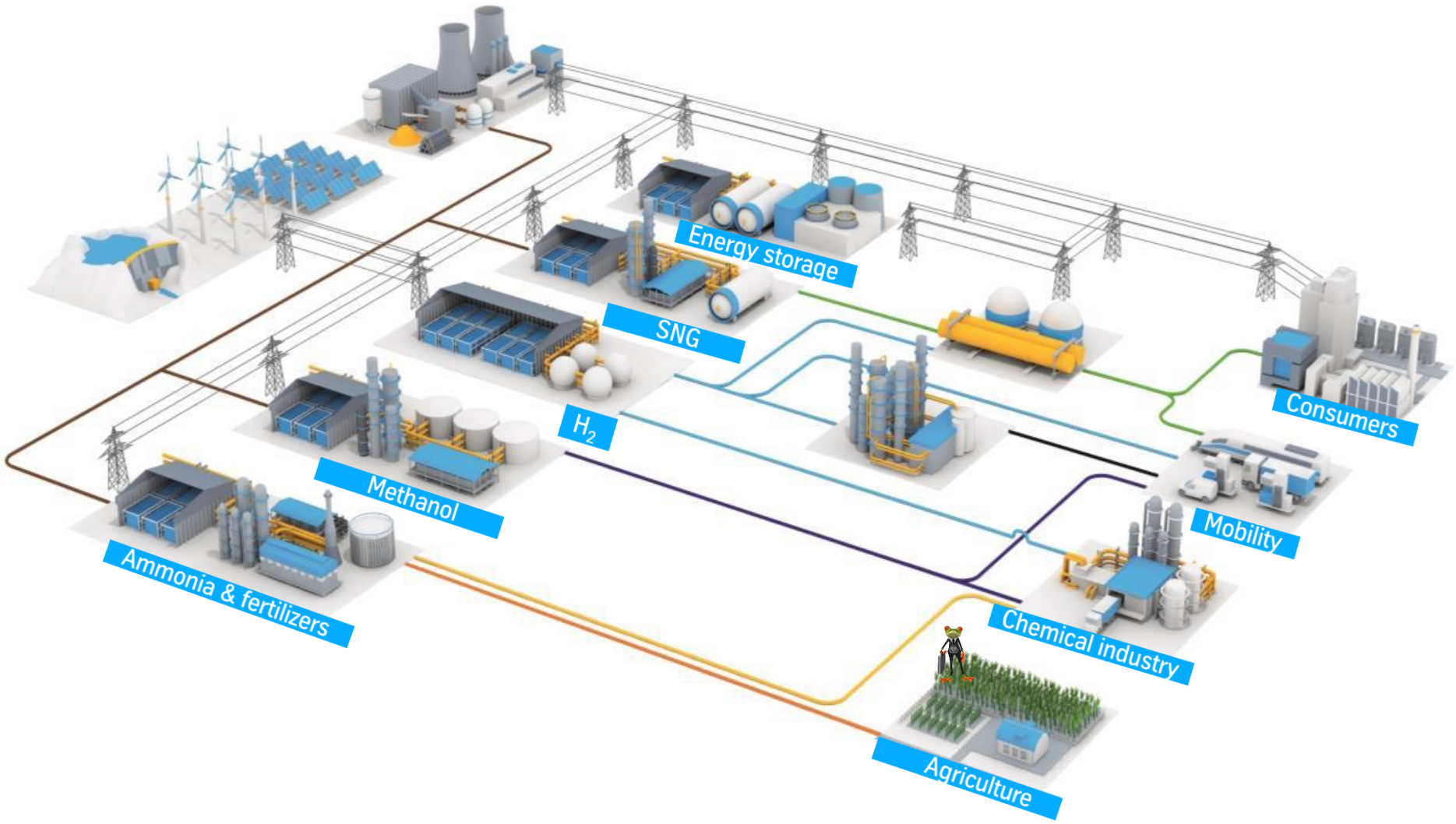
Kunde:	Vestolit
Standort:	Marl, Germany
Kapazität:	236,900 t/a of NaOH 210,000 t/a Cl_2

Transition of existing hydrogen demand to “green” alone requires significant electrolysis capacities



Green chemical value chains and markets will develop

Water electrolysis the enabler of growing (green) hydrogen markets



Applications

Power-to-fuels (SNG, Methanol, GTL)

- Chemical feedstock
- Carbon-neutral fuels in mobility and heat applications
- Re-electrification (long-term storage)
- Methanol as energy carrier for hydrogen

Power-to-hydrogen

- Chemical feedstock (e.g. power to steel)
- Re-electrification (long-term storage)
- Direct use in mobility applications (fuel cells)

Power-to-ammonia

- Chemical feedstock
- Fertilizer
- Energy carrier for hydrogen or direct use for energy
- Re-electrification (long-term storage)

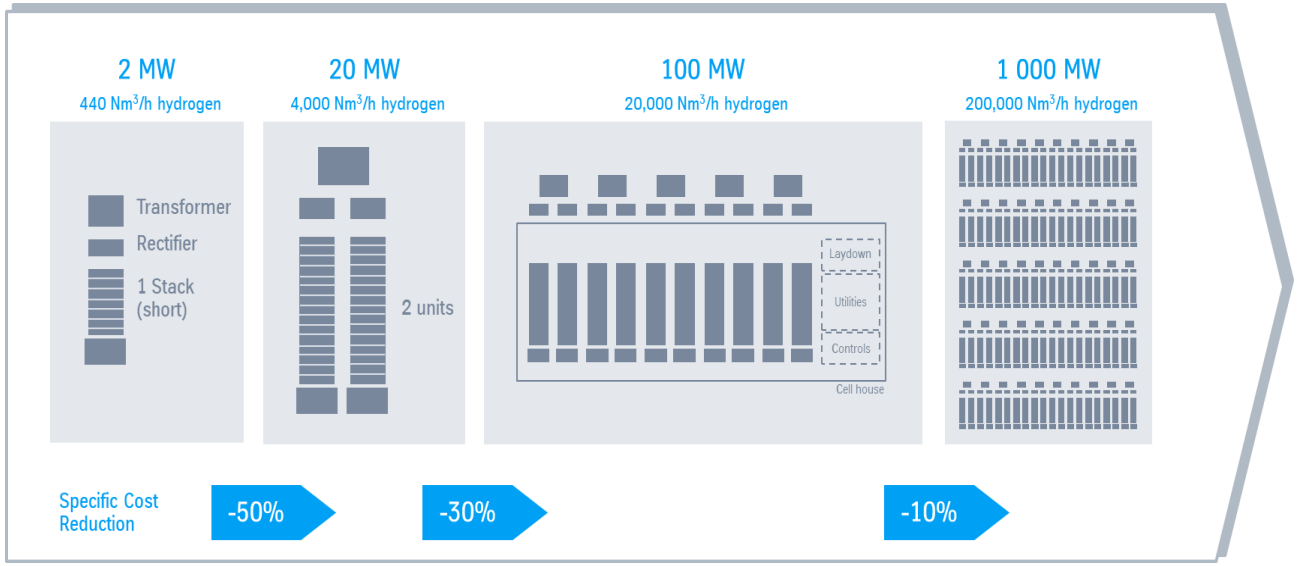
Water electrolysis market ramp-up and industrial scale plant sizes will lead to significant cost reduction

Small scale pilots so far

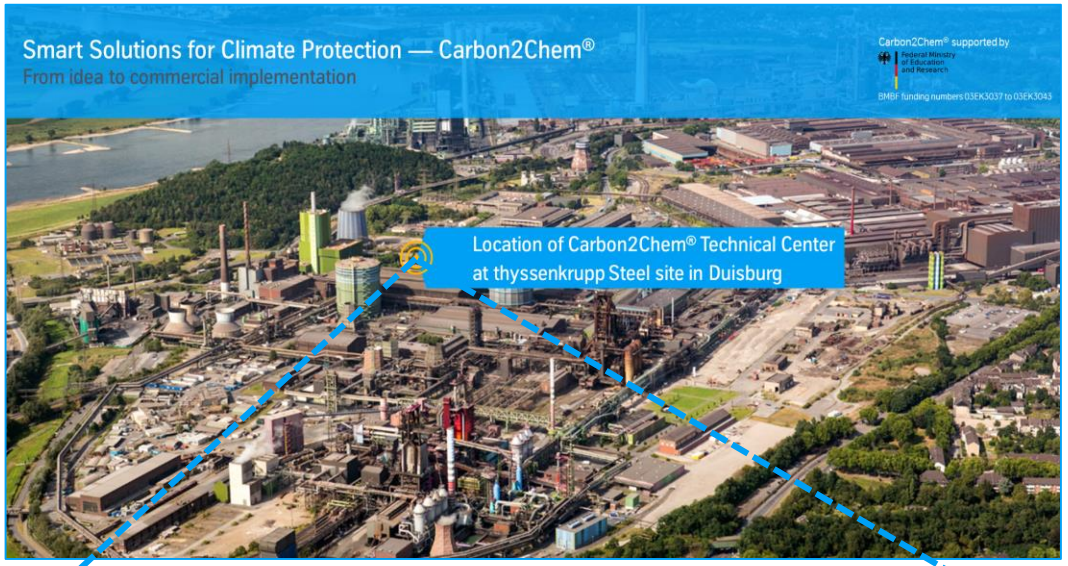
- Small scale projects, R&D context
- Hydrogen expensive due to high specific costs
- Little development of scaled technology and supply chains
- No commercial hydrogen offtake

Industry scale solutions commencing now

- Refineries and ammonia plants request large volumes
- Scaling reduces hydrogen costs below benchmark of 2 €/kg: supply chains, highly efficient equipment, efficient project development



Large scale industrial projects with tk as supplier for water electrolysis



"Carbon2Chem" Project, Germany

"NEOM" Project, KSA – industrial scale

Phase 1:	20 MW electrolysis
Phase 2:	2 GW electrolysis
Location:	NEOM, KSA
RE Feed:	Wind and PV
Concept:	Green hydrogen feedstock to green ammonia Green ammonia as energy carrier
Startup:	2025 (Phase 2)

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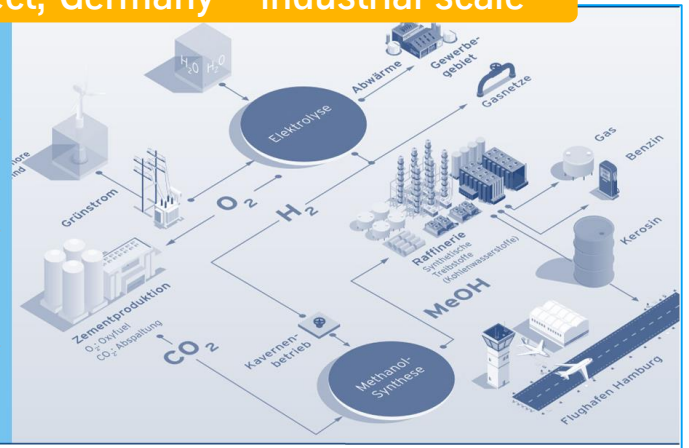
"Westküste 100" Project, Germany – industrial scale

Phase 1:	30 MW electrolysis
Phase 2:	700 MW electrolysis green methanol and fuel for aviation
Location:	Heide, Germany
Funding:	by BMWi
RE Feed:	Offshore wind
Concept:	Green hydrogen feedstock to refinery of Heide Green methanol / fuel production by refinery Green hydrogen for fueling stations
Startup:	2023



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