# A technology leader in hydrogen ($H_2$)

## thyssenkrupp Uhde Chlorine Engineers (tkUCE)

November 2021

engineering.tomorrow.together.

thyssenkrupp

# Today’s presenters

## Denis Krude

**CEO**

CEO of tkUCE since 2016

More than 25 years of industry experience

18 years of electrolysis experience

With thyssenkrupp since 1998

## Dr. Arno Pfannschmidt

**CFO**

CFO of tkUCE since 2014

More than 25 years of industry experience

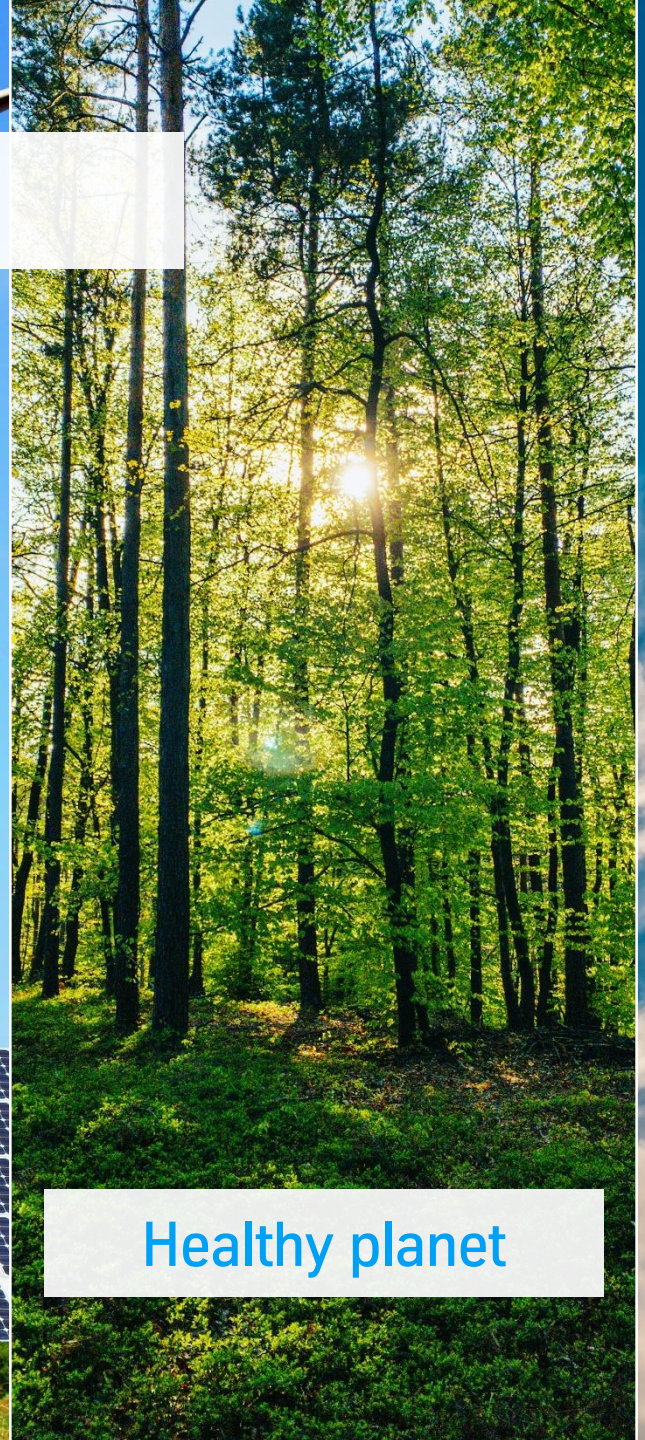
7 years of electrolysis experience

With thyssenkrupp since 1993

# We need to save the global climate

Clean food & water

Renewable energy



Healthy planet

Clean air

# Enabling the global energy transition

- Enabler for industries to decarbonize
- High growth water electrolysis market
- A technology leader for industrial-scale electrolysis
- Global organization with reputable partners
- High value-add life cycle service offering
- Highly experienced management team
- Fast growing AWE order backlog

# Electrolysis connects the renewable power sector with a wide range of industries and enables its decarbonization

## Renewable Power

- Renewable electricity is expected to be the primary energy source for all market segments

## Green Hydrogen

- Electrolysis converts renewable power into Green Hydrogen
- Makes renewables usable in wide range of industries
- Replaces fossil based processes

## Hydrogen Markets

- Hydrogen decarbonizes industry processes:

  mobility, substitute natural gas, refineries, fertilizers, steel, chemicals, etc.

## Green hydrogen driver & enabler

Climate & environmental protection

Growing renewable power sector at low cost

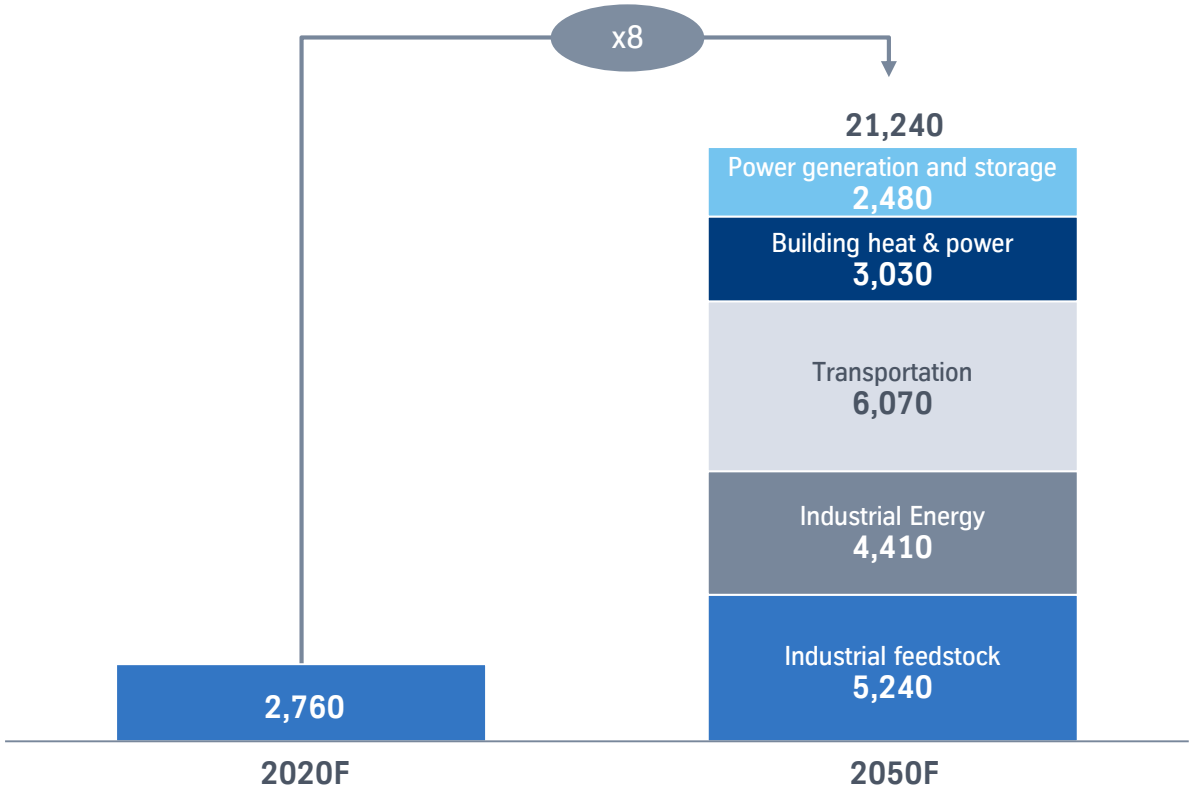
Appropriate legal frameworks

# Strong growth outlook for the hydrogen market

## The hydrogen economy has broad-based secular support for growth

| | |
|---|---|
| Government Policy and Consumer Demand | Countries with announced $H_2$ strategy represent **c.80%**[1] of global GDP |
| Cost and Availability of Renewable Energy | **c.11%** Annual decline rate of renewable power prices between 2010 and 2020 |
| Opportunity for Scalable Green $H_2$ Solutions | **>28 giga-scale** production projects announced by July 2021 |

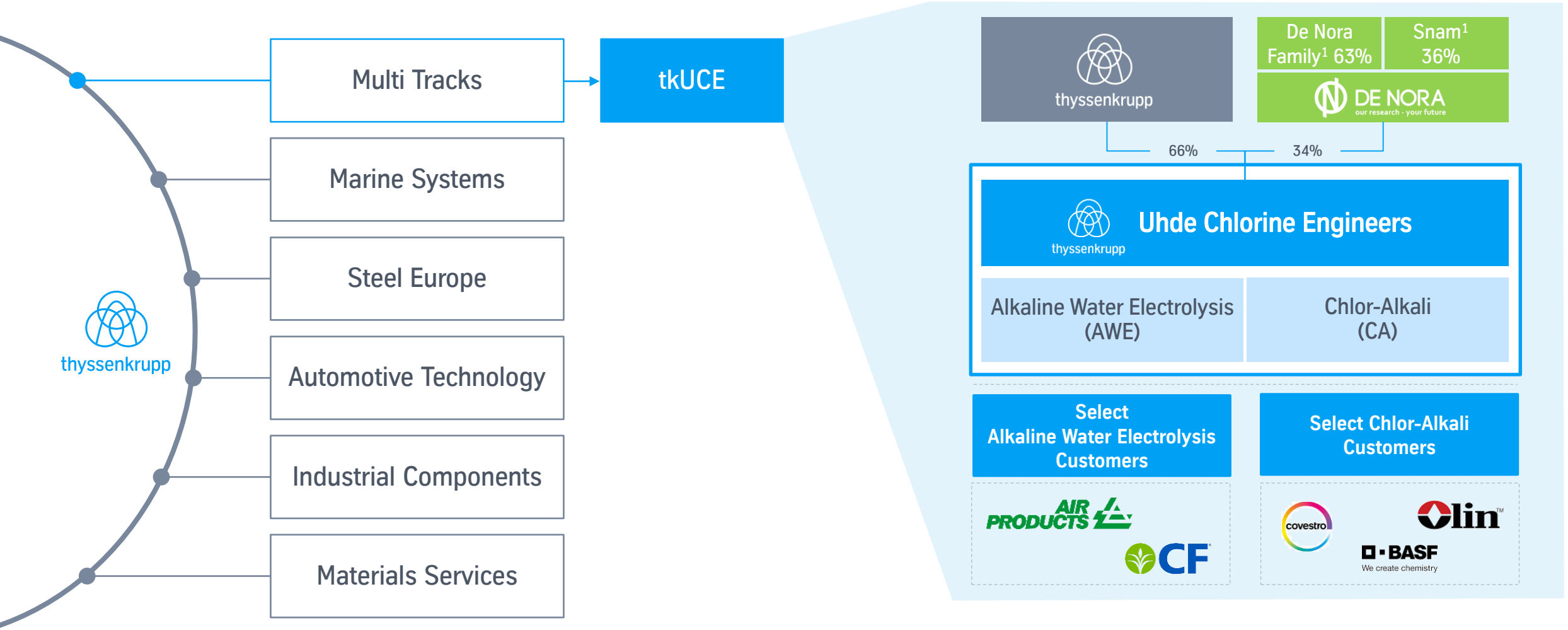
## Possible hydrogen consumption by 2050 ($TWh^2$ p.a.)




**c. €110 bn market in 2020F**
Large opportunities for electrolysis within existing hydrogen market

Source: Hydrogen Council, Kearney Energy Transition Institute, Bloomberg
Note: 1 Including the United States and European Union 2 Energy content of 1kg of hydrogen equal to 141.9 MJ (HHV) = 39.4 KWh

# We are the Alkaline Water Electrolysis and Chlor-Alkali technology provider to customers globally




1. De Nora shareholding structure – De Nora Family 63.1%, Snam 35.6%, Cordusio Fiduciary (Board Members and Management) 1.2%

# Building on a world class global organization with a network close to customers

## Experienced management with strong track record leading an…

CEO
Denis Krude

CFO
Dr. Arno Pfannschmidt

CTO
Fulvio Federico

Head of Green Hydrogen
Dr. Christoph Noeres

Head of Chlor-Alkali
Dr. Roland Beckmann

Head of Service & Innovation Center
Dr. Ulf Steffen Bäumer

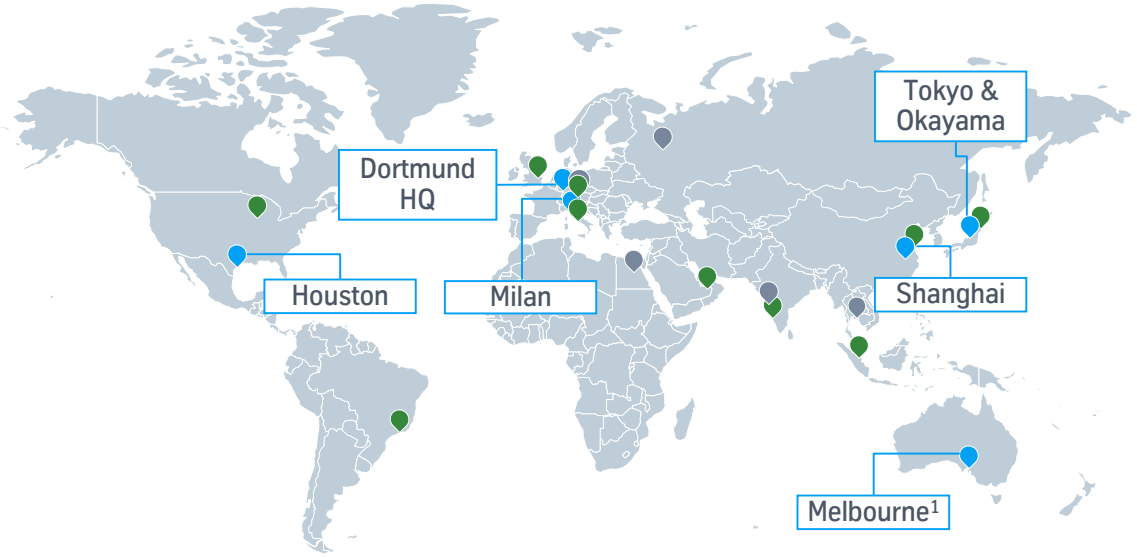
**Management structure**

**Global headcount of more than 370**

6 local organizations operating in regional markets

| | | |
|---|---|---|
| Dortmund | Tokyo & Okayama | Shanghai |
| Houston | Milan | Melbourne[1] |

## …organization that is worldwide close to its customers




6 centers of excellence, global reach

tkUCE locations · Industrie De Nora partner · tk plant technology partner

1. Newly opened office, build-up ongoing

# Select tkUCE Green hydrogen milestones timeline solidifies position as an industry leader

## Carbon2Chem

**tkUCE**'s Duisburg demonstrator hydrogen plant started operations, a green world premiere

**Sep 2018**

## Air Products

**tkUCE** signed an exclusive strategic cooperation agreement for world-scale electrolysis plants to be developed in key regions

**Jul 2020**

## NEOM[1]

Air Products, ACWA Power and NEOM signed agreement for $5 billion production facility in NEOM, **tkUCE** selected as electrolysis technology provider (650 t/day of hydrogen)

**Jul 2020**

## 20 MW installation

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

**Apr 2021**

## $H_2$Global green hydrogen initiative

**tkUCE** as founding member of Germany's initiative to support 500 MW electrolyzers outside the EU with $1.1 billion of funding support

**Jun 2021**

## $H_2$Giga

Expansion to 5 GW p.a. capacity: **tkUCE** represented in all three BMBF hydrogen lead projects[2]

**Oct 2021**

1. As reported in Air Products press release 2. $H_2$Giga, $H_2$Mare and TransHyDE as the three German Federal Ministry of Education and Research (BMBF) lead hydrogen projects

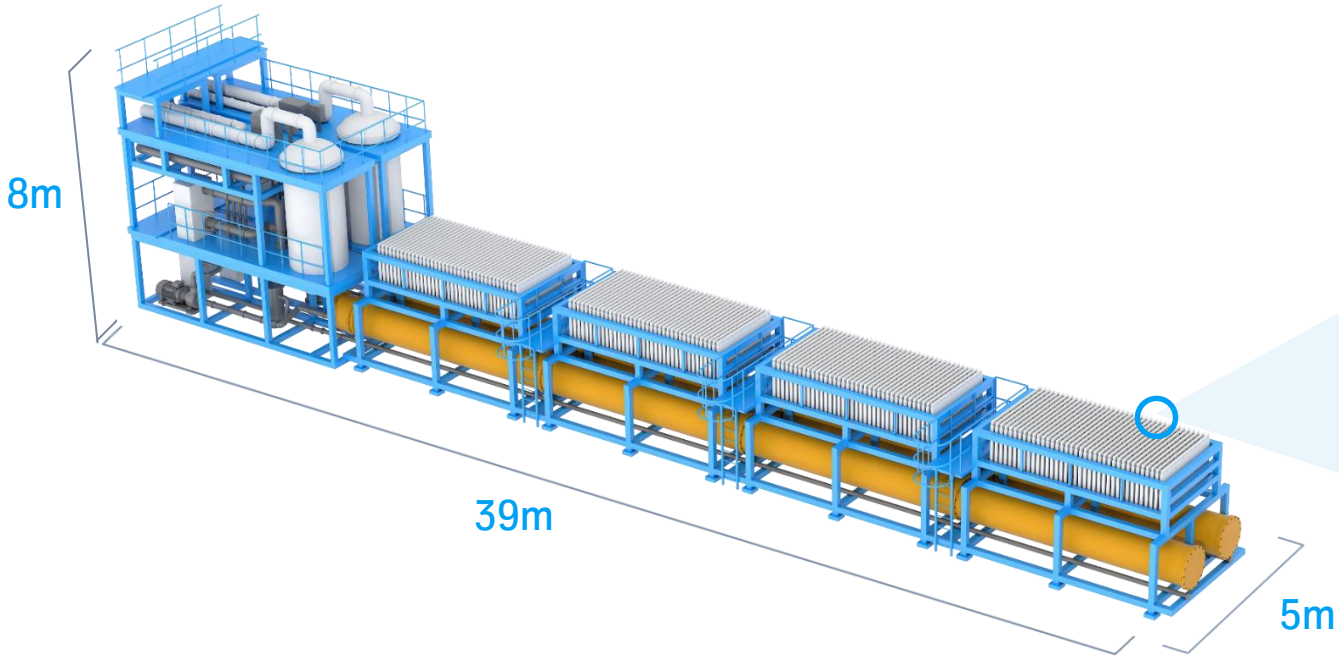
# tkUCE's proven experience in Chlor-Alkali business provides a strong basis for AWE scale-up

| | Chlor-Alkali Electrolysis | Alkaline Water Electrolysis |
|---|---|---|
| | Proven experience with over **600 projects & 200,000 electrolytic cell elements** | Building on Chlor-Alkali experience to be **#1 in AWE** |
| Market Readiness | • Industrial-scale installations<br>• Proven quality supply chain | • Industrial-scale hydrogen plants<br>• Expand to 5GW supply chain |
| Product | • A technology leader for electrolysis<br>• Handling of hydrogen as a by-product | • Standardized AWE product with leading TCO[1]<br>• Hydrogen as the main product |
| Organization & Network | • Holistic life cycle services<br>• Global network with partners | • Successful service model<br>• Automation and digitalization |

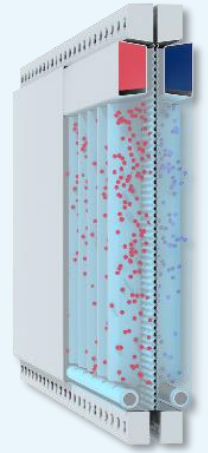
1. TCO: Total cost of ownership

# tkUCE's Alkaline Water Electrolyzers – designed for industrial-scale roll-out

## Alkaline Water Electrolyzer (AWE)




Single Element



**Quality**
Proven cell design

**Longevity**
High durability proven by Chlor-Alkali

**High Performance**
Long-term technology experience

**Service**
Global service network with partners

# Demonstrator and test stand of AWE technology at Carbon2Chem

## Operation of technical evaluation demonstrator plant for Carbon2Chem, Duisburg

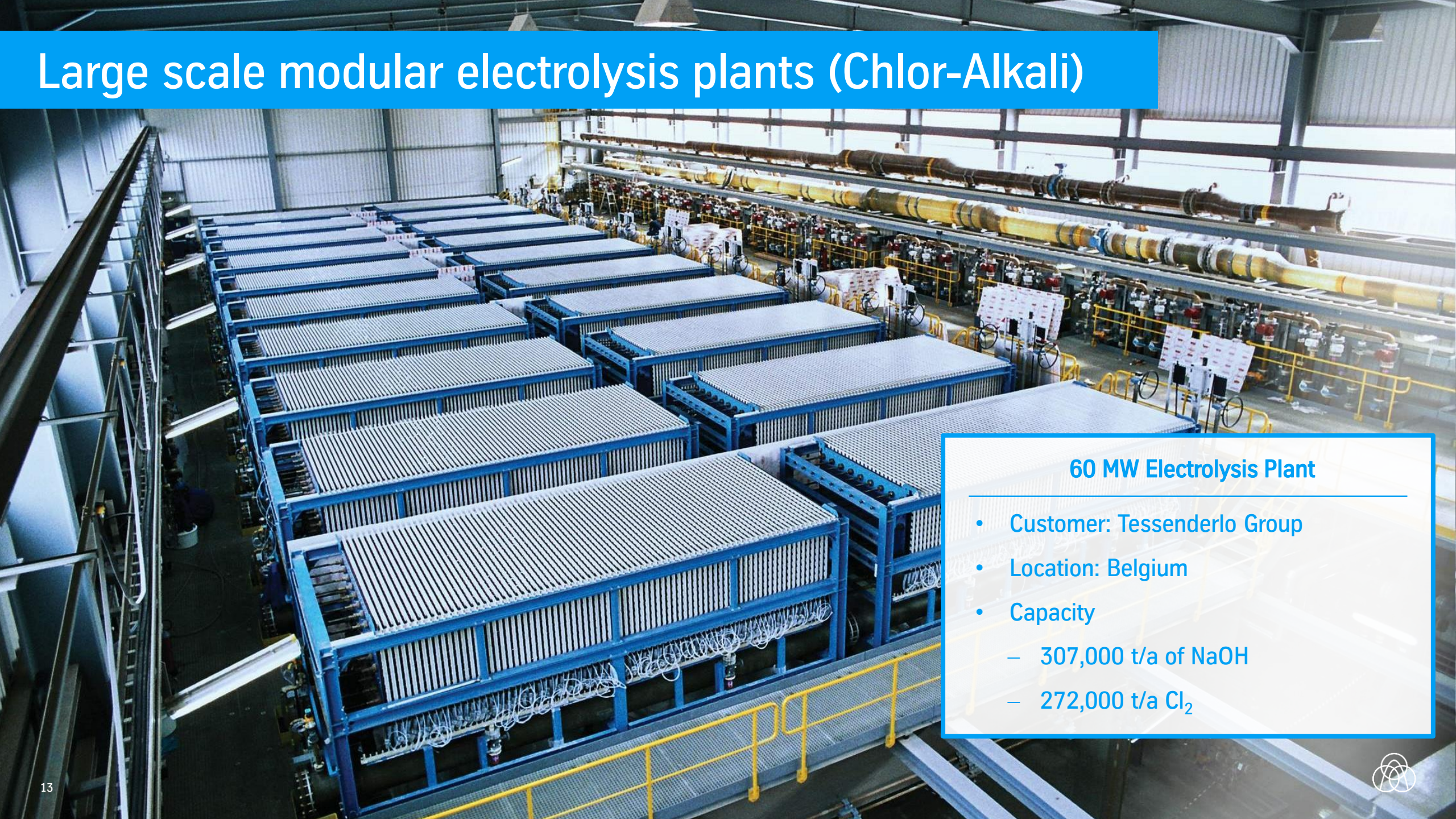
- Capacity: up to 2 MW
- $H_2$ production: 440 $Nm^3/h$
- $H_2$ purity: > 99.95 % (dry)

Carbon2Chem® supported by

Federal Ministry of Education and Research

BMBF funding numbers
3EK3037 to 03EK3043

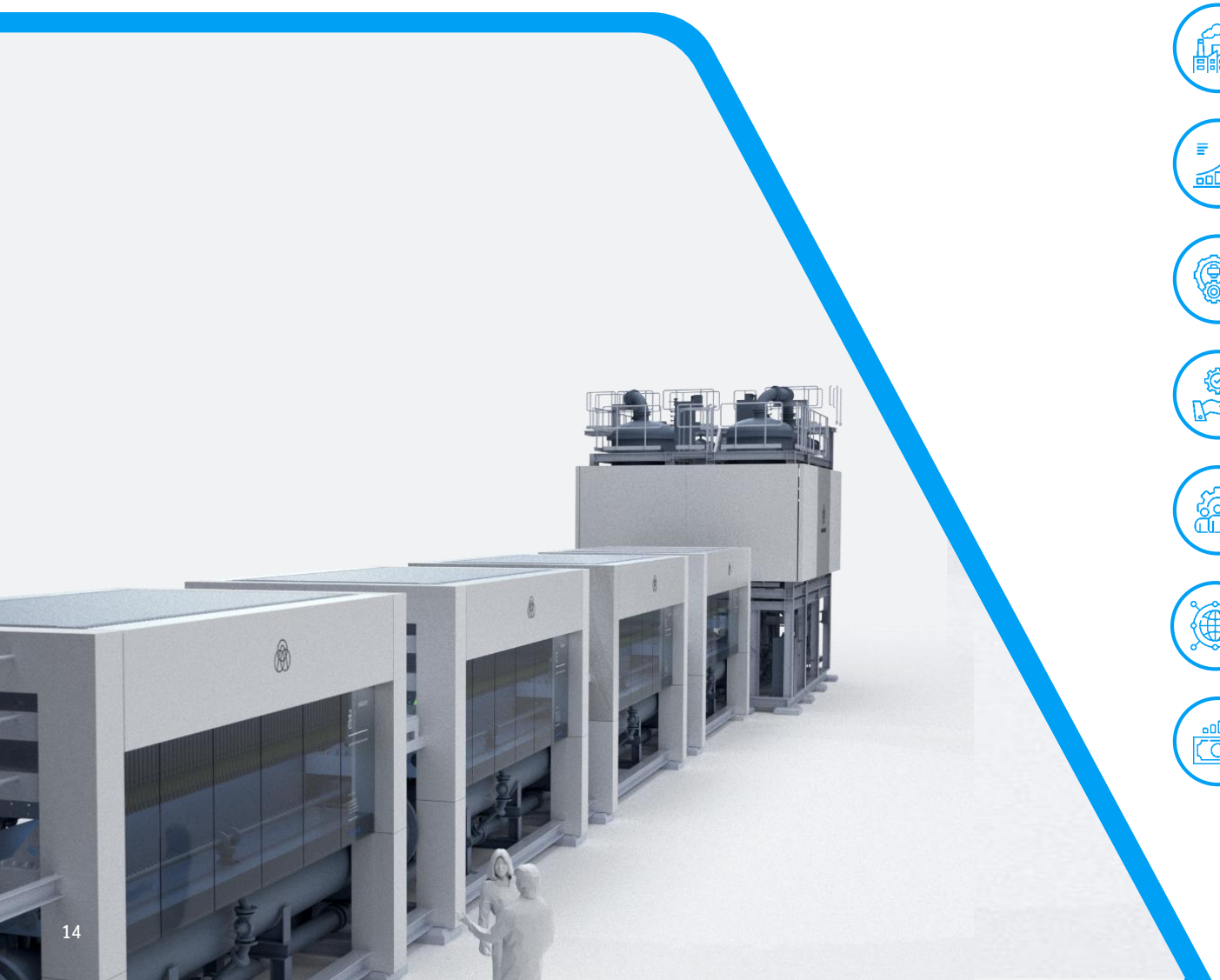
# Large scale modular electrolysis plants (Chlor-Alkali)



## 60 MW Electrolysis Plant

- Customer: Tessenderlo Group
- Location: Belgium
- Capacity
  - 307,000 t/a of NaOH
  - 272,000 t/a $Cl_2$

# Creating the global leader of Alkaline Water Electrolysis



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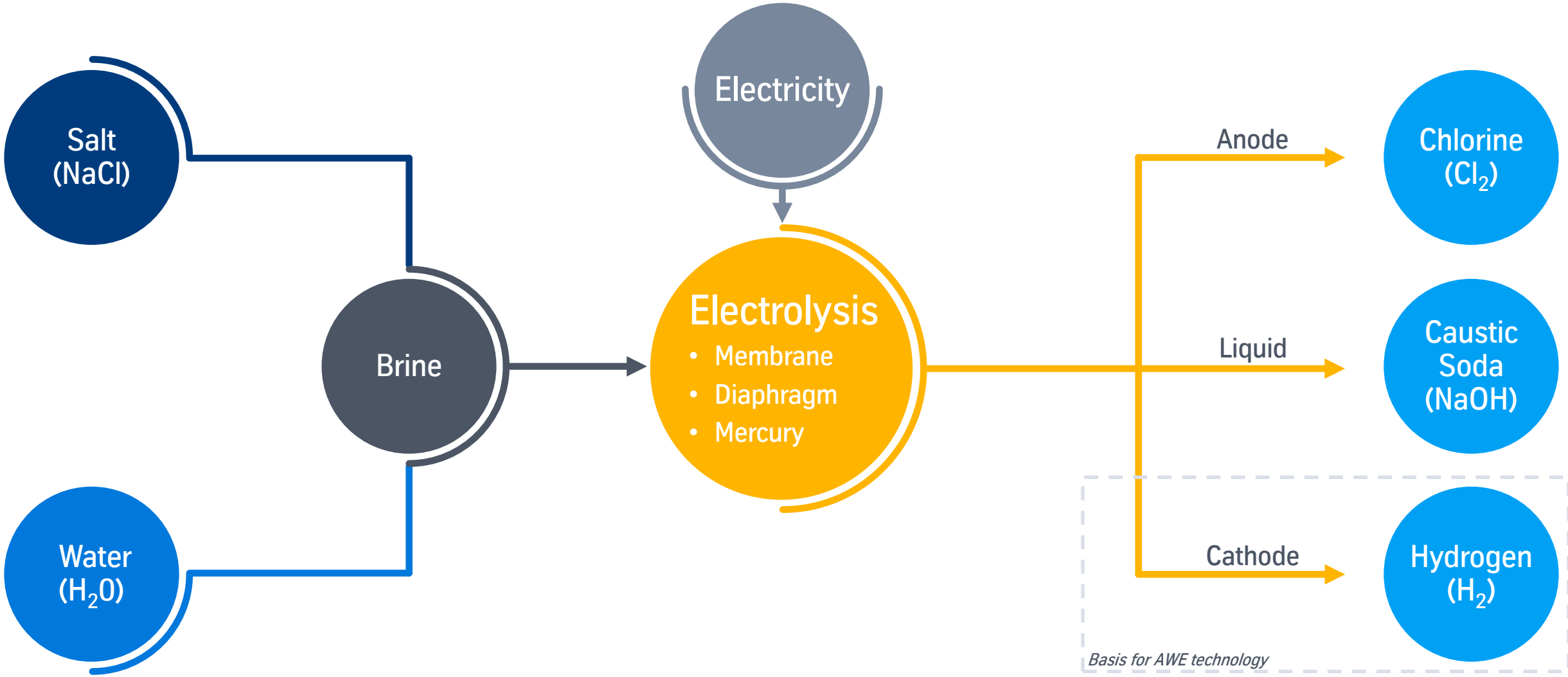
# Appendix

# Chlor-Alkali chemical process in a nutshell




Chlor-Alkali chemistry describes the process of splitting salt (NaCl) into Chlorine ($Cl_2$), Caustic Soda (NaOH) and Hydrogen ($H_2$)