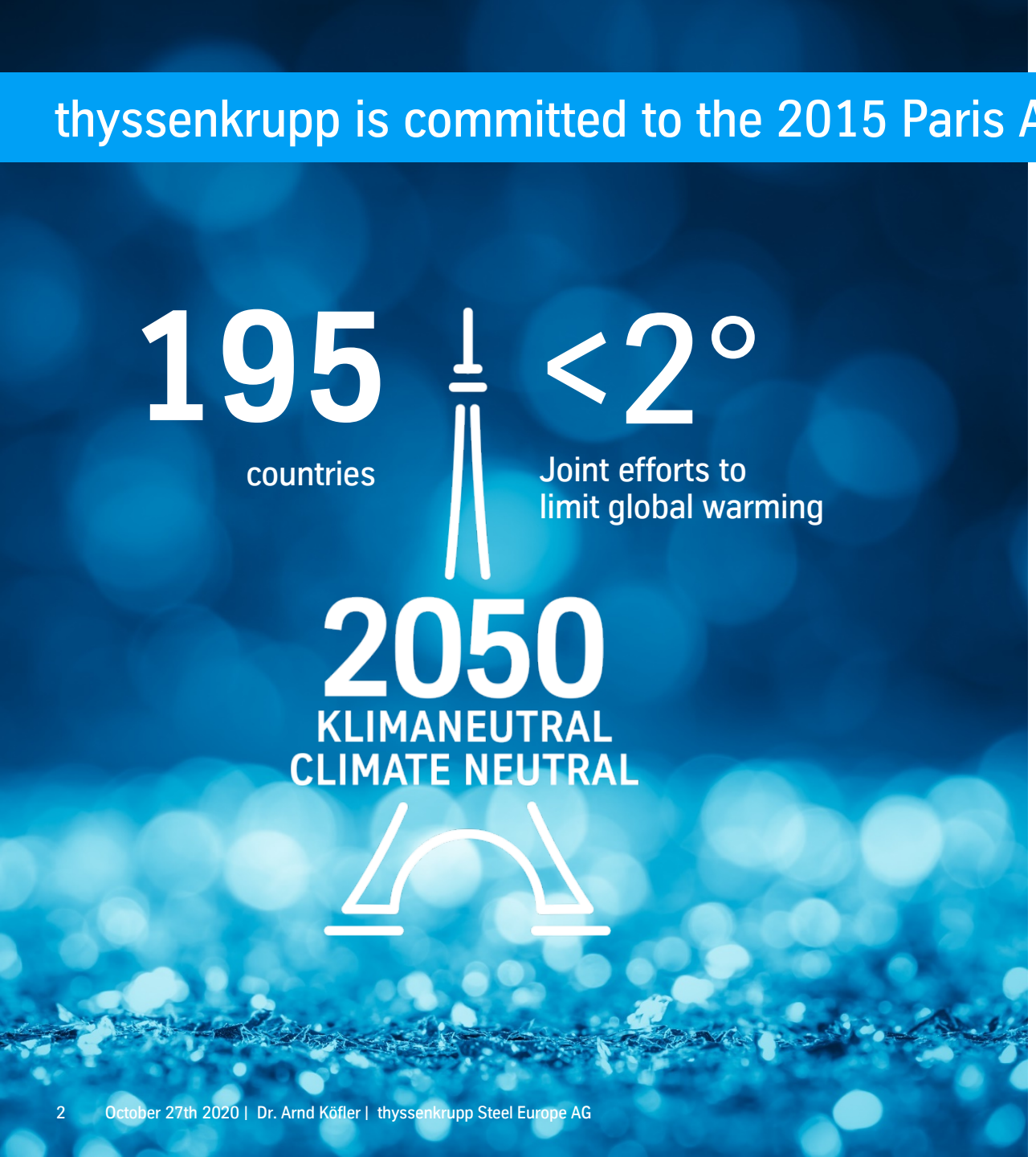
CO_2 free steel production: Contribution of Carbon2Chem®and other routes

October 27th 2020 | Berlin | Dr. Arnd Köfler
thyssenkrupp Steel Europe AG

thyssenkrupp is committed to the 2015 Paris Agreement



2030

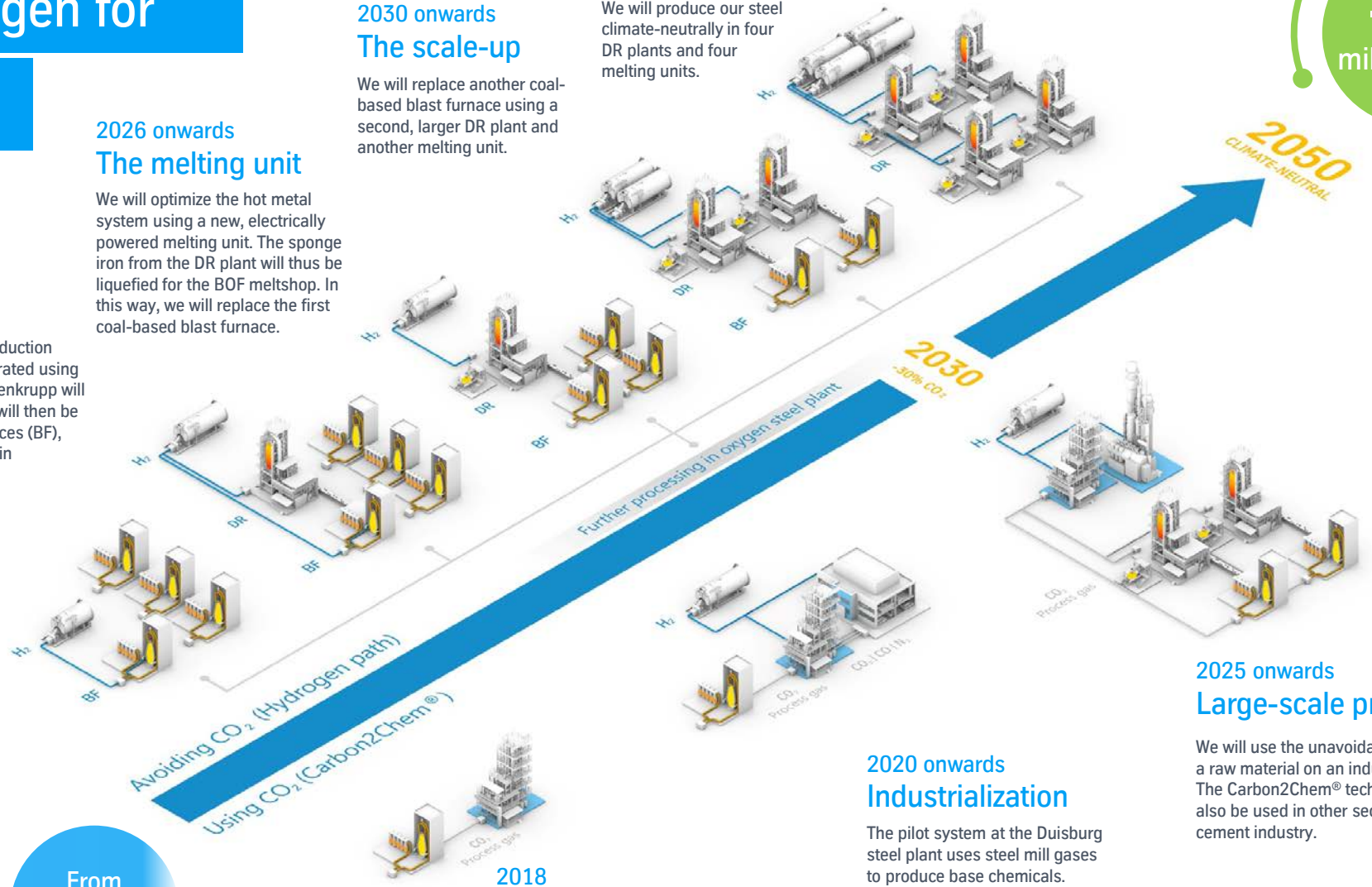
-30% CO_2 emissions

2050

Climate-neutral

Clear strategy: hydrogen for climate-neutral steel

-20 million t CO_2



2019 – 2022
H2 in the blast furnace

We have been testing the use of hydrogen in a working blast furnace since 2019. The goal: The equipping of blast furnace 9.

2024 onwards
The milestone

Using a large-scale direct reduction plant (DR) which will be operated using green H_2 in the future, thyssenkrupp will produce sponge iron which will then be processed in the blast furnaces (BF), allowing a further reduction in emissions.

2026 onwards
The melting unit

We will optimize the hot metal system using a new, electrically powered melting unit. The sponge iron from the DR plant will thus be liquefied for the BOF meltshop. In this way, we will replace the first coal-based blast furnace.

2030 onwards
The scale-up

We will replace another coal-based blast furnace using a second, larger DR plant and another melting unit.

2050 onwards
Climate-neutrality

We will produce our steel climate-neutrally in four DR plants and four melting units.

Available quantity of climate-neutral steel (per year)

- From 2022: 50,000 t
- From 2025: 400,000 t
- From 2027: 950,000 t
- From 2030: 3m t

2018
The world first

The concept: CO_2 becomes a raw material. In September 2018, thyssenkrupp produced methanol from steel mill gases for the first time at its Carbon2Chem® technical center in Duisburg.

2020 onwards
Industrialization

The pilot system at the Duisburg steel plant uses steel mill gases to produce base chemicals.

2025 onwards
Large-scale production

We will use the unavoidable CO_2 as a raw material on an industrial scale. The Carbon2Chem® technology can also be used in other sectors, like the cement industry.

Core of CDA path:

Direct reduction plant with melting unit produces “electrical hot metal”

PROCESS INNOVATION WITH SUBSTANTIAL ECOLOGICAL AND ECONOMIC ADVANTAGES

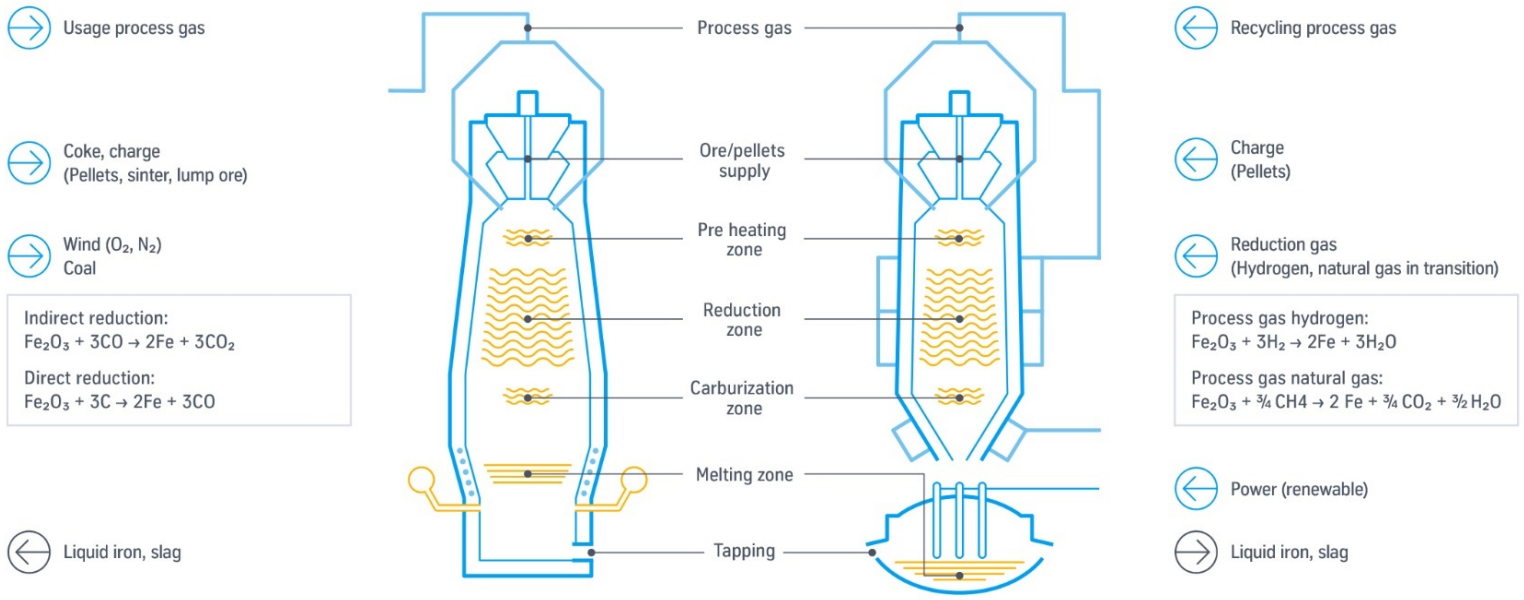
- Innovation: First-time use of melting unit in ironmaking
- Technical innovation: Engineering of the melting unit
- Ecological advantage: Hydrogen and green power substitute coal and eliminate CO_2
- Electrical hot metal is used like hot metal, therefore all products can still be produced

CONVENTIONAL BLAST FURNACE

Carbon as reducing agent and energy source

DR PLANT WITH MELTING UNIT

Hydrogen as reducing agent in DR plant
Green power as energy source of melting unit



Some CO_2 emissions in steel making can't be prevented through CDA

tkH2Steel

Carbon2Chem®

RESIDUAL EMISSIONS MAY OCCUR FROM HYDROGEN PRODUCTION, USAGE OF NATURAL GAS AND DOWNSTREAM OPERATIONS

- Hydrogen: only green hydrogen is truly climate-neutral and has to be available in sufficient amounts
- Natural gas: can bridge the time until green hydrogen can cover 100%, but comes with CO_2 emissions
- Downstream: BOFs, hot-rolling mills and other downstream units associated with CO_2 emissions

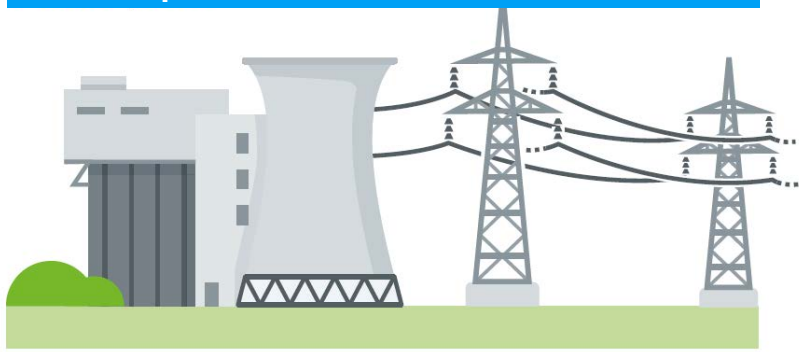
Carbon2Chem can absorb residual CO_2 emissions.

Carbon2Chem®fits all steel making paths

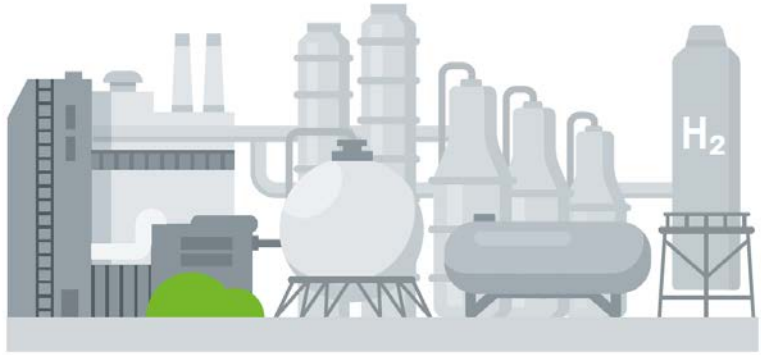
C2C with BF route

C2C with H_2 route

Power plant



Chemical plant



Fuels

Plastics

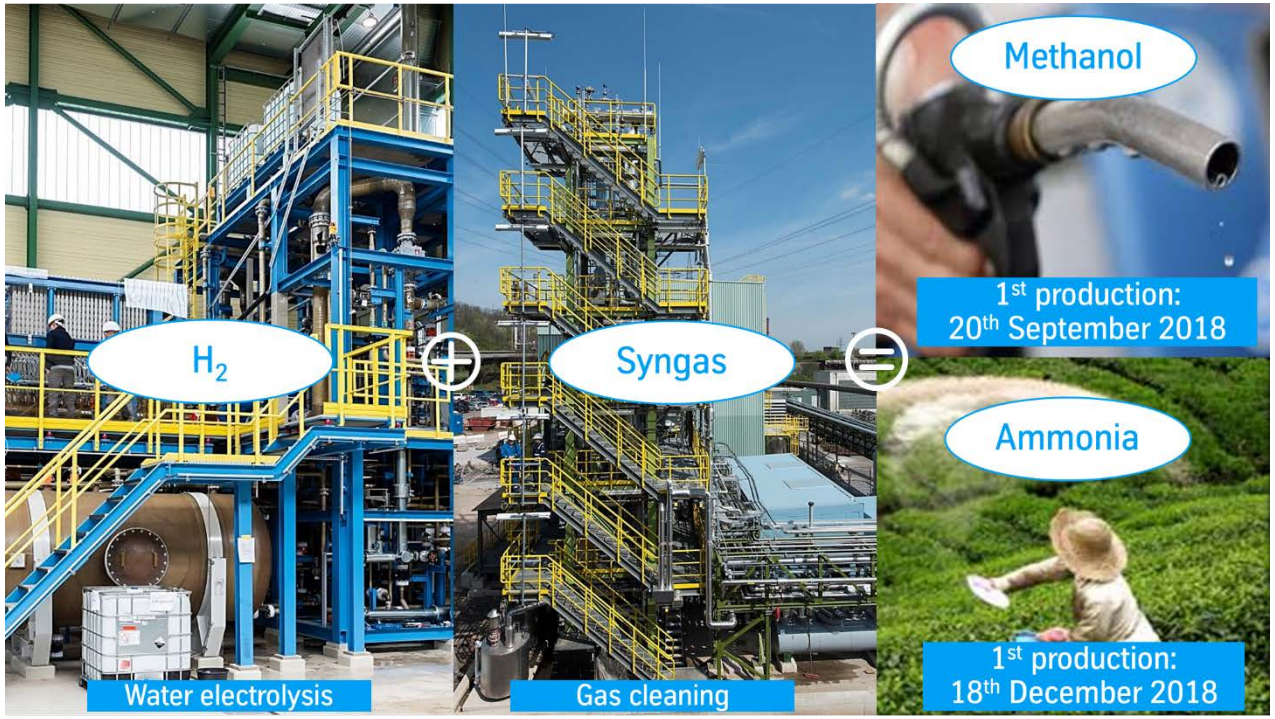
Fertilizer

Carbon2Chem successfully finished first phase

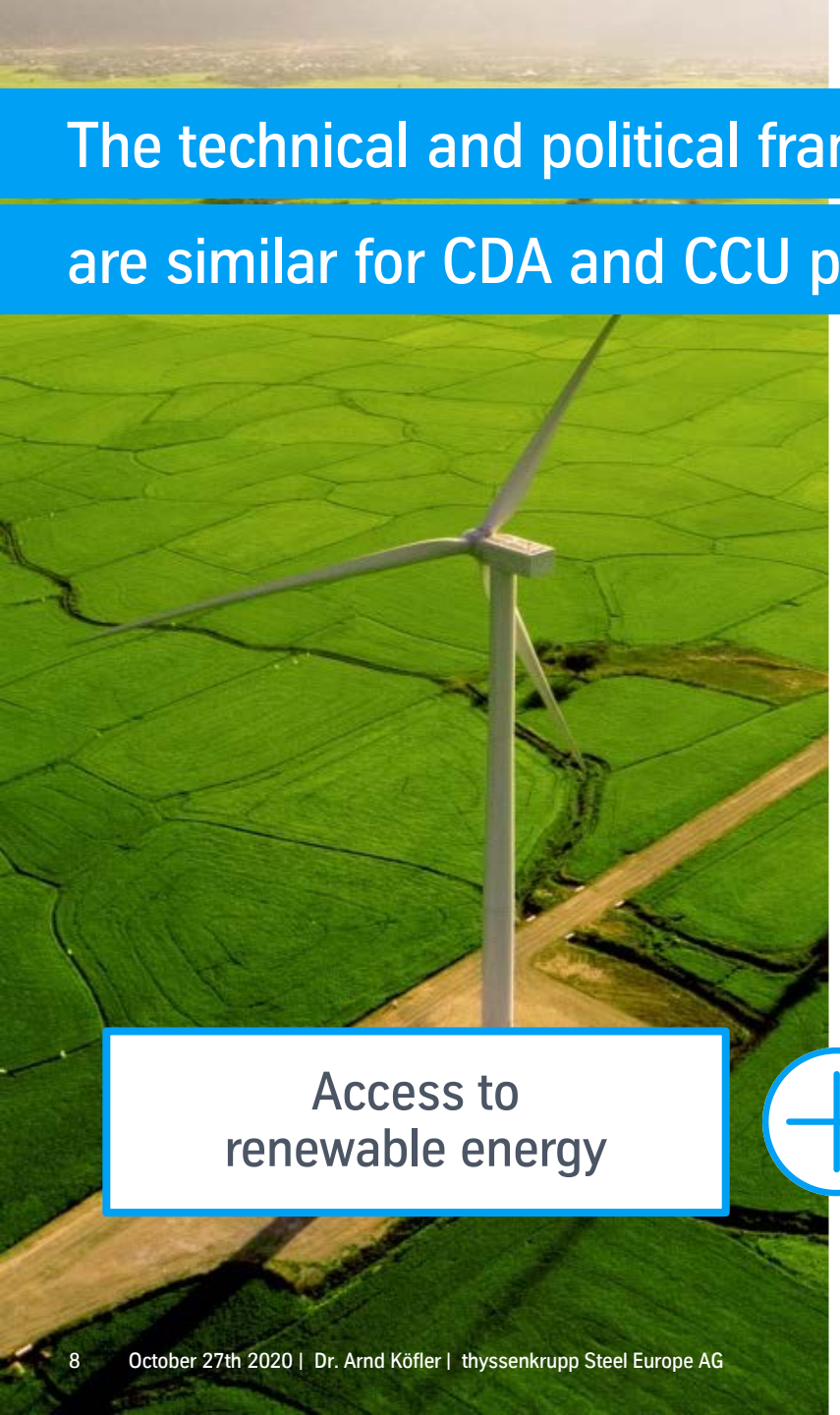
Achievements

- No barriers identified for technical implementation of methanol and ammonia synthesized with standard processes and catalysts from real metallurgical gases
- The economic efficiency of the project was confirmed by all industrial partners (milestone in the project)
- A positive environmental impact was also confirmed by all partners
- Industrial-scale feasibility possible around 2025
- Water electrolysis from tk UCE can be operated at high volatility and is therefore particularly suitable for hydrogen production and integration into the primary control energy market

First products



The technical and political framework conditions are similar for CDA and CCU paths



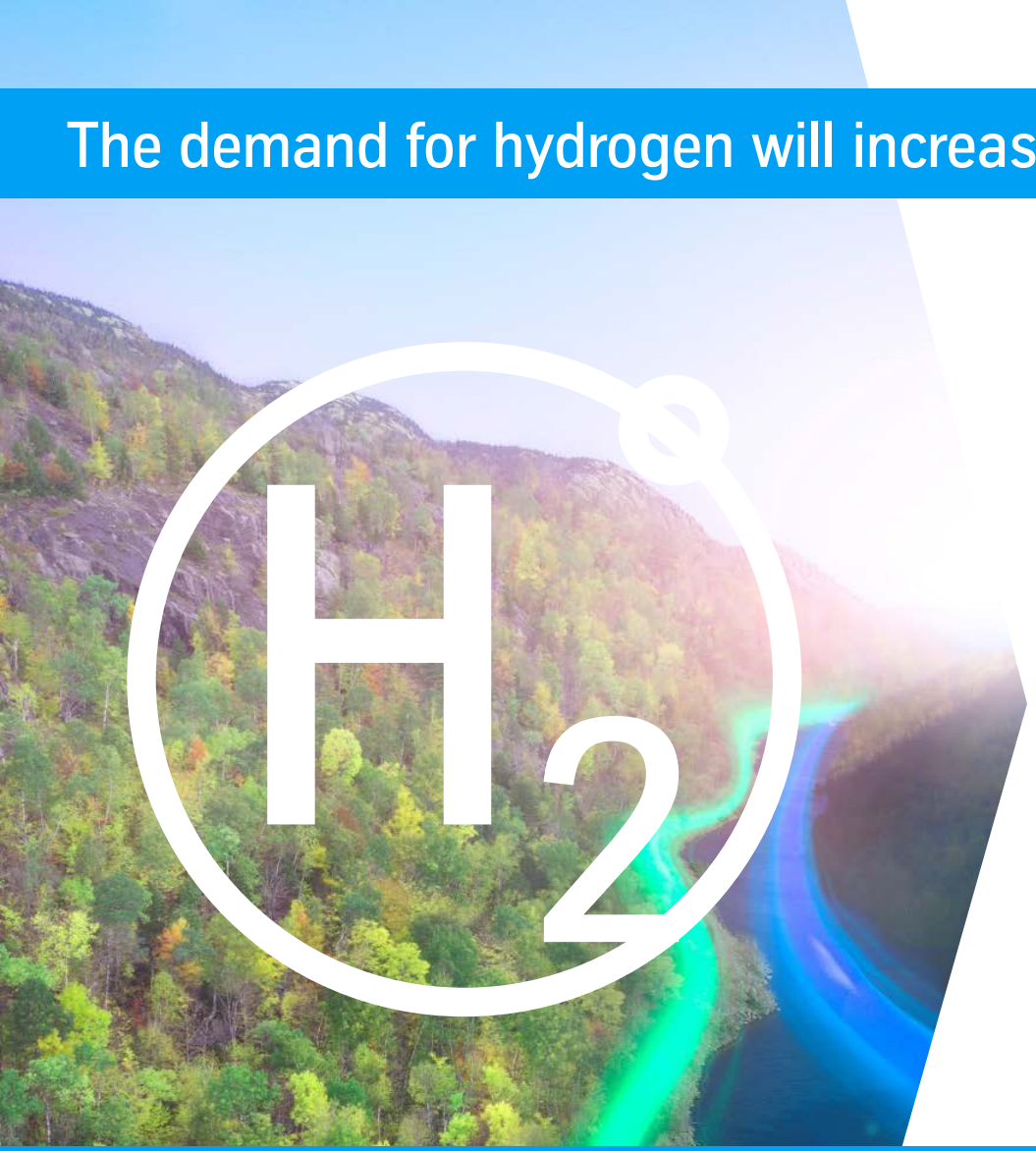
Access to renewable energy

+

Access to cheap green hydrogen

Right political framework conditions

The demand for hydrogen will increase significantly



H_2

- Produced in existing industrial processes (e.g. refineries and chemical plants)
- Available, but causes CO_2 emissions

H_2

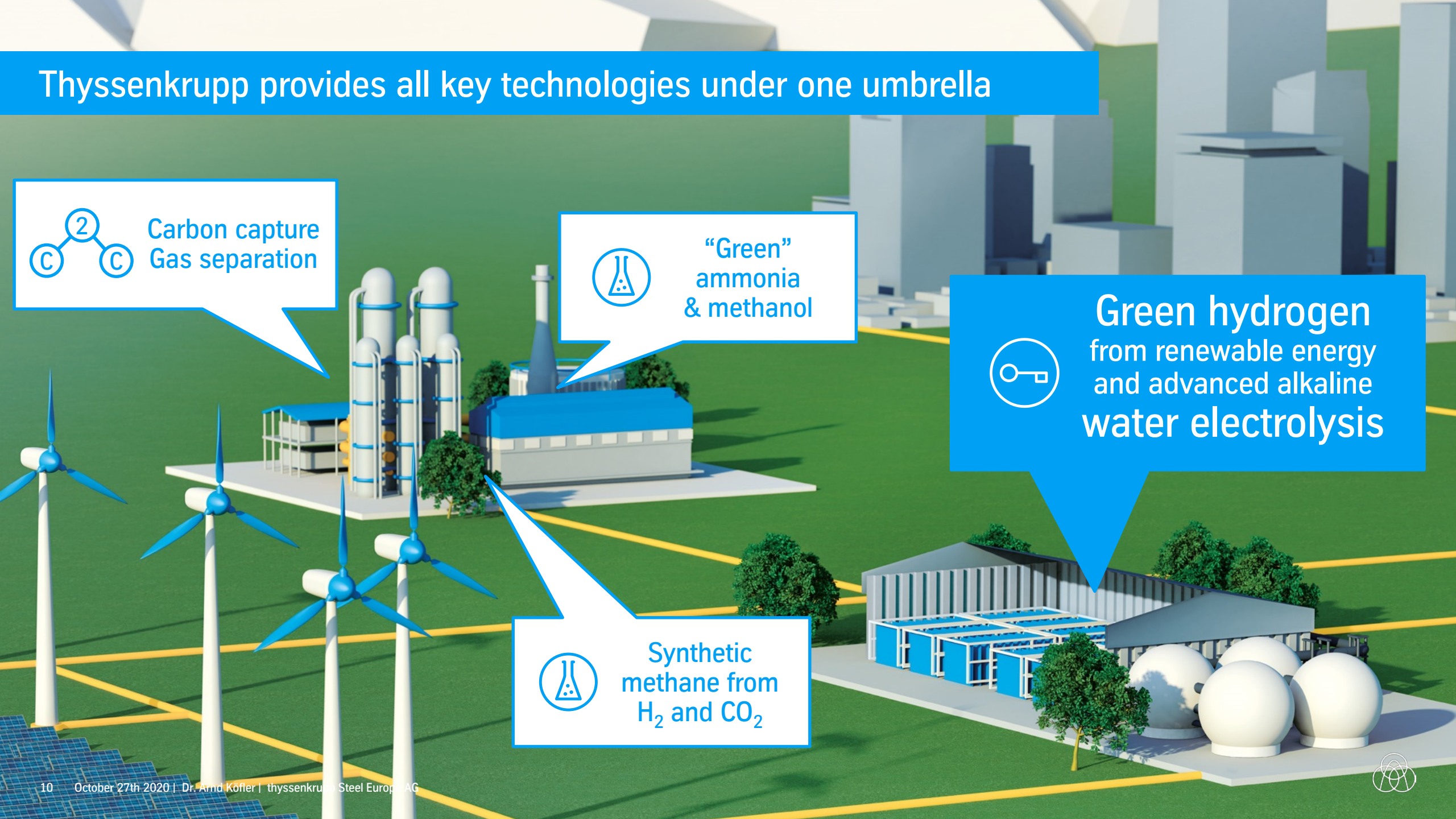
- Produced from natural gas
- Available in the medium term and climate-neutral using offshore CCS

H_2

- Produced by electrolysis with electricity from renewable energies
- Climate-neutral
- Large quantities only available in the long term

Complete climate neutrality in steel requires large amounts of green hydrogen.

Thyssenkrupp provides all key technologies under one umbrella



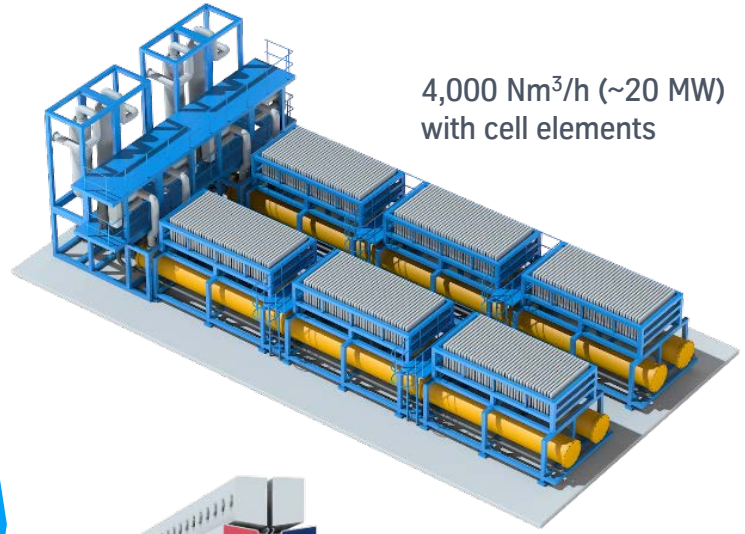
thyssenkrupp is the No.1 electrolysis supplier for industrial scale solutions

10 gigawatts
installed power (chlor-alkali electrolysis)

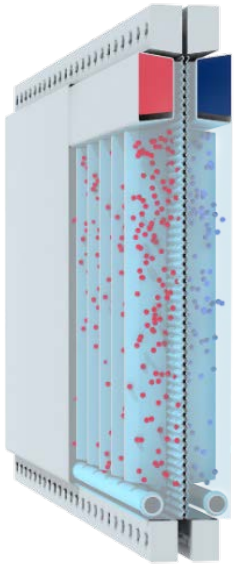
50 years
expertise in design, construction and operation

> 1 gigawatt
of water electrolysis equipment capacity can be manufactured in Germany per year

> 600 plants
installed capacity worldwide (chlor-alkali electrolysis)



4,000 Nm^3/h (~20 MW) with cell elements



Cell element

- Reliable & proven technology
- High efficiency
- Fast dynamics to join the power market
- Mass production, supply chain at scale

Funding and framework are decisive for the transformation's success

- In general, we appreciate the stimulus program, hydrogen strategy, steel action plan and the EU's Green Deal
- The transformation needs adequate support and competitiveness has to be preserved
- Decisive: investments, operating costs, regulation and establishing green markets
- Production conditions in Germany must not deteriorate
- To be solved short-term:
  - EEG exemption for electrolysers
  - Inclusion of hydrogen as an energy carrier in EnWG
  - Contracts for differences; funding (e.g. IPCEI)

Thank you

for your attention!

engineering. tomorrow. together.

thyssenkrupp