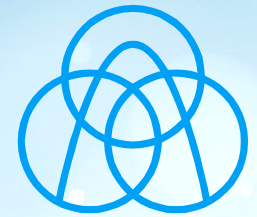


Ammonia: Powering the Hydrogen Economy of Tomorrow

PtX Lab Talk+

12th November 2024 | Thore Lohmann | Executive Director Ammonia & Methanol | thyssenkrupp Uhde GmbH

engineering.tomorrow.together.



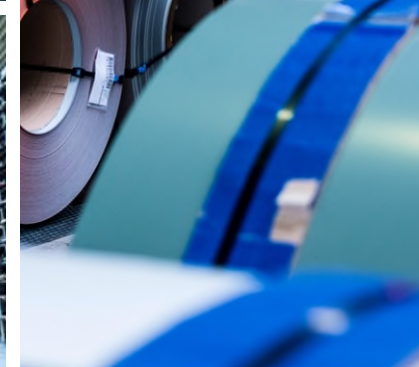
thyssenkrupp

thyssenkrupp in profile

We are an international group of companies
comprising largely independent industrial
and technology businesses



Our businesses



Segments of thyssenkrupp

AT



Automotive
Technologies

MX



Materials
Services

DT



Decarbon
Technologies

MS



Marine
Systems

SE



Steel
Europe

Uhde

nucera

Polysius

rothe erde



thyssenkrupp Uhde: Uniquely positioned market leader in providing one stop shop solutions based on inhouse technology and EPx capability

Leading **global plant engineering company** for a variety of chemicals such as ammonia & methanol



Offering innovative technology portfolio & focus on developing and offering future leading clean technologies

We **create & realize value** by providing **technology** as well as project delivery **know how**



Close to our customers with a global **footprint** and strategically placed **key locations**

Market leader with an installed base of **>3,000 chemical & process plants** built across 100+ years



Standardization & modularization of plants to **improve project execution**



Overview: We support customers across diverse industries and value chains - both as technology provider and project execution partner



Sustainable agriculture & NH₃ derivatives

Ammonia

Nitric Acid

Nitrates

Urea

UFT® Urea Granulation

Phosphates



Clean chemicals & energy vector

Ammonia Cracking

Biomass Gasification

Methanol

Methanol to X

Gas Treatment

SAF



Circular systems & emission reduction

EnviNOx®

Carbon Capture

Phosphogypsum

Coke Plants

Oleochemicals

Propylene Oxide

Polyamide

Polyester / recycle PET

Vinyl Chain

PLA/ Bio Plastic

Iso Propyl Alcohol

High Pressure Eq.



What is ammonia and where can we find it today?

~180 million tons per year,
~80% is processed into fertilizer



Nitrogen +
Hydrogen

Other applications:
e.g. cooling, chemical processes



Ammonia: An ideal hydrogen carrier



Hydrogen only liquefies
at extremely low temperatures:

-253°C

This consumes up to 40% of the energy
bound in the hydrogen



Ammonia liquefies at a
temperature slightly below
a household freezer:

-33°C

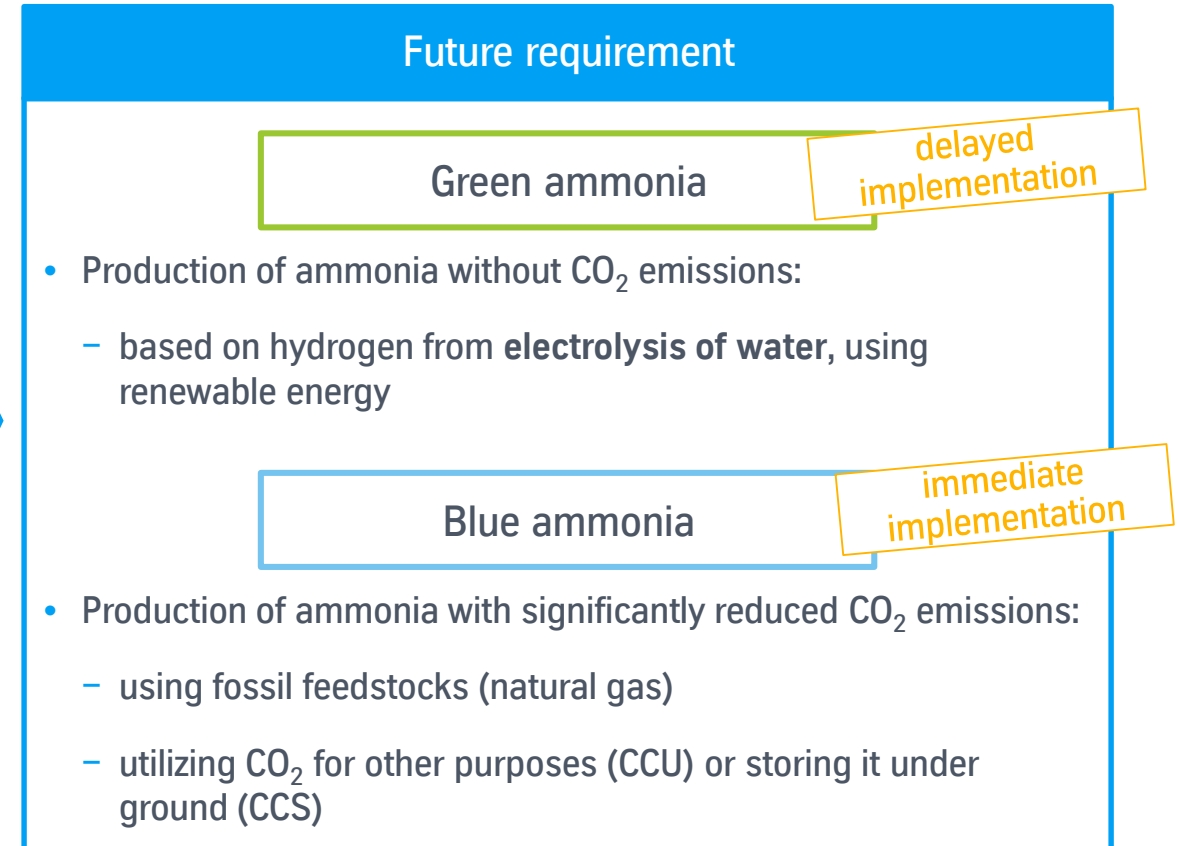
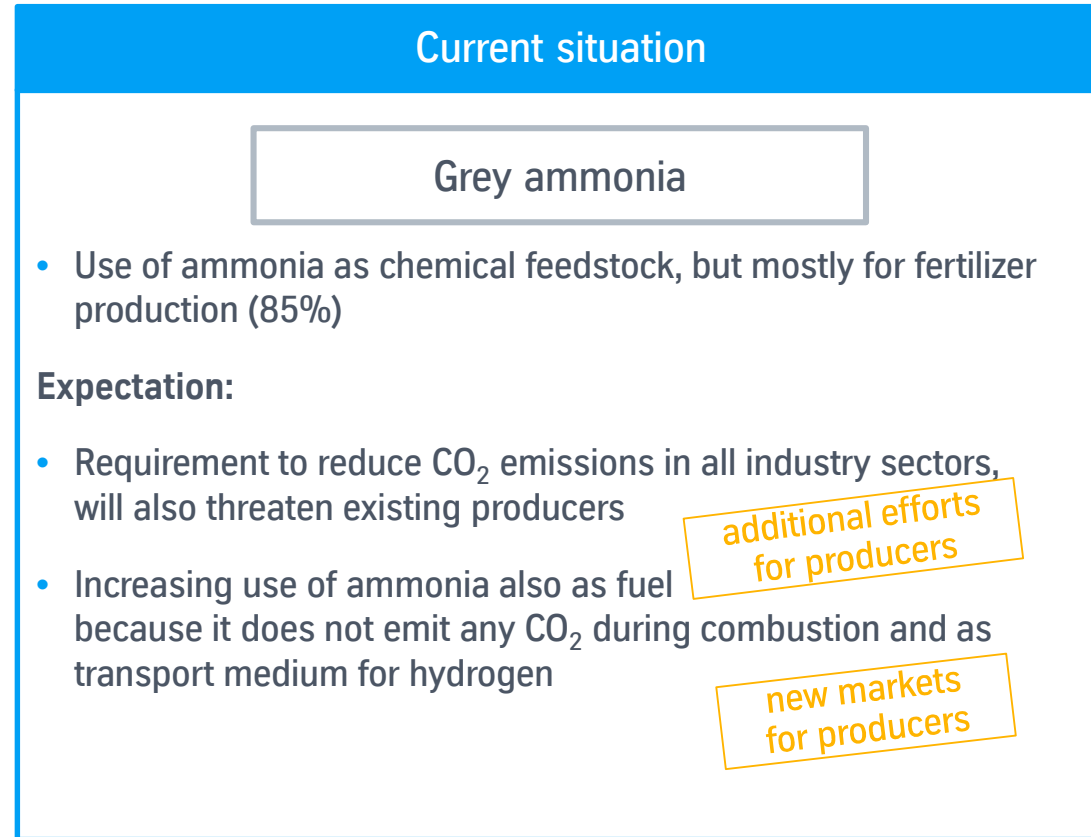
...and has a higher energy density than
hydrogen (by volume):

33% more energy



Ammonia production pathway

From gray to green and blue ammonia



Ammonia: Market growth and new production pathways



What are the market drivers for the new low carbon ammonia energy market?

Clean ammonia as a future market for the fertilizer industry

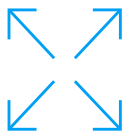
Two fundamental shifts...

1 Existing uses shift from 'grey' to 'clean' ammonia



Fertilizer & industrial

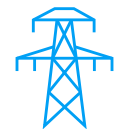
2 New 'green energy' end-uses emerge for which 'clean' ammonia is required



Hydrogen carrier



Maritime fuel



Power generation

...driven by a range of factors

Regulatory pressure across regions with end of free CO2 allowances in EU ETS most significant

End-consumer demand for climate-friendly food pushes companies to decarbonize value chain

Spatial mismatch between global H2 demand and supply, whereby key demand regions (i.e., EU, Japan, Korea) have limited local supply options

Industry push to decarbonize, as indicated by IMO target of 50% GHG reduction by 2050 and further corroborated by Maersk announcement of 8 ocean going vessels on decarbonized fuel by 2025

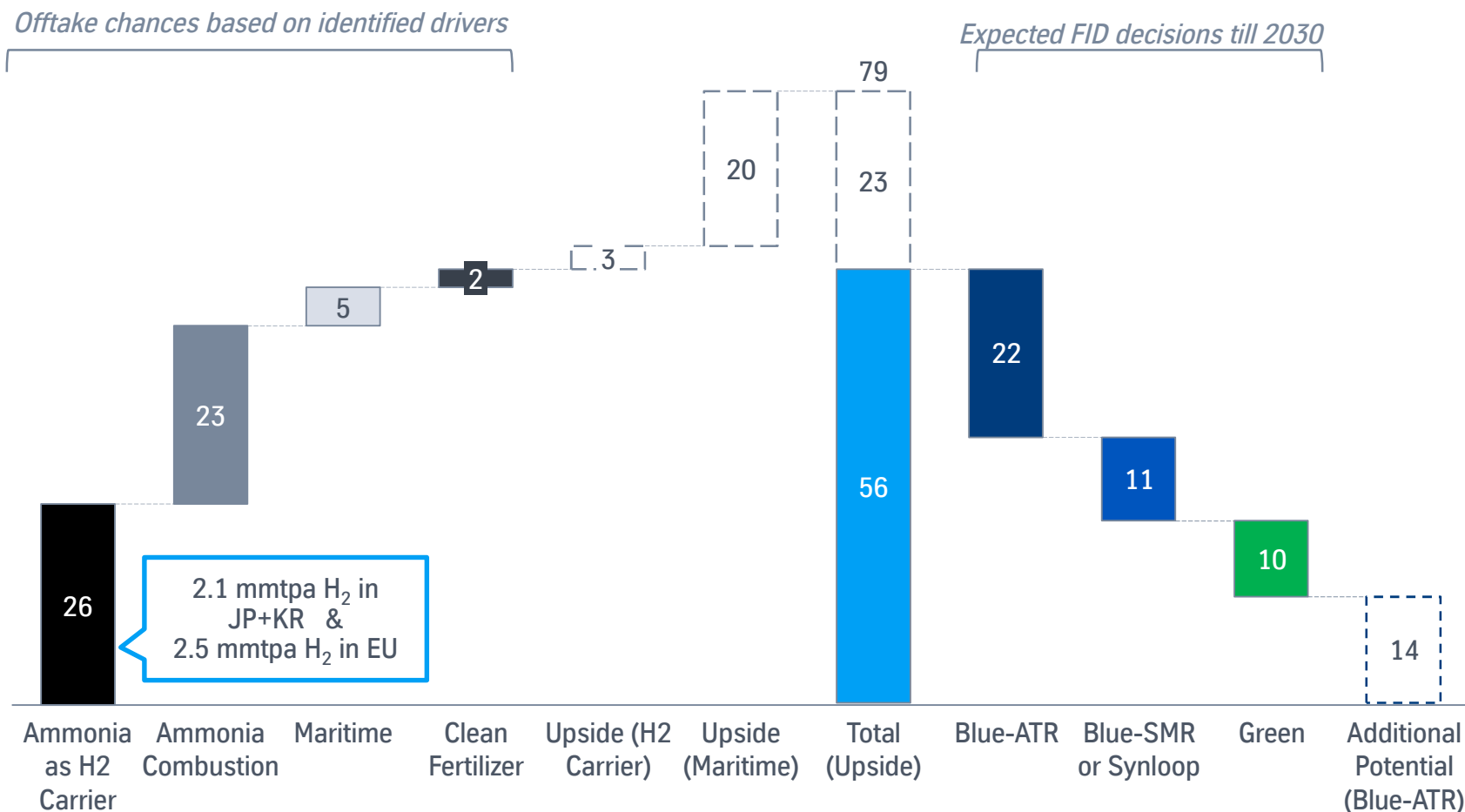
Government-mandated quotas in Japan & Korea of co-firing clean ammonia with aim to meet stringent decarb targets while utilizing existing coal assets

The ammonia market is undergoing a fundamental shift, opening up new sectors and increasing the need for 'clean ammonia'



How big will be the market in the next years?

Clean ammonia demand – blue remains dominant option till mid-term



- North America and ME are most cost competitive; Australia and India accelerating, supported by domestic fertilizer subsidies
- Nordics, Spain and Portugal will be production sites for green by 2030, supported by carbon price
- North. Africa, South. Africa, Namibia, Chile and Brazil show good long-term potential, but lack of infrastructure which may delay the onset of projects
- Ammonia Combustion and Maritime indicates massive upsides in mid-long term – need support from regulatory bodies
- EU, South Korea and Japan are net importers of Ammonia - market for cracking

Japan, S. Korea & Germany showed acceptance for Blue as a transitional step – acceptable Carbon Intensity still unclear!

Source: Uhde Internal, IHS

thyssenkrupp Uhde GmbH

11 | 12th November 2024 | Ammonia: Powering the Hydrogen Economy of Tomorrow | Thore Lohmann

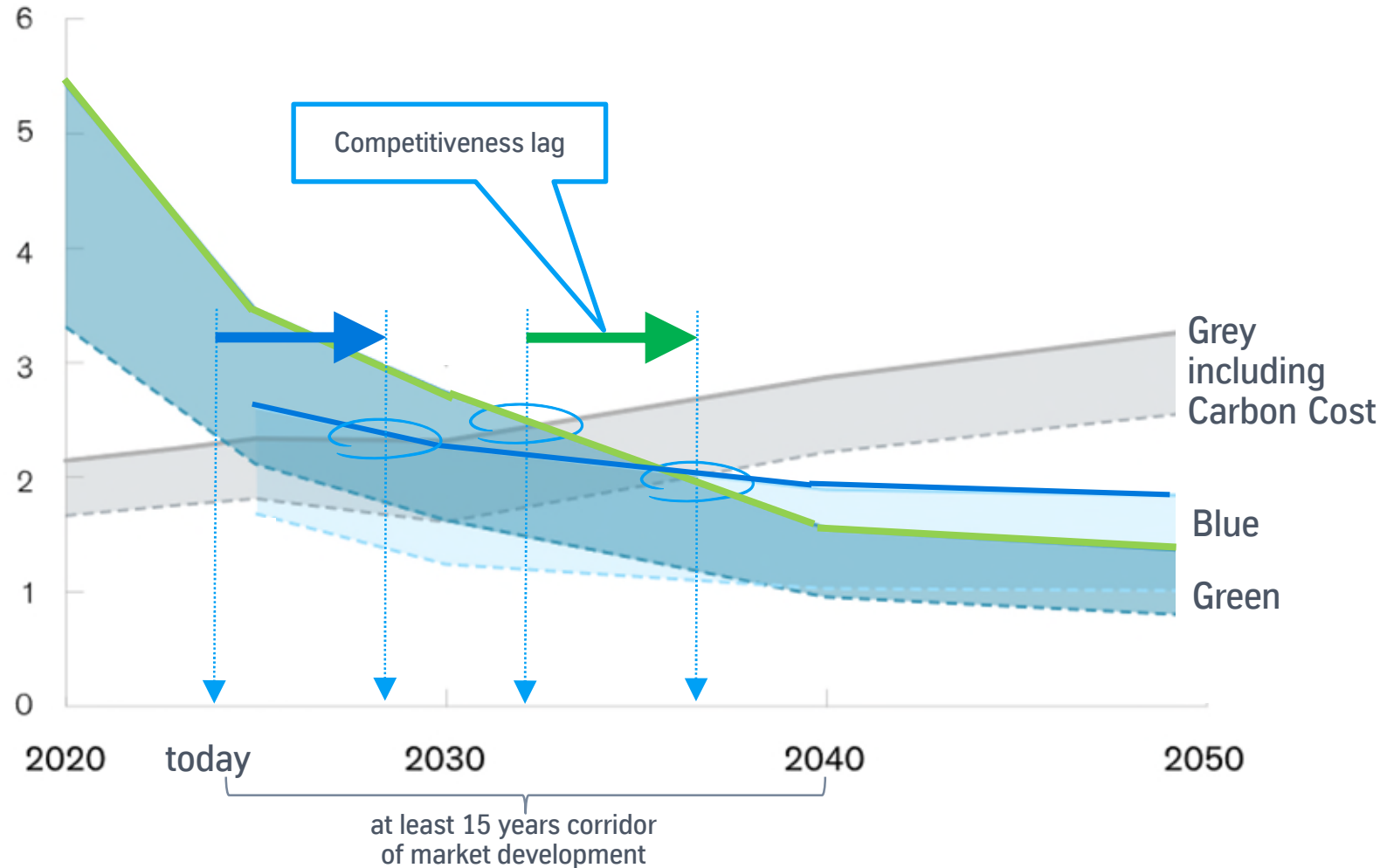
Öffentlich

Entwurf zur Diskussion



When will we see the new market?

Global EPC costs are on the high side, and political decisions are being delayed.



- Due to several global crises, **EPC costs** are currently at high cost scenarios.
- **Political decisions** on carbon taxes are being delayed.
- **Different global standards** for defining low carbon ammonia.
- Different cross-border approaches.
- Integrated oil companies and hydrogen rich countries are likely to play a major role in the clean transition.

Due to political uncertainties and lack of approved technical standards, we see a delay in the market ramp-up

Source: McKinsey September 2022



Nothing is moving?

EU sets the target for 10 million tons, Japan with 3 million tons and South Korea ~ 4 million tons of H2 demand by 2030

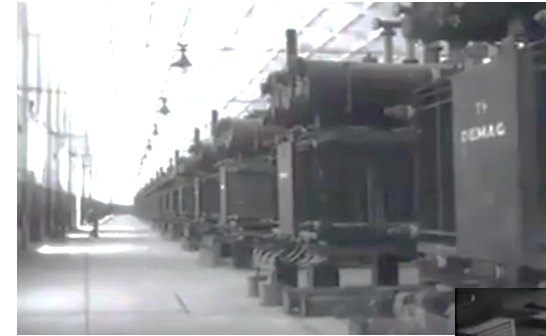


- German hydrogen strategy:
 - >50% hydrogen import quota
 - Ammonia as main hydrogen carrier identified
- Germany will invest till 2032 around €20 billion in a hydrogen pipeline network.
 - Three locations of ammonia import cracker
- H2Global initiative
 - Australia is joining the H2Global initiative with \$660 Mio.
 - Uhde client Fertiglobe as winning bidder in H2Global pilot auction for supply of renewable ammonia at a delivered price of €1,000 per ton into Europe.

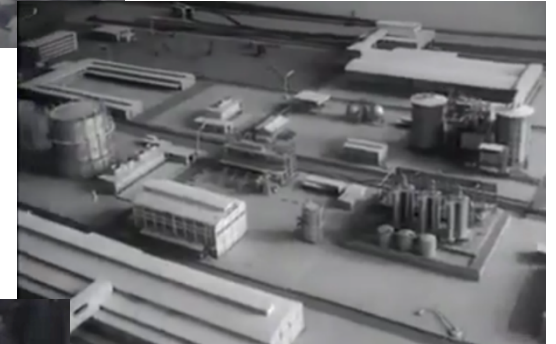


Pioneer in green fertilizer from renewable energy – thyssenkrupp Uhde

First ammonia plant in Egypt (1950s, Aswan Dam)



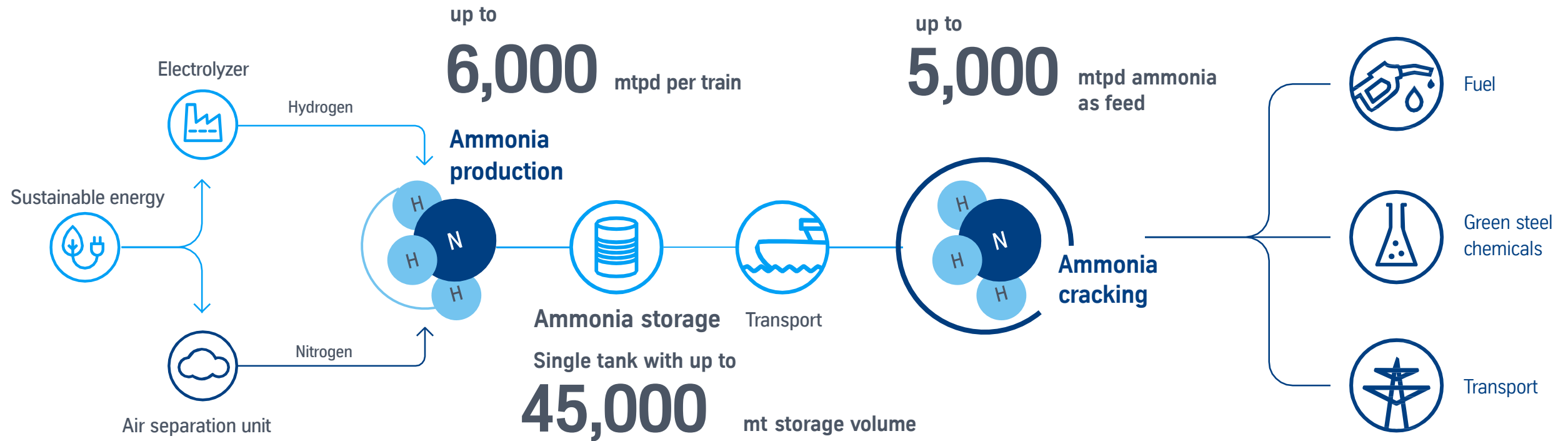
Gamal Abdel Nasser inaugurates dam and plant in the 1950s



330.000 t/year green fertilizer (ammonium nitrate) from hydropower

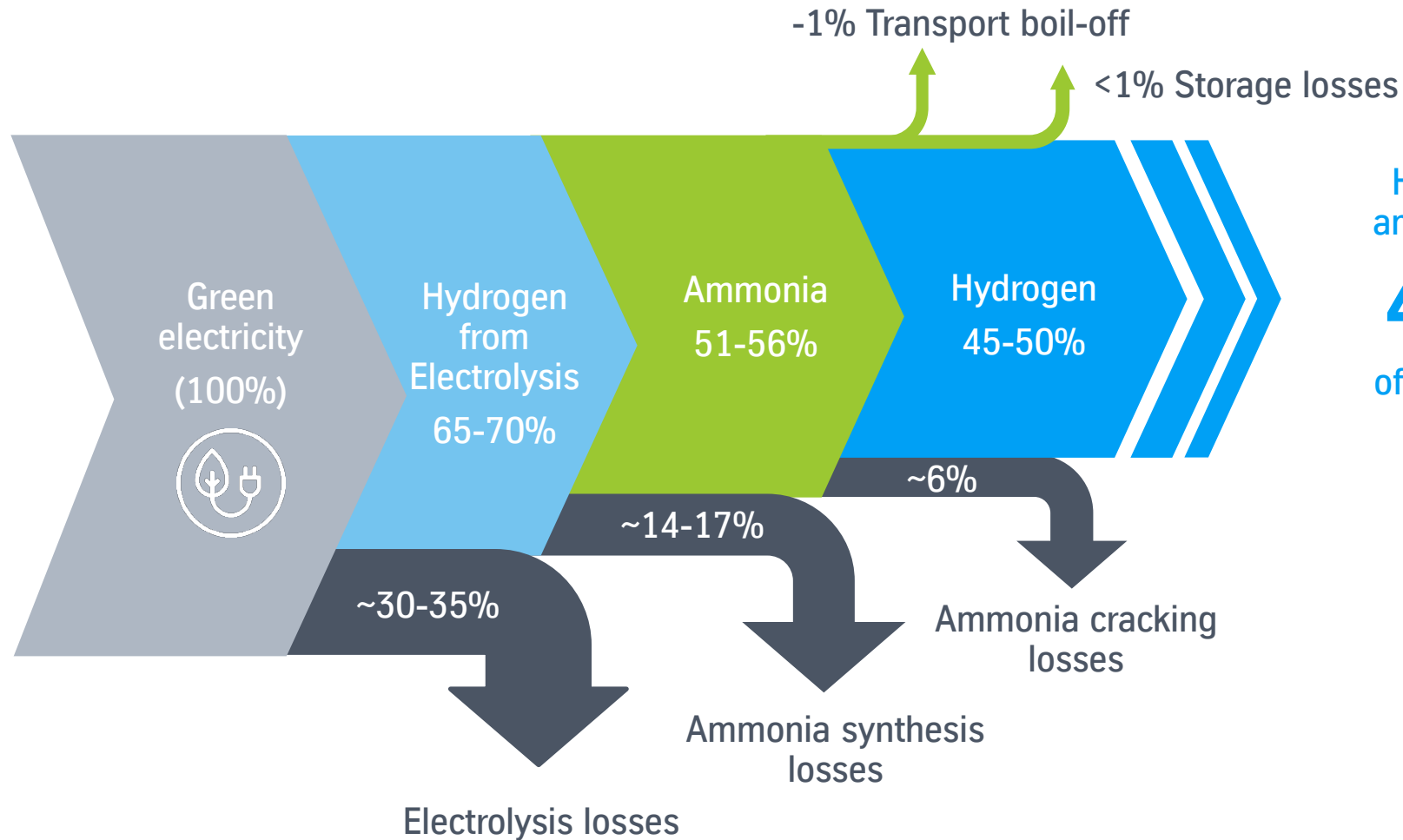


Completing the final puzzle piece in the clean hydrogen transportation chain



Energy flow diagram

Hydrogen transport via ammonia and cracking

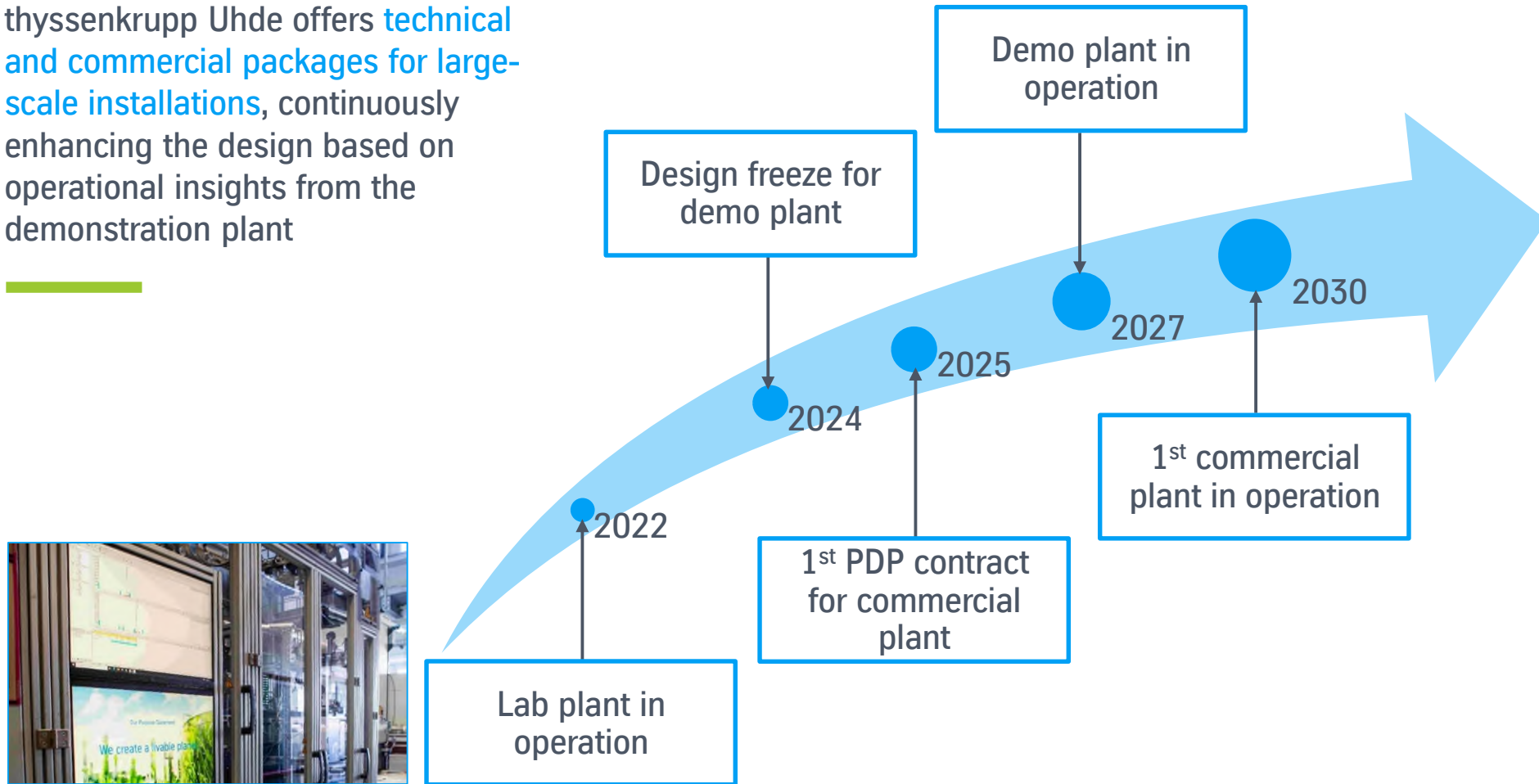


Hydrogen from cracked ammonia has still roughly
45-50%
of the initial energy of the green electricity



Ammonia cracking | Go to market timeline

thyssenkrupp Uhde offers **technical and commercial packages for large-scale installations**, continuously enhancing the design based on operational insights from the demonstration plant

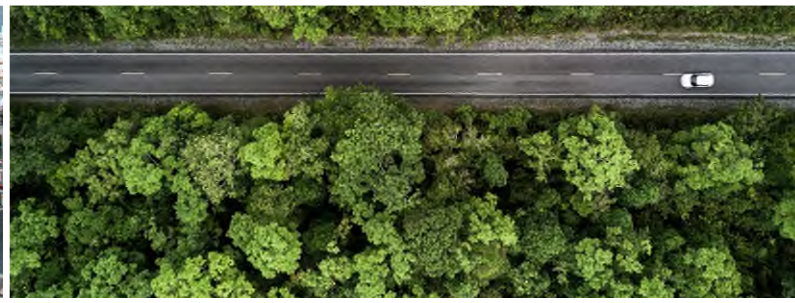


- Ammonia is an important element in a future hydrogen economy.
- CCS and CCU for “blue ammonia/hydrogen” are needed bridge technologies to kickstart the business.
- Political clarity and international alignment is required.
- But also technology innovations are needed to close the value chain.





Innovate.
Integrate.
Impact.



Thank you for your attention



thore.lohmann@thyssenkrupp.com



Friedrich-Uhde-Straße 15
44141 Dortmund, Germany



www.thyssenkrupp-uhde.com

