

Sustainability and fertilizer industry – Part of the problem or solution driver?

30th AFA conference, Cairo | Thore Lohmann | thyssenkrupp Uhde GmbH

Our commitment as human beings

1 NO
POVERTY



2 ZERO
HUNGER



3 GOOD HEALTH
AND WELL-BEING



4 QUALITY
EDUCATION



5 GENDER
EQUALITY



6 CLEAN WATER
AND SANITATION



7 AFFORDABLE AND
CLEAN ENERGY



8 DECENT WORK AND
ECONOMIC GROWTH



9 INDUSTRY, INNOVATION
AND INFRASTRUCTURE



10 REDUCED
INEQUALITIES



11 SUSTAINABLE CITIES
AND COMMUNITIES



12 RESPONSIBLE
CONSUMPTION
AND PRODUCTION



13 CLIMATE
ACTION



14 LIFE
BELOW WATER



15 LIFE
ON LAND



16 PEACE, JUSTICE
AND STRONG
INSTITUTIONS



17 PARTNERSHIPS
FOR THE GOALS



UN SUSTAINABLE
DEVELOPMENT GOALS

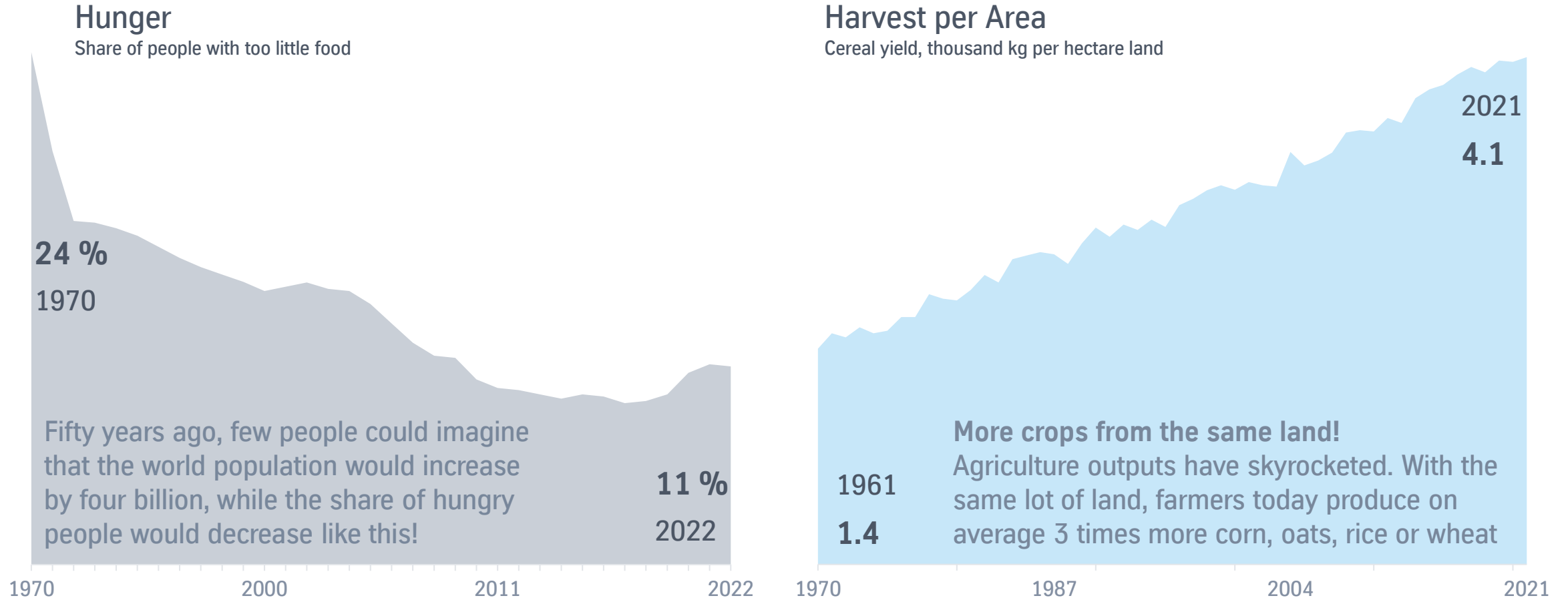


Our commitment as human beings – the historical purpose of our industry



The classical goal – zero hunger in a growing global population

The challenge is still there



A lot of progress has been made, but 11% are still 760 million people and negative trend since Corona Pandemic.

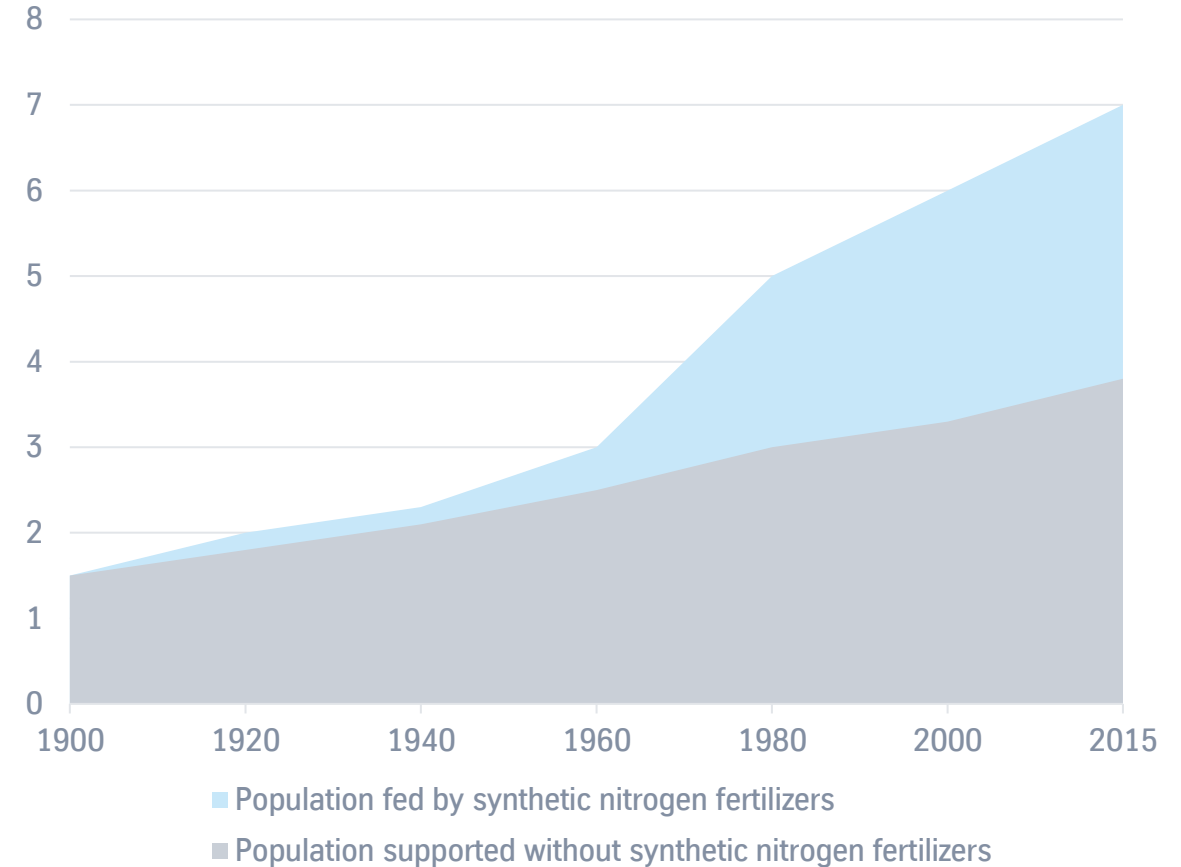
Sources: By DooFi - Own work, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=6627159>; Data: UN FAO's Prevalence of Undernourishment;



The classical goal – zero hunger in a growing global population

Fertilizer industry is contributing to the success

- During the 19th century, the demand for nitrates and ammonia for use as fertilizers and industrial feedstocks rapidly increased. The main source was mining niter deposits and guano from tropical islands
- At the beginning of the 20th century these reserves were thought insufficient to satisfy future demands
- Ammonia was first manufactured using the Haber process on an industrial scale in 1913 in BASF's Oppau plant in Germany, reaching 20 t/day in 1914
- Today large-scale ammonia plants are producing 3500 t/day
- The yearly production is around 200 million tons
- Almost 50% of the world population are fed by synthetic fertilizers



Fertilizer industry is a success story since decades

Sources: Erisman et al. (2008); Smil (2002); Stewart (2005); Wikipedia



Our commitment as human beings -

1 NO POVERTY



2 ZERO HUNGER



3 GOOD HEALTH AND WELL-BEING



4 QUALITY EDUCATION



5 GENDER EQUALITY



6 CLEAN WATER AND SANITATION



7 AFFORDABLE AND CLEAN ENERGY



8 DECENT WORK AND ECONOMIC GROWTH



9 INDUSTRY, INNOVATION AND INFRASTRUCTURE



10 REDUCED INEQUALITIES



11 SUSTAINABLE CITIES AND COMMUNITIES



12 RESPONSIBLE CONSUMPTION AND PRODUCTION



13 CLIMATE ACTION



14 LIFE BELOW WATER



15 LIFE ON LAND



16 PEACE, JUSTICE AND STRONG INSTITUTIONS



17 PARTNERSHIPS FOR THE GOALS



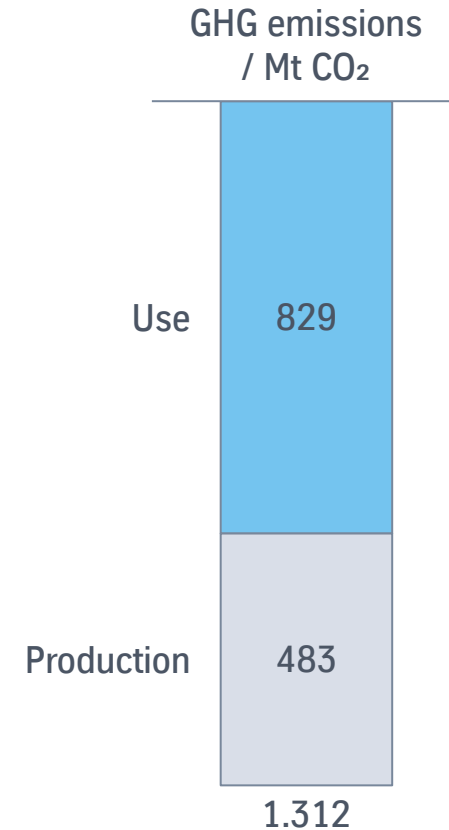
UN SUSTAINABLE DEVELOPMENT GOALS



Responsible consumption and production

Fertilizer industry is contributing 7% of the global green house gas (GHG) emissions

- The fertilizer industry has a share of 7% of the global GHG emissions
- Both production and use of nitrogen fertilizer lead to release CO_2 , N_2O and CH_4 , three of the major GHG
- The synthesis of ammonia accounts alone for 0.8% of the global GHG and 2% of global energy
- N_2O , a GHG with a global warming potential 256 times greater than CO_2 is released by the production of nitric acid
- Most of the GHG will be released by the use of fertilizers in the cropland as N_2O and CO_2



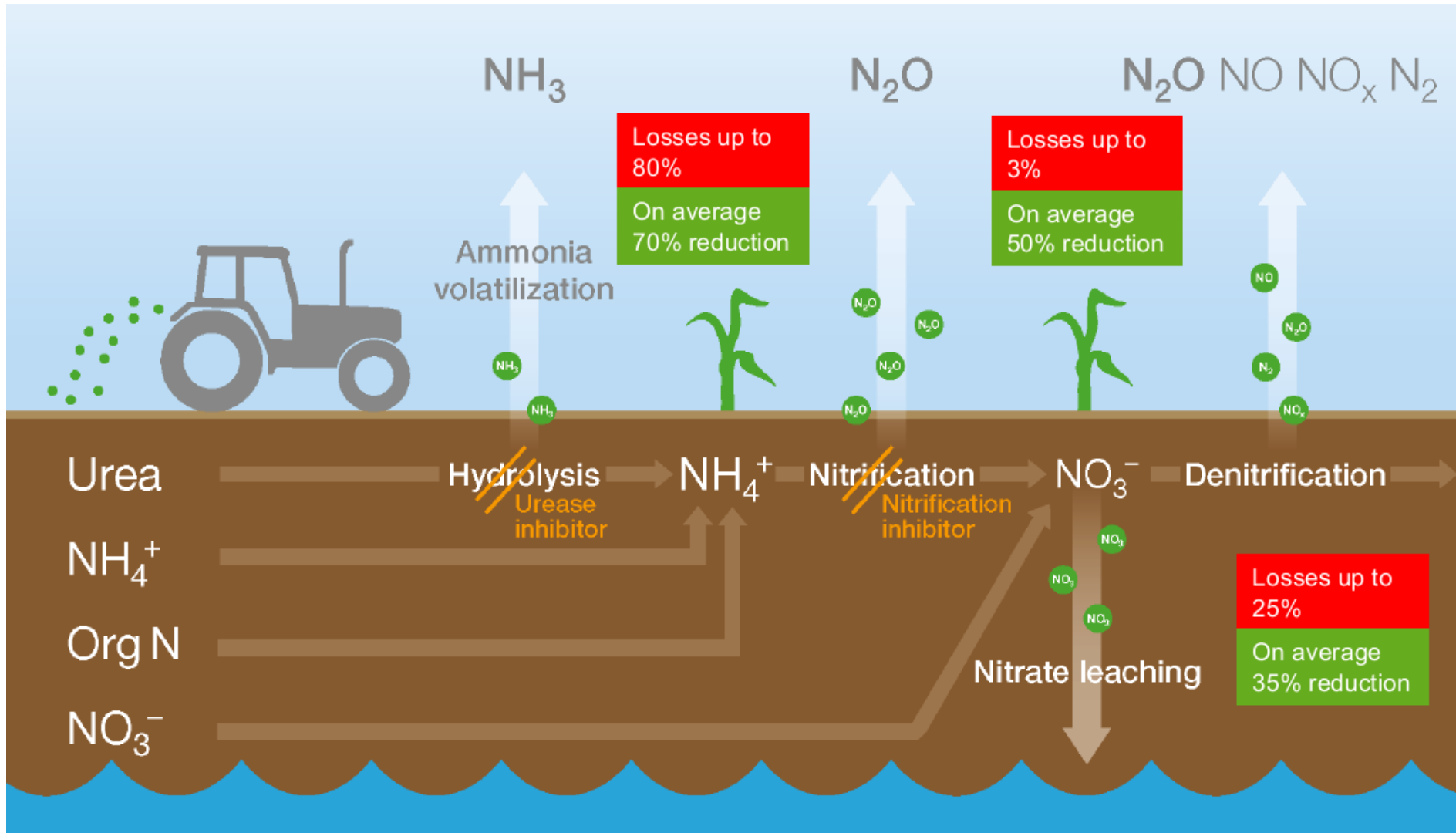
Fertilizer industry and use are one of the major GHG emitters

Greenhouse gas emissions from nitrogen fertilizers could be reduced by up to one-fifth of current levels by 2050 with combined interventions Yunhu Gao, André Cabrera Serrenho* Department of Engineering, University of Cambridge, Trumpington Street, Cambridge, CB2 1PZ, UK.



Nitrogen losses during the use

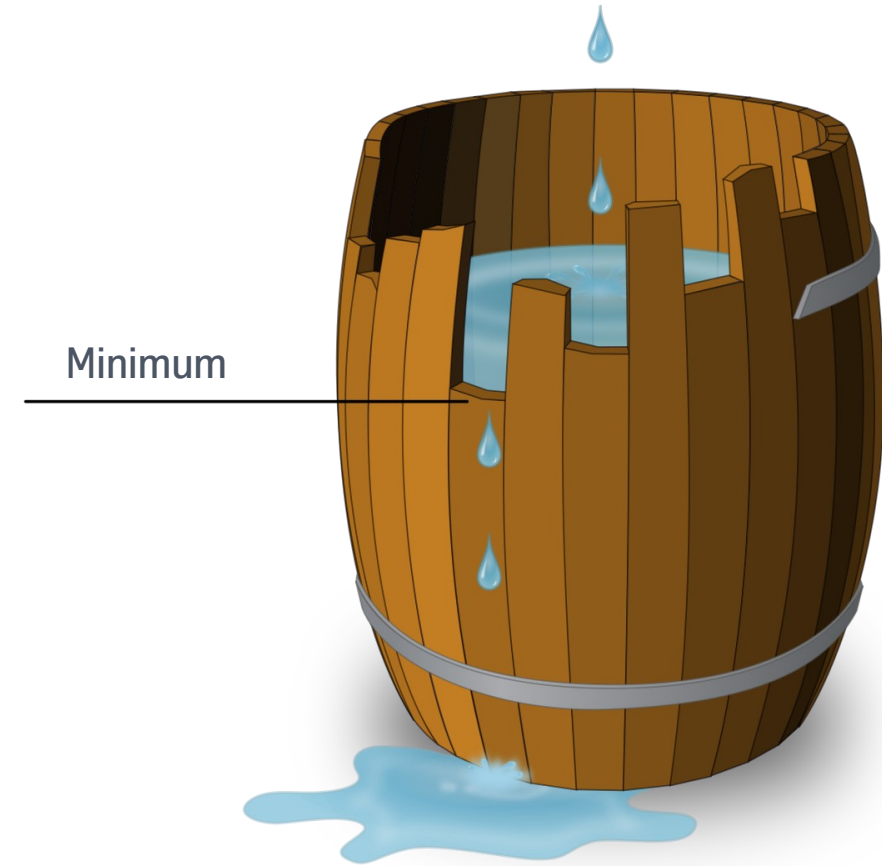
Solutions to mitigate nitrogen losses



Demand reduction would lead to the greatest mitigation potential

But would lead to less to shrinking industry...

- In the early 19th century Justus von Liebig laid the foundation of our understanding of organic chemistry as the basis for modern fertilizer.
- Liebig identified the chemical elements of nitrogen (N), phosphorus (P), and potassium (K) as essential to plant growth.
- Liebig also popularized Carl Sprengel's "theorem of minimum".
- Increasing the global efficiency of nitrogen use from currently 42% to 67% by 2050 the total nitrogen demand could be reduced by 48% N in 2050.



More does not mean better – efficiency is our goal

Sources: By DooFi - Own work, Public Domain, <https://commons.wikimedia.org/w/index.php?curid=6627159>



Ammonia production pathway

From gray to green and blue ammonia and green.

Current situation

Grey ammonia

- Use of ammonia as chemical feedstock, but mostly for fertilizer production (85%)

Expectation:

- Requirement to reduce CO₂ emissions in all industry sectors, will also threaten existing producers
- Increasing use of ammonia also as fuel because it does not emit any CO₂ during combustion and as transport medium for hydrogen

additional efforts
for producers

new markets
for producers

Future requirement

Green ammonia

delayed
implementation

- Production of ammonia without CO₂ emissions:
 - based on hydrogen from **electrolysis of water**, using renewable energy

Blue ammonia

immediate
implementation

- Production of ammonia with significantly reduced CO₂ emissions:
 - using fossil feedstocks (natural gas)
 - utilizing CO₂ for other purposes (CCU) or storing it under ground (CCS)

Ammonia: Market growth and new production pathways

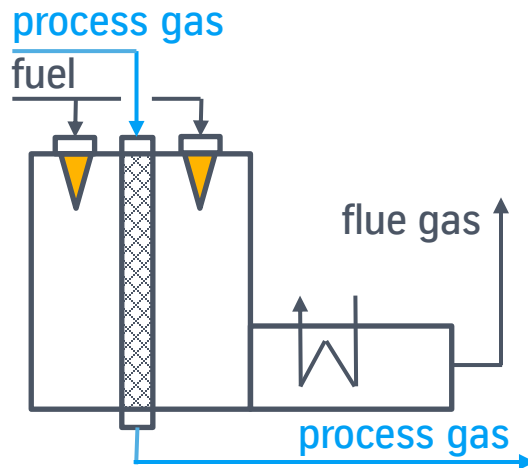


Blue ammonia

Two alternative process steps for production of hydrogen from natural gas

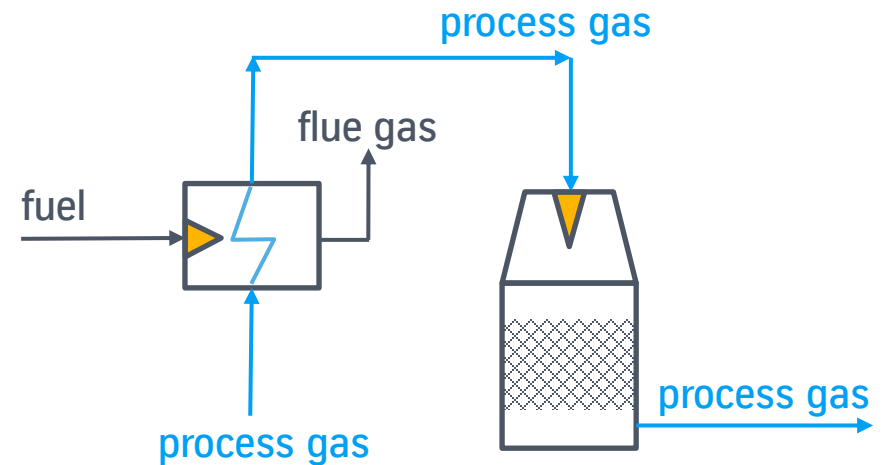
Steam reformer (SMR):

- Heat for **reforming** is supplied by combustion and **heat transfer** into the process equipment (reformer tubes)
- High amount of flue gas for preheating of inlet streams and steam superheating

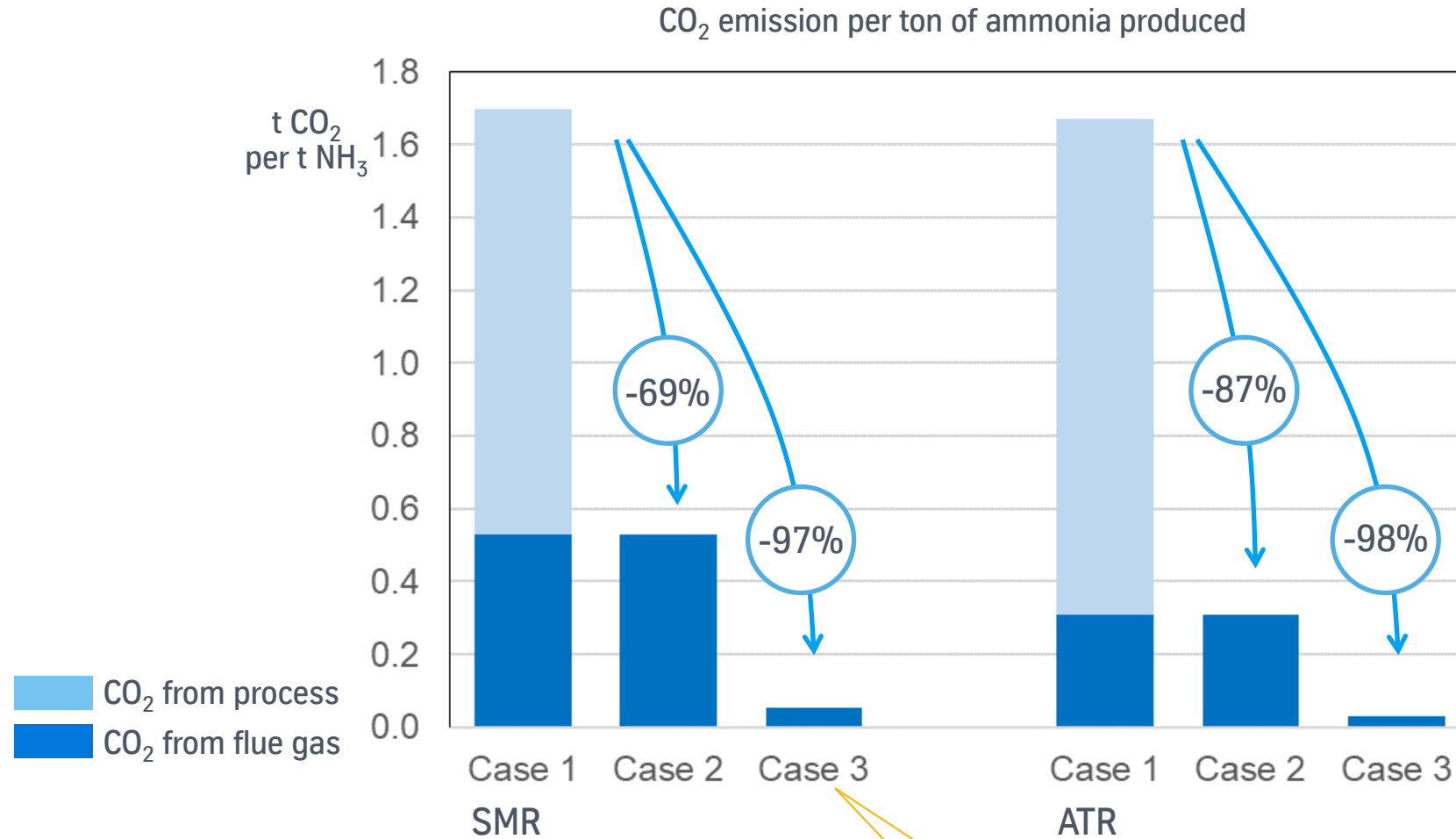


Autothermal reformer (ATR):

- Heat for reforming is supplied by **combustion** of a portion of the feedstock **inside the process vessel**
- Separate fired heater for preheating of ATR inlet streams



Case studies – CO₂ emission from ammonia production



Cases:

- Case 1: All CO₂ to atmosphere
- Case 2: CO₂ capture from process only
- Case 3: CO₂ capture from process and from flue gas

Steam reformer:

- Less emission reduction in case 2, but still > 60% reduction

Autothermal reformer:

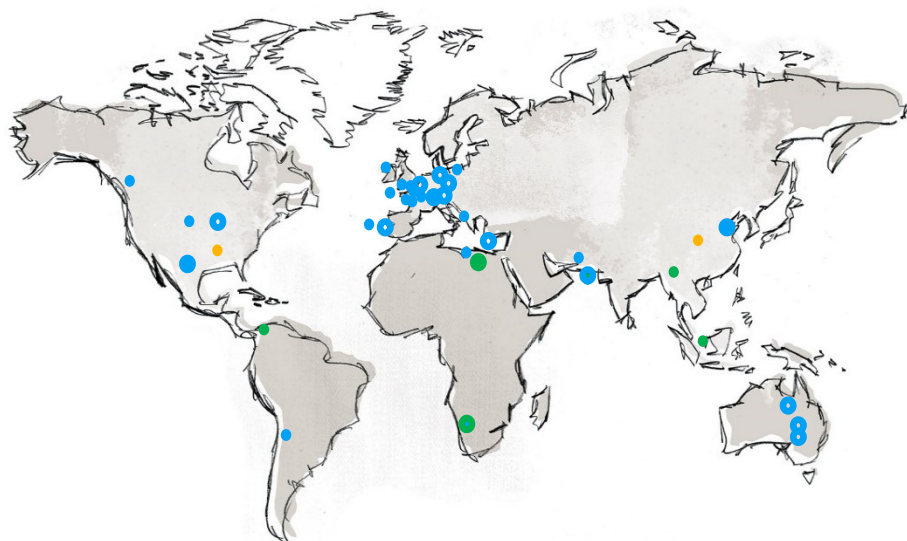
- Higher emission reduction in case 2 compared to SMR

Also an option for existing plants as a retrofit.
Flue gas CO₂ capture technology is commercially available.



And what about the N₂O emissions during production?

EnviNOx[®] Technology removes N₂O and NO_x

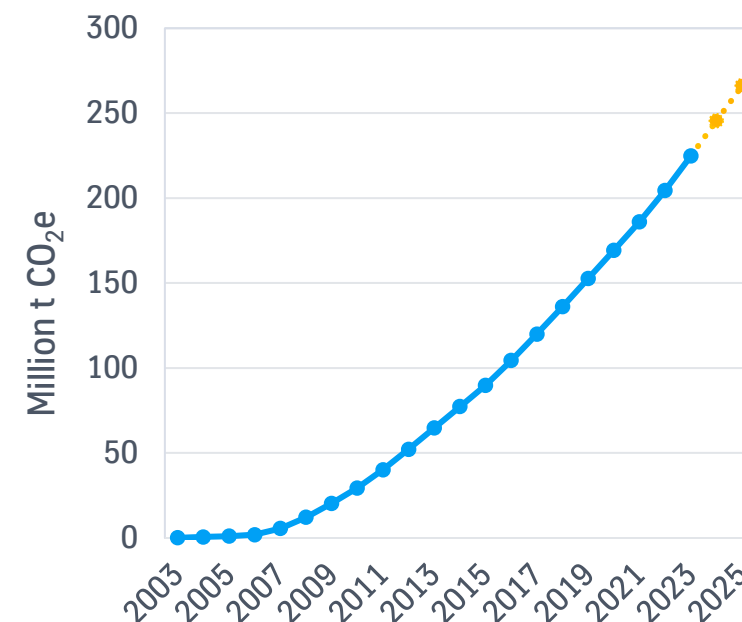


● EnviNOx[®]
● DeN₂O[®]
● DeNO_x

● in operation
○ to be commissioned

- Proven Technology for Nitric Acid plants
- End-of-Pipe technology (no interaction with process)
- Tailor-made design on basis of client's requirements
- Meets all current and conceivable future emission limits
- At Abu Qir Fertilizers since 2006 in operations

Total cumulative CO₂ equivalent reductions from EnviNOx[®] plants

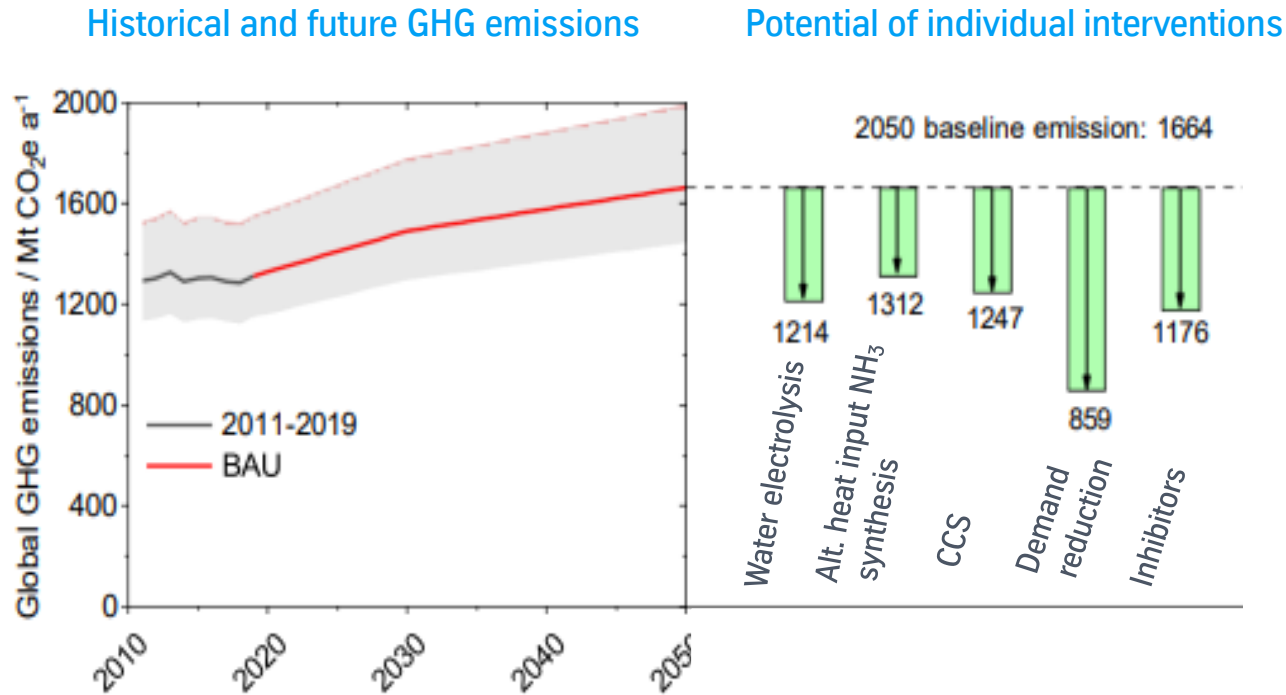


More than 60 customized EnviNOx[®] units contribute to global climate and environmental protection

1. Greenhouse Gas Nitrous Oxide; 2. (Other) Nitrogen Oxides; 3. DeNOx systems in operation for more than 40 years



Business as usual and the impact of interventions



- If we follow the business as usual (BAU) case, the GHG emission would increase in the following decades. (red line)
- Demand reduction biggest single contributor.
- The combination of interventions would lead to a maximum reduction to 20% by 2050.

With the combination of interventions 80% of GHG emissions can be avoided

Source: Greenhouse gas emissions from nitrogen fertilisers could be reduced by up to one-fifth of current levels by 2050 with combined interventions Yunhu Gao, André Cabrera Serrenho* Department of Engineering, University of Cambridge, Trumpington Street, Cambridge, CB2 1PZ, UK.



Our commitment as human



Clean ammonia as a future market for the fertilizer industry

Two fundamental shifts...

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



Fertilizer & industrial

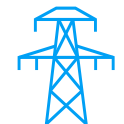
2 New 'green energy' end-uses emerge for which 'clean' ammonia is required



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

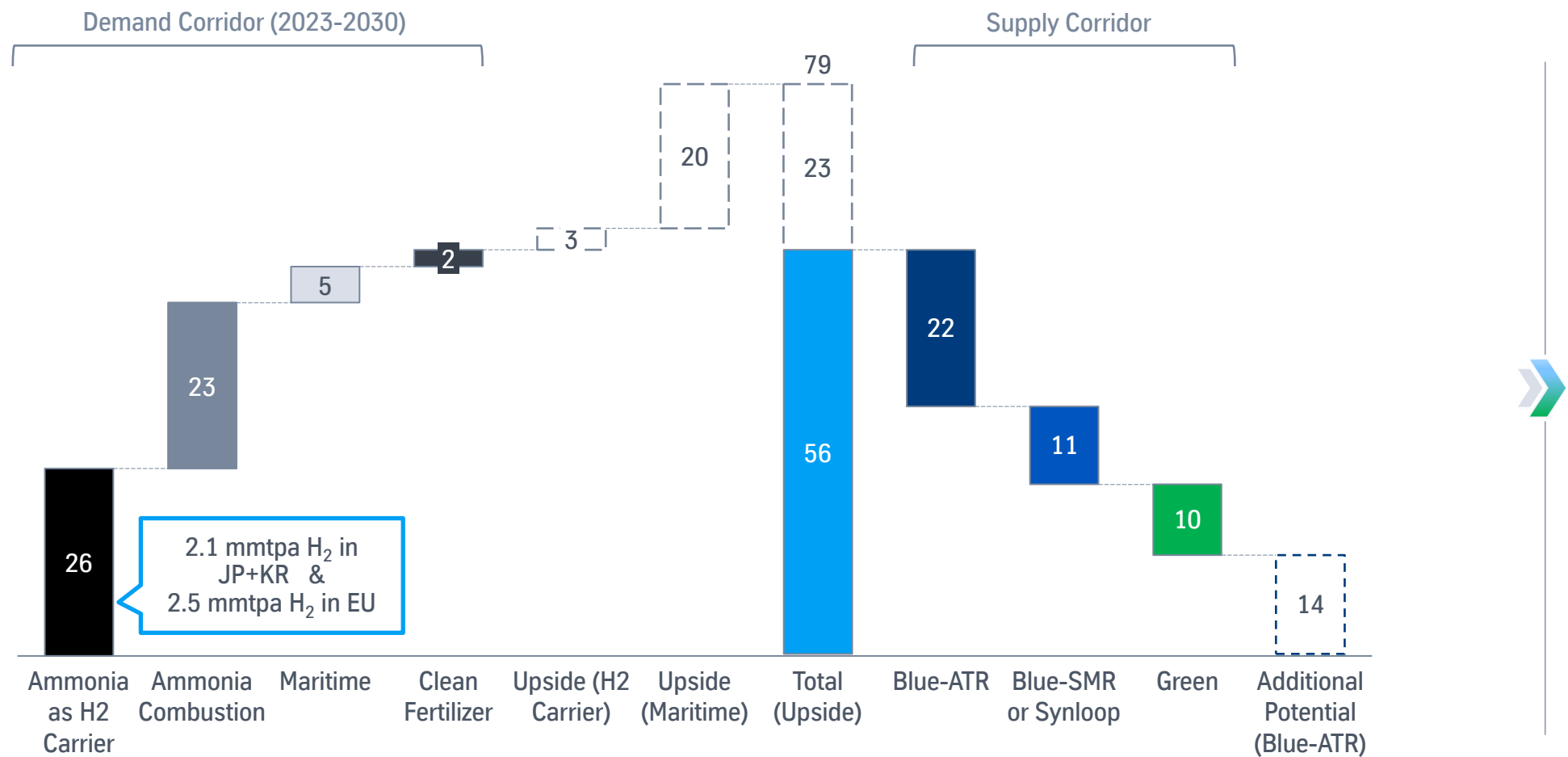
Industry push to decarbonize, as indicated by IMO target of 50% GHG reduction by 2050 and further corroborated by Maersk announcement of 8 ocean going vessels on decarbonized fuel by 2025

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'



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

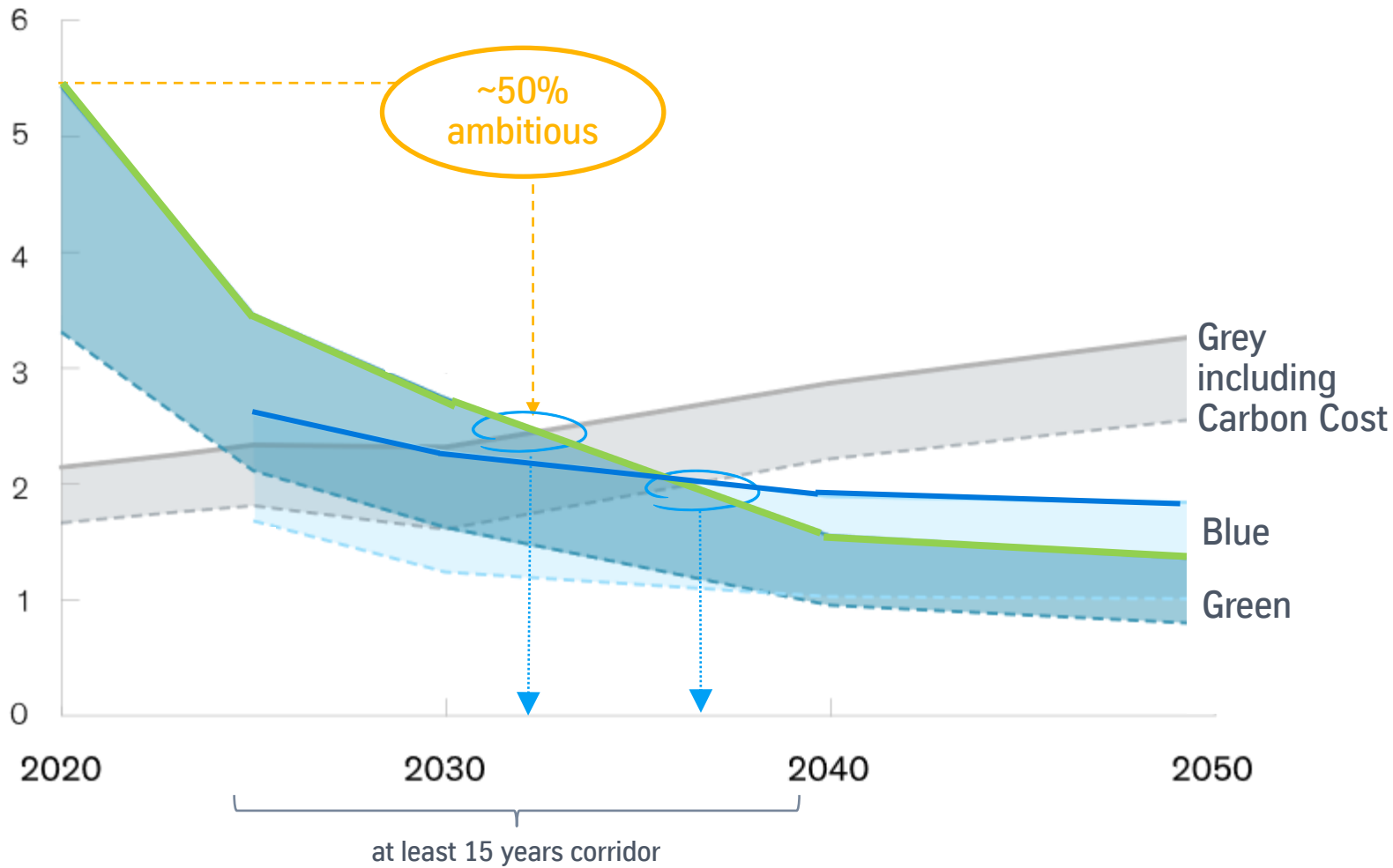
Japan, South Korea and now Germany showed acceptance for Blue as a transitional step!

Source: Uhde Internal, IHS



Global hydrogen costs drops significantly – impact on ammonia LCOA is noticeable!

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



50% drop in the cost of green hydrogen for end users by 2030

Large Blue Hydrogen projects are expected to be built by mid of the current decade (US IOC's new announcements)

Integrated oil companies and Hydrogen rich countries are likely to play major role in the clean transition

Source: McKinsey September 2022



- The fertilizer industry is a major contributor to the sustainable development of our world.
- We must actively work on the challenges in our industry to drastically reduce greenhouse gas emissions.
- New business opportunities lie ahead with ammonia as a future carbon-free energy carrier.



Shipping the sunshine and feeding the world

Thank you for your attention



thore.lohmann@thyssenkrupp.com



Friedrich-Uhde-Straße 15
44141 Dortmund, Germany



www.thyssenkrupp-uhde.com

