Decarbonizing Energy sector: Low-Carbon Hydrogen and Ammonia as energy carrier

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About Speaker

Hady Abdulhady is the Director of Business Development and Sales of thyssenkrupp Uhde for Ammonia and Fertilizers technologies, and responsible for North American region.
With over 15 years of experience in Hydrogen/Syngas and Ammonia technologies in Middle East and USA, Hady held different roles from project management, application engineering and business development throughout his career.

Prior to joining thyssenkrupp Uhde, Hady worked with KBR in USA, and with Linde in Saudi Arabia and USA, focusing on Technology Licensing & Commercialization as well as EPC.

Hady holds a bachelor degree in Chemical Engineering from Al-Baath University and an Executive MBA in Energy candidate at the University of Oklahoma.

Decarbonization

Korean Hydrogen Roadmap

"the roadmap notes the government's long-term aim of building

a specialized hydrogen pipeline network across the country while

the development of hydrogen-receiving infrastructure

is set to begin in 2022"

www.csis.org/analysis/south-koreas-hydrogen-industrial-strategy

RWE AG

Import of green energy: RWE builds ammonia terminal in Brunsbüttel

www.rwe.com/en/press/rwe-ag/2022-03-18-import-of-green-enery-rwe-builds-ammonia-terminal-in-brunsbuettel

OCI to charter ammonia-fueled vessels

OCI NV – the world's fourth largest ammonia producer – announced two new, exciting agreements this week:

www.ammoniaenergy.org/articles/the-ammonia-wrap-oci-to-charter-ammonia-fueled-vessels-japanese-ccgt-units-await-ammonia-more-green-ammonia-for-chile-new-south-korea-and-uruguay-updates/

OCI Announces ESG Strategy Focused on Capitalizing on the Hydrogen Opportunity

08 March 2021

www.oci.nl/news/2021-oci-nv-2/

EHB (**European** Hydrogen Backbone) group presents a vision for a 39,700km hydrogen pipeline infrastructure in 21 countries

www.gasforclimate2050.eu/news-item/european-hydrogen-backbone-grows-to-40000-km/

"The backbone infrastructure of the hydrogen economy starts consolidating through the emergence of large-scale, low-carbon hydrogen production facilities across the **US**, a hydrogen distribution pipeline network, and a large fueling station infrastructure network"

www.cafcp.org/sites/default/files/Road+Map+to+a+US+Hydrogen+Economy+Full+Report.pdf

'More than 85% of export-oriented low-carbon hydrogen projects plan to ship ammonia, not H2'

transition/more-than-85-of-export-oriented-low-carbon-hydrogen-projects-plan-to-ship-ammonia-not-h2/2-1-1144059

Key Drivers for Transition

Key Drivers for Transition…

- Zero-Carbon Goals
- Carbon Taxes
- Incentive Programs

Key Drivers for Green…

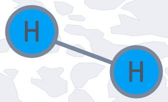
- High availability of renewables
- Emerging electrolysis technologies
- Localized production

Key Drivers for Blue…

- CCS/CCU availability
- Abundance of Natural Gas
- Lower LCOH/LCOA
- Large Capacities

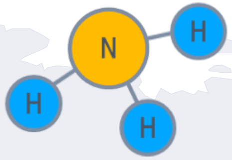
Ammonia as Hydrogen carrier

Why Ammonia?



Transport of hydrogen

- Low volumetric energy density
- High pressure to transport as a gas or extremely low temperature of -253 °C for transport as a liquid
- High effort/energy input
- Infrastructure needs to be developed



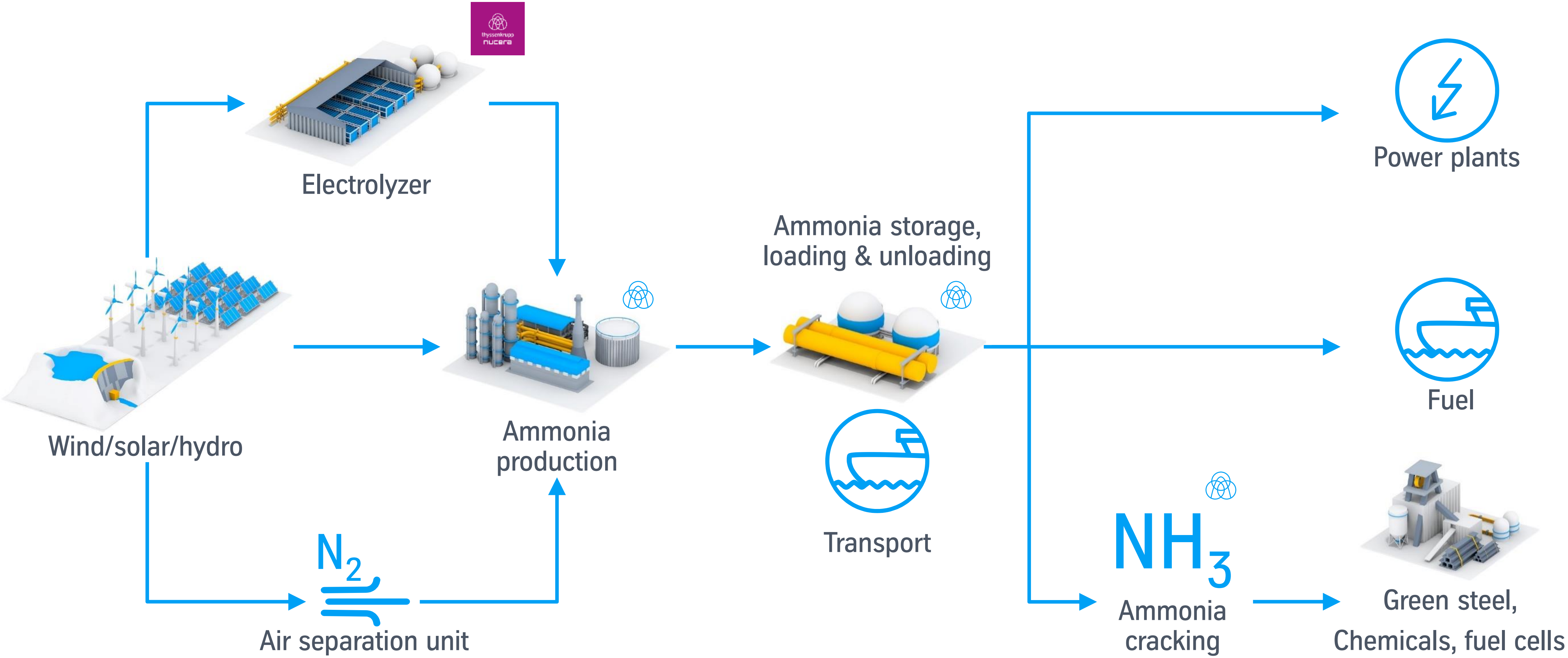
Transport of ammonia

- High hydrogen density (17.8 wt.-%)
- -33 °C for transport as a liquid
- High, but known effort
- Transport by ship is proven technology
- Large-scale infrastructure available

Transport of NH_3 over long distances is state of the art

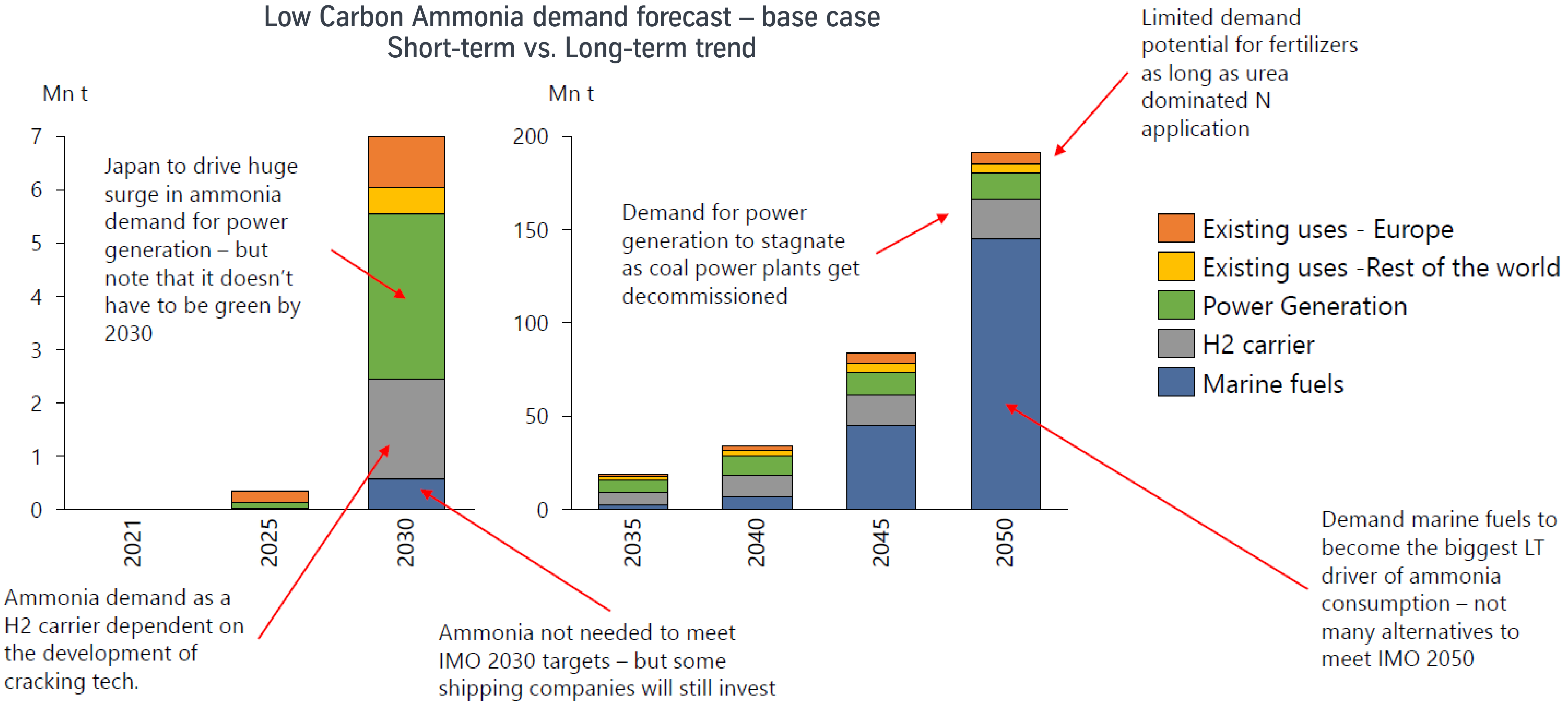
Green Ammonia as energy carrier – Set up along the whole energy supply chain

The complete solution from one source



Ammonia usage for energy transport, utilization as energy carrier or re-conversion to hydrogen

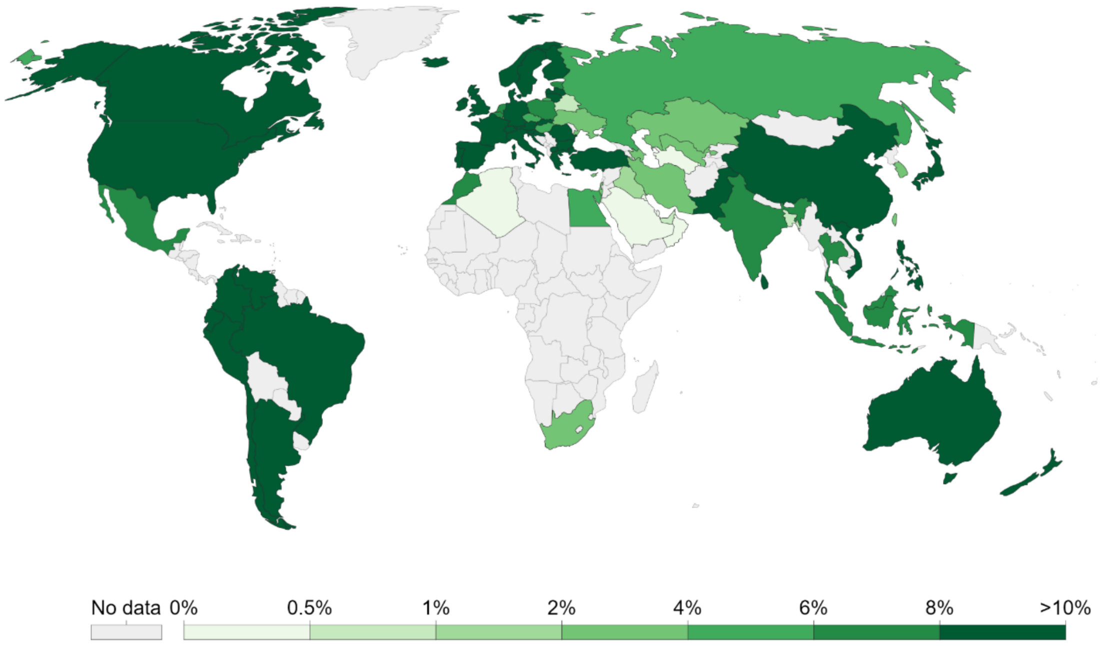
Ammonia New Markets: Non-fertilizer Low Carbon Ammonia Forecast



Source: Argus Media Group © 2021

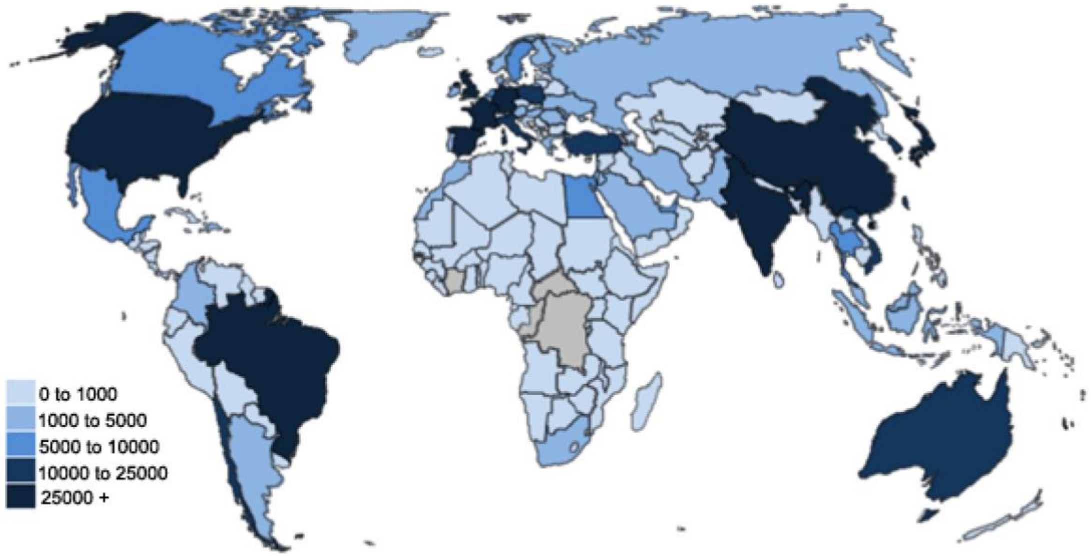
Renewable Energy Installations – Enough for Green Ammonia / Power-to-x?

Share of Primary Energy from Renewable Sources (2019)



Source: Our World in Data based on BP Statistical Review of World Energy (2020)

Renewables Capacity Additions by Country in MW (2020-2029)



Source: Fitch Solutions, Global Renewables Market Outlook, September 2020 (hydropower is neglected)

By the end of the decade, non-hydropower renewables capacity is expected to grow by just over 1,400 GW, with a total of 2,770 GW[1]

1 Source: Fitch Solutions, Global Renewables Market Outlook, September 2020

Decarbonizing Conventional Ammonia Process

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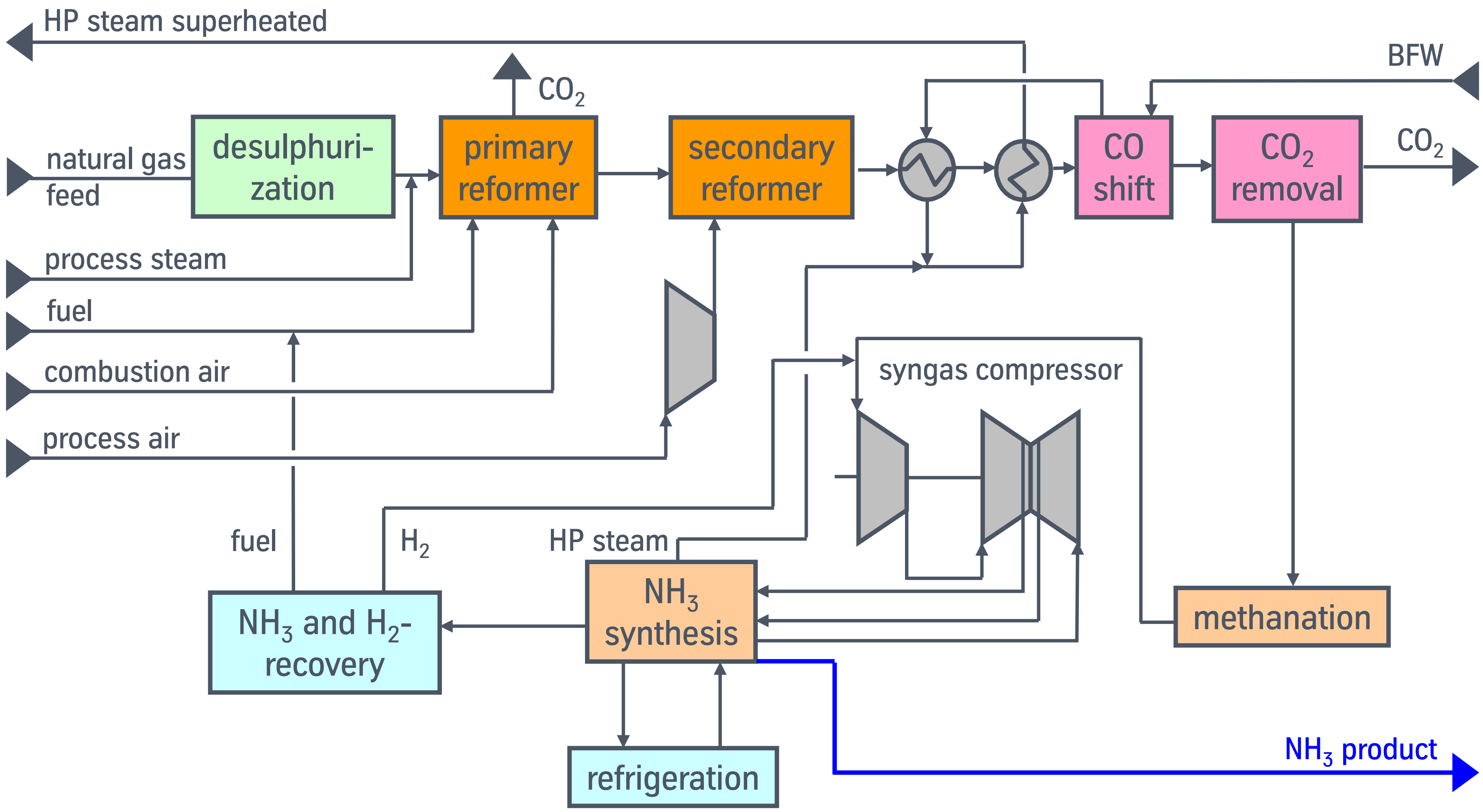
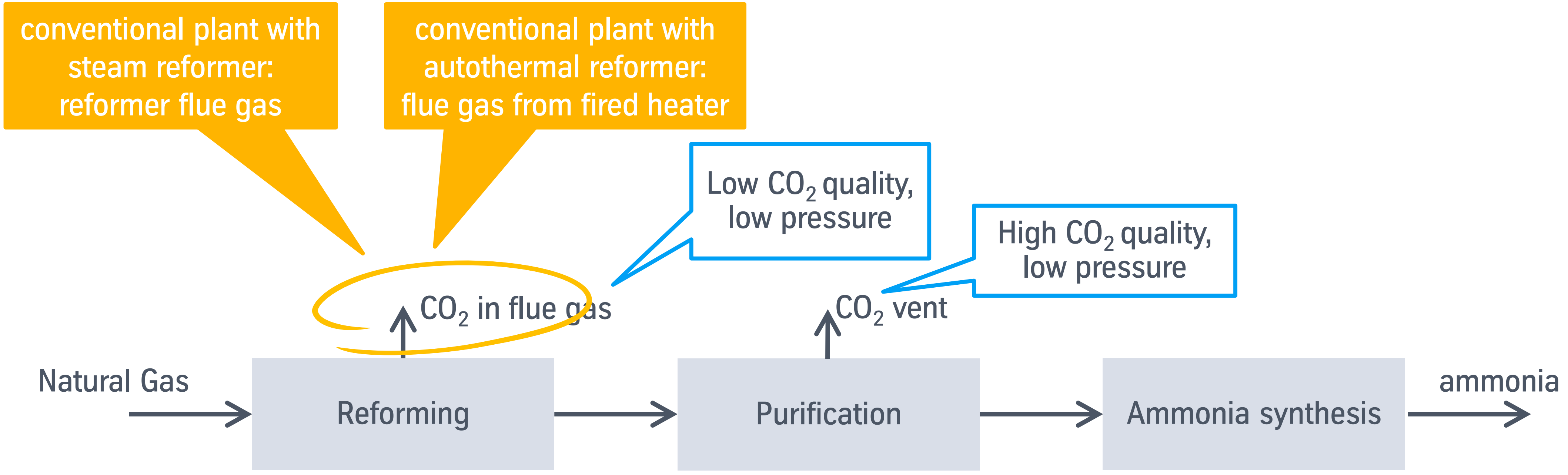
Conventional Ammonia Plant Block Diagram



Carbon Emissions

Sources of CO_2 Emission from Conventional Ammonia Production

Ammonia plant: Two points of CO_2 emission:



Low Carbon Ammonia Process

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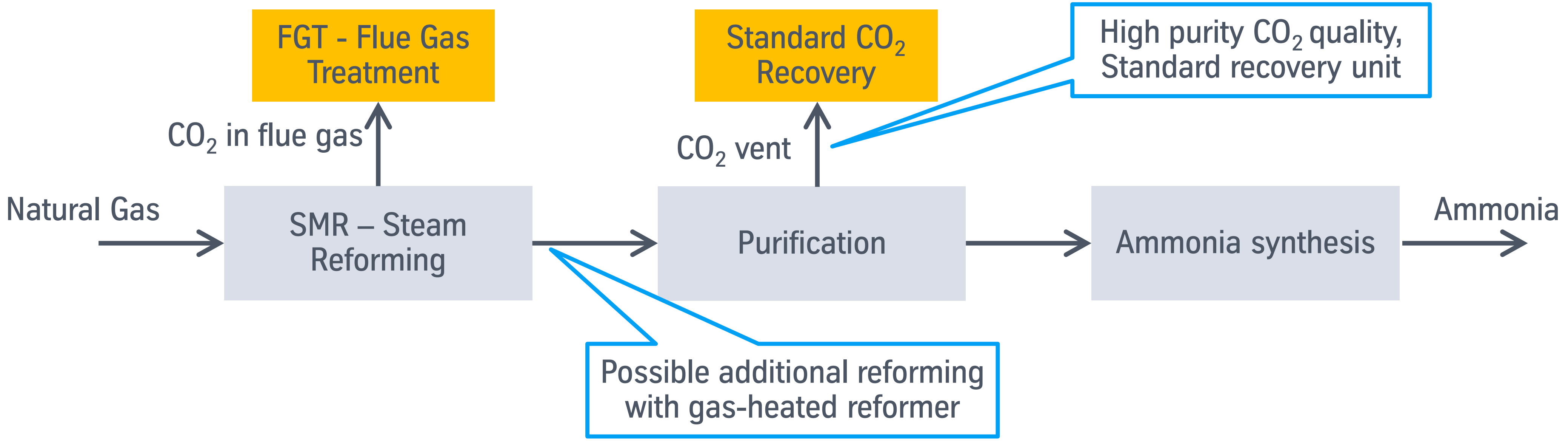
Low Carbon Ammonia

First Approach

Carbon Recovery Rate: up ~ 68-73% without FGT

~ 95% with FGT

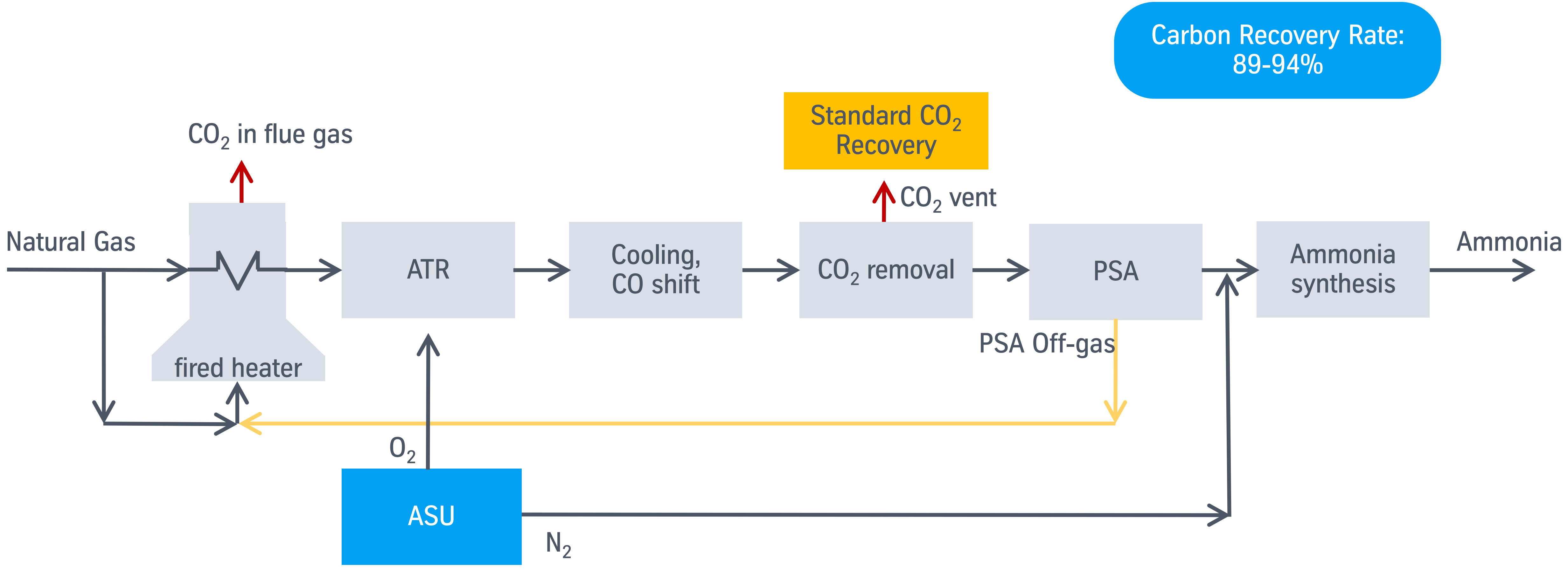
Recovering flue-gas CO_2 in addition to standard CO_2 recovery



Low Carbon Ammonia

Second Approach

Plant with ATR: 2 points of CO_2 emission to be tackled in case CO_2 emission shall be avoided

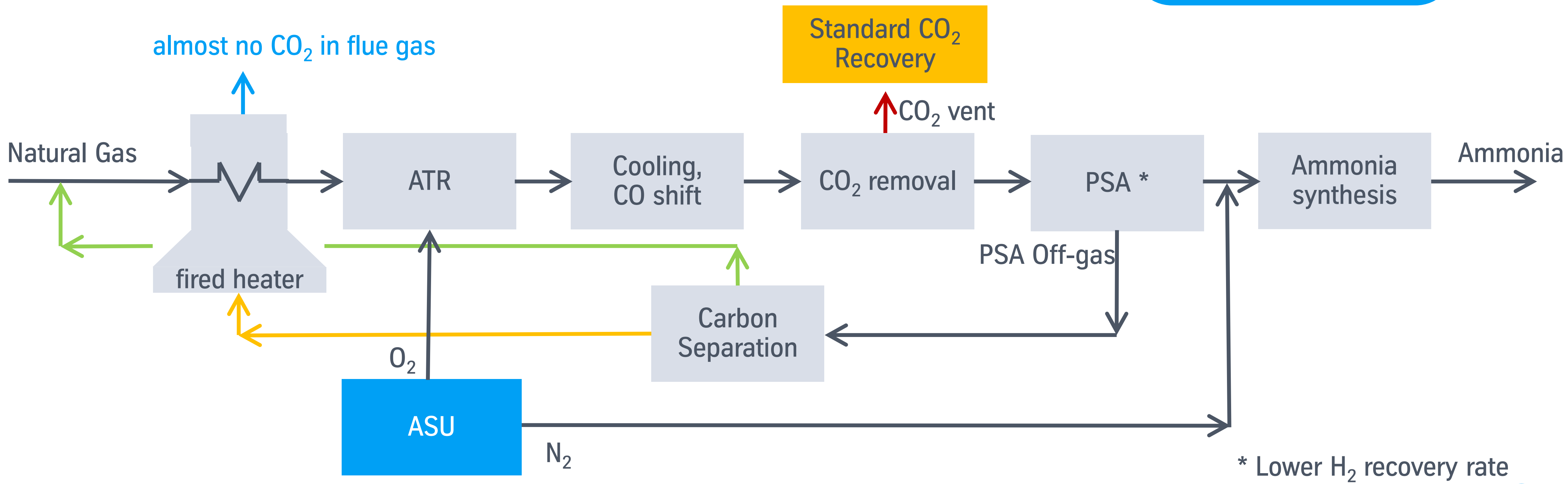


Low Carbon Ammonia

Second Approach

Plant with ATR, optimized: only 1 point of CO_2 emission to be tackled in case CO_2 emission shall be avoided

Carbon Recovery Rate: up to 99%



* Lower H_2 recovery rate

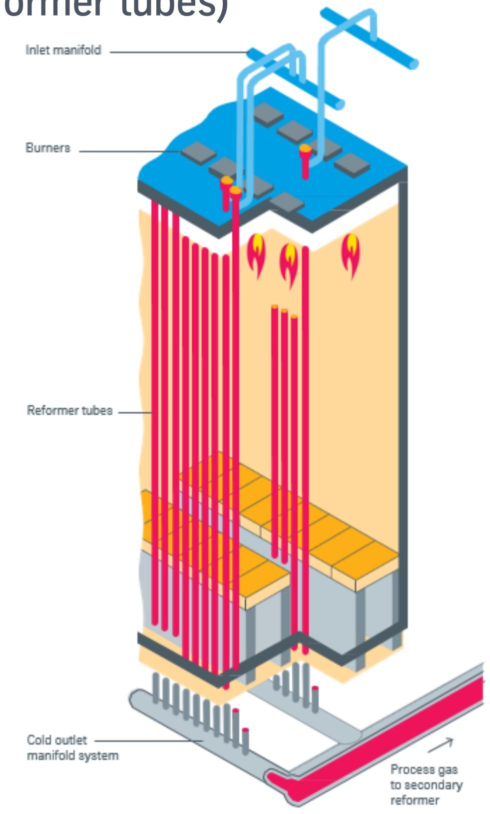
Reformer Types

CO_2 Capture: Steam Reformer (SMR) vs. Autothermal Reformer (ATR)

Comparison

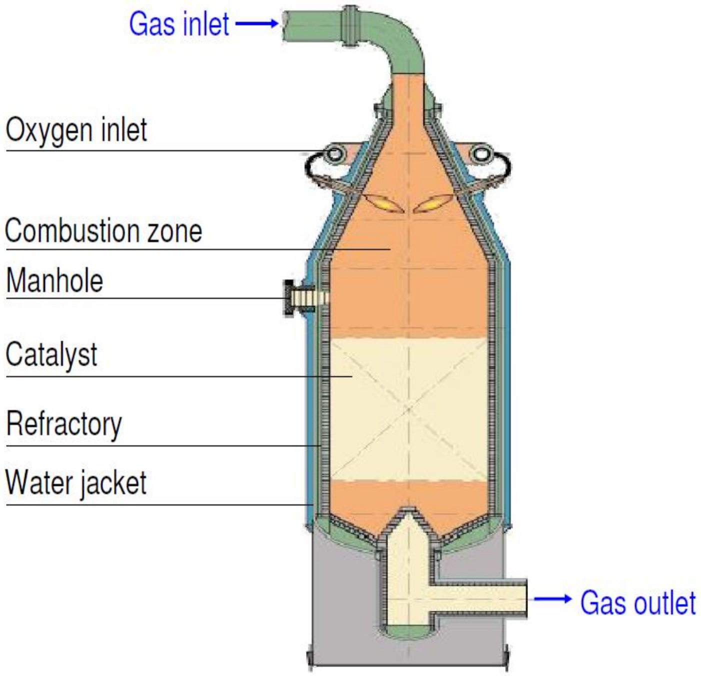
Steam Methane Reformer:

- 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:

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



Reformers Comparison

SMR vs. ATR

SMR

- **Advantages:**
  - Reference plants available
  - Syngas composition is already as required d/s reformer section (integrated Ammonia plant with Front/Back End) → No ASU necessary
  - Better CAPEX for small capacities
- **Disadvantages:**
  - More CO_2 in flue gas → higher CAPEX for CO_2 Removal unit
  - Large capacities has no little gain from economy of scale

ATR

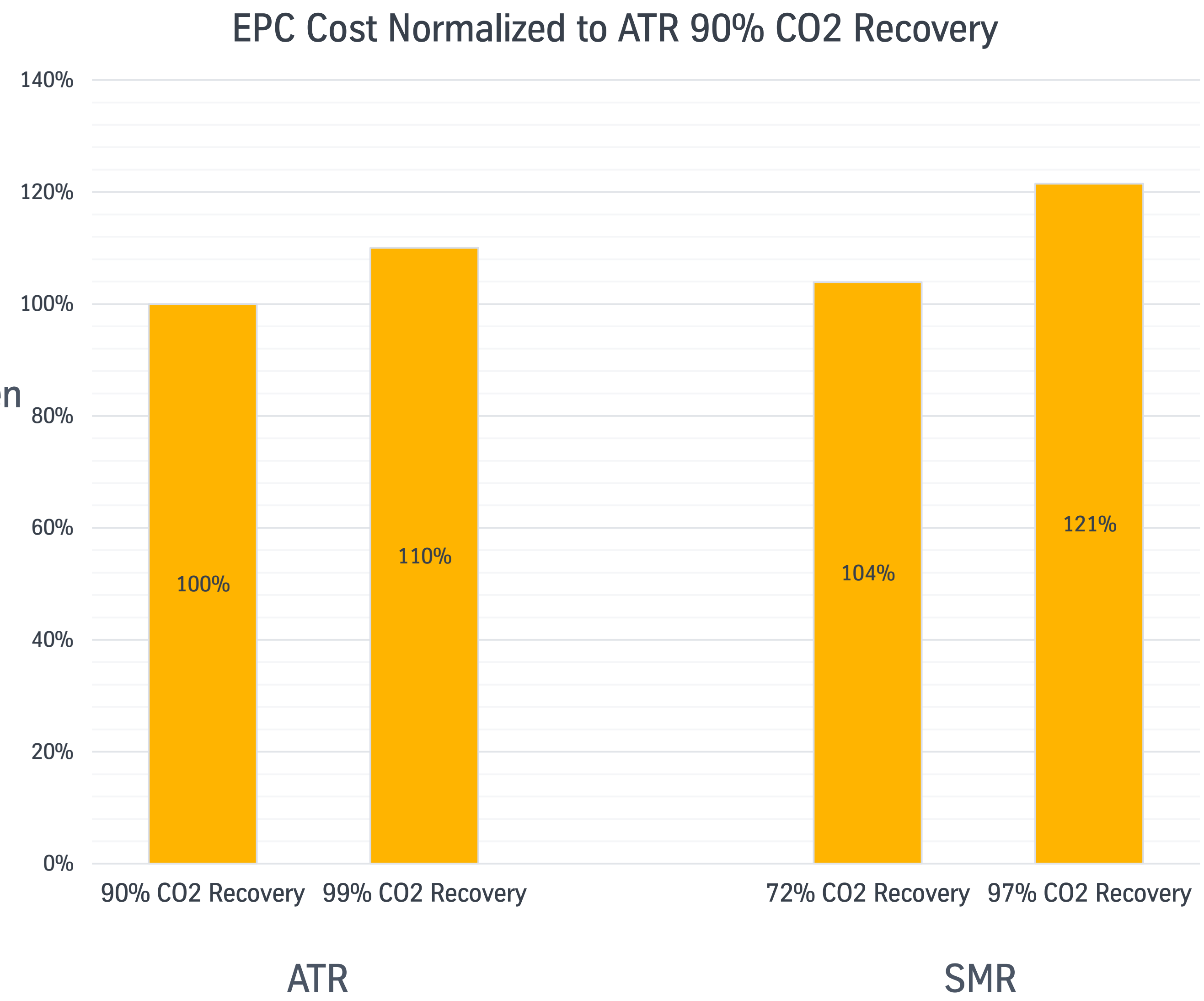
- **Advantages:**
  - Less CO_2 in Flue Gas (overall approx. same amount of CO_2)
  - Blue Ammonia solution without flue gas scrubbing possible
  - Better CAPEX for large capacities
  - Blue Hydrogen as additional (by-)product possible
  - Easier integration/transition to Green Ammonia
- **Disadvantages:**
  - Higher CAPEX for smaller capacities
  - Higher space requirement for the overall plant
  - First reference is still being built (1.2Million mtpa)

Best option depending on client's requirements & boundaries

EPC Cost Estimate of ATR vs SMR

Assumptions

- Capacity 3,500 MTPD
- ASU is included for ATR cases
- Flue gas scrubbing system and additional hydrogen for fuel are included for SMR 97% CO_2 recovery
- Carbon Capture equipment are included



Ammonia Cracking

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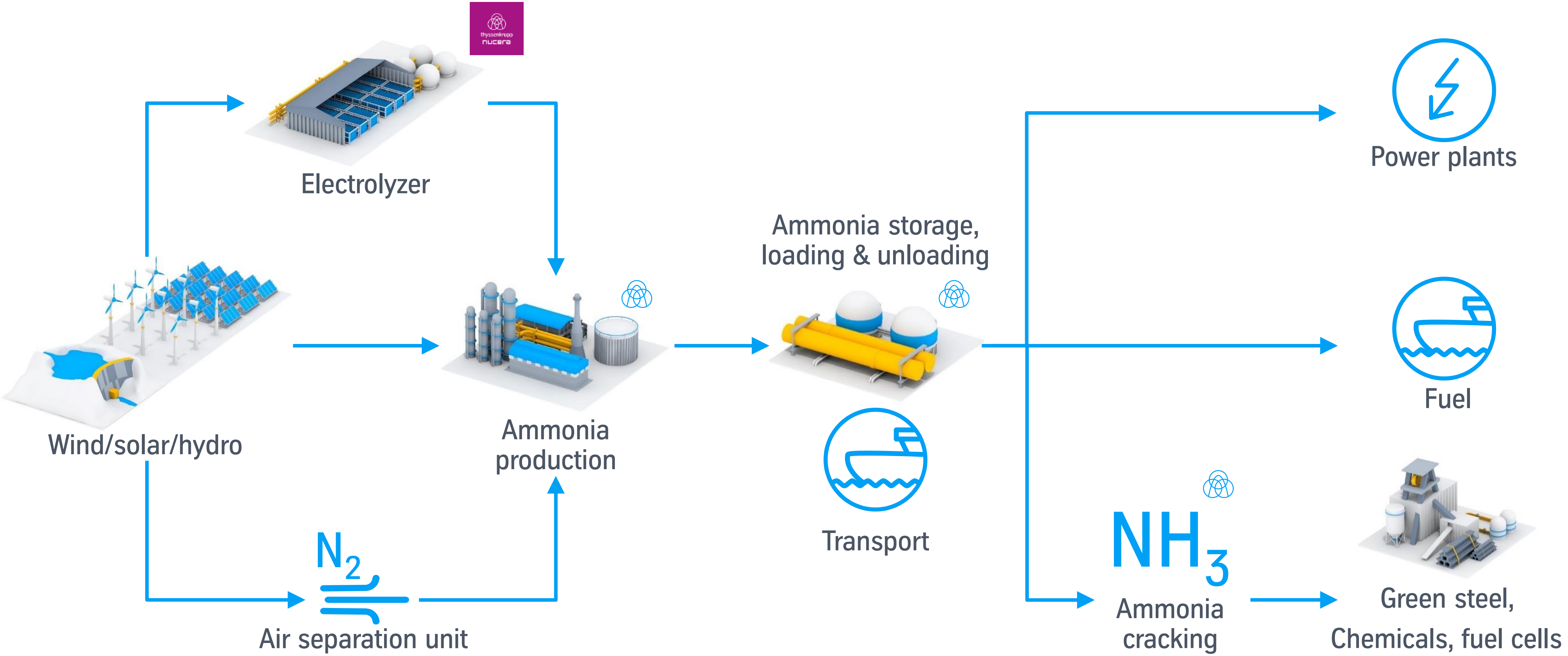
Green Ammonia as energy carrier – Set up along the whole energy supply chain

The complete solution from one source



Ammonia usage for energy transport, utilization as energy carrier or re-conversion to hydrogen

Location of ammonia cracking

Centralized vs. local NH_3 cracking

Location of Ammonia Cracking

1 Local small-scale cracking

Pros:

- No hydrogen infrastructure required
- Advantages of ammonia transport up to consumer
- Electrically heated process suitable

Cons:

- Additional ammonia infrastructure needs to be developed in parallel to hydrogen if available
- Risks/restrictions for ammonia transport by train or truck
- Higher specific investment/operation costs
- Increased CO_2 footprint if electric power is not generated totally from renewables

2 Centralized large-scale cracking

Pros:

- Economy of scale
- Integration into an existing regional hydrogen economy
- Fired reactor technology suitable

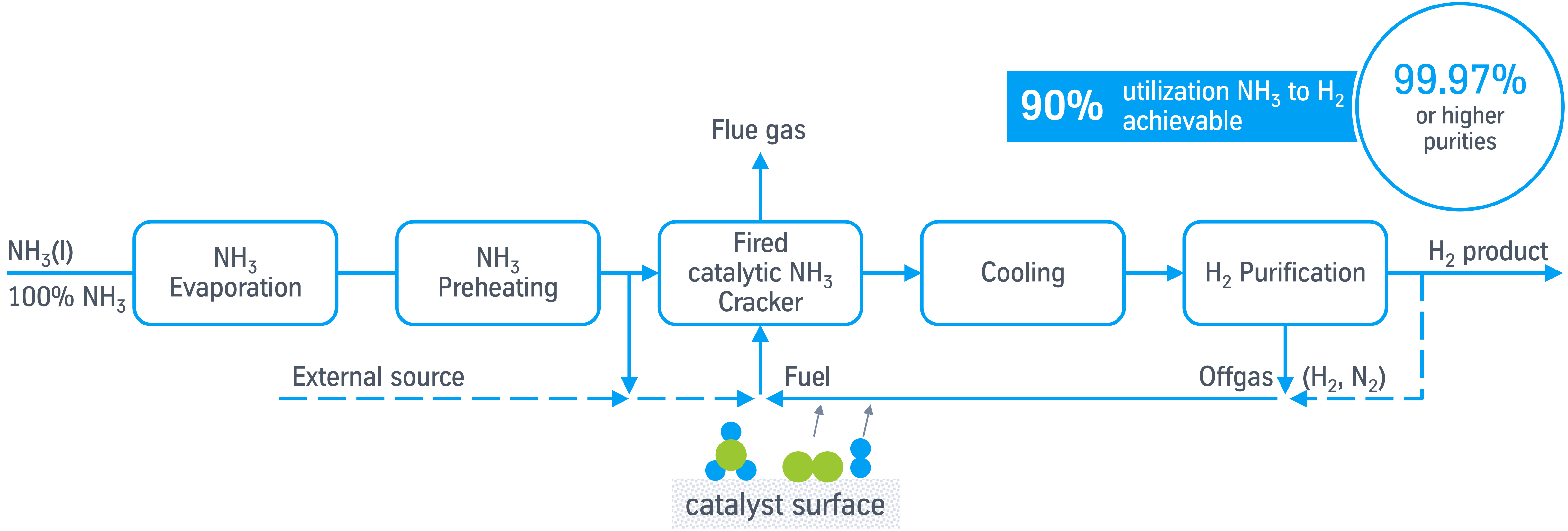
Cons:

- Hydrogen infrastructure needs to be developed if not available
- High effort for authorities' approval

Centralized large-scale units can achieve higher energy efficiency and lower CO_2 emissions

Hydrogen from Ammonia - Ammonia cracking

thyssenkrupp Uhde developments



- Based on Uhde's well proven SMR prop. equipment
- High catalytic NH_3 conversion to H_2 (above 98%)
- Purities adaptable to requirements of user

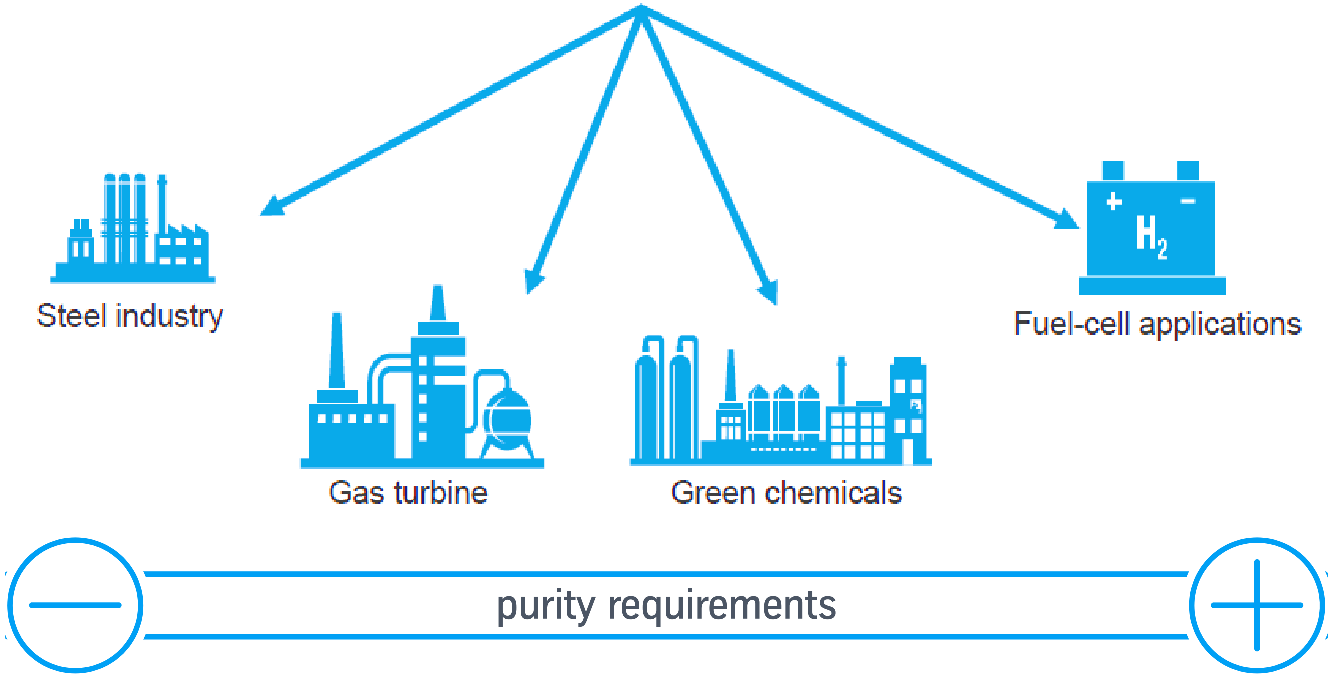
- Already proven in 1970's in small-scale units
- Designed for large scale solutions up to 3,000mtpd
- State-of-the art catalysts

Green ammonia to green hydrogen

Our technology, your market

Decision on:

- Product purity with respect to residual NH_3 and N_2 content
- Technology for last purification step (e.g. PSA, membrane)



Thank you for attention!

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