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Technology for Ammonia to Hydrogen Conversion

NAP Meeting February 29, 2024

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- Why & When do we need this AHC technology?
- SCO (ammonia combustion) Technology
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Legacy & spirit of innovation

1919 — Technical Office of J. Duiker Founded in The Netherlands

1942 — First Luynet Multiple Vortex burners installed

1961 — Duiker is sold to Laidlaw Drew and is renamed as LD Duiker.

1978 — Duiker develops and sells low NO_X ammonia burners.

Thousands of process solution

1989 — J. Duiker & Co Listed as joint-stock-company

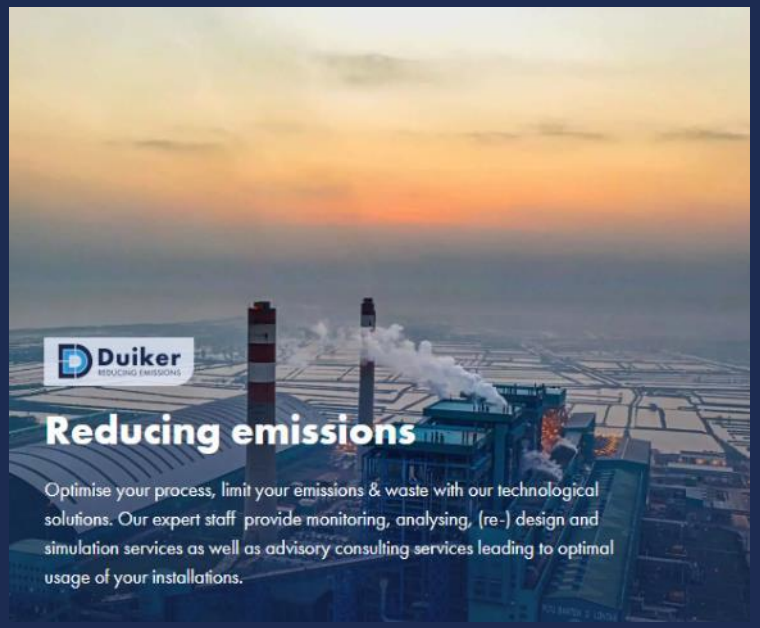
2004 — Babcock acquires Duiker projects for its expertise

2009 — Management buyouts out LD to make Duiker combustion engineers.

2022 — Duiker develops and launches ammonia crackers.

Experience you can rely on

Focus on clean technologies



Duiker SULFUR SOLUTIONS

Duiker CLEAN ENERGY

Duiker REDUCING EMISSIONS

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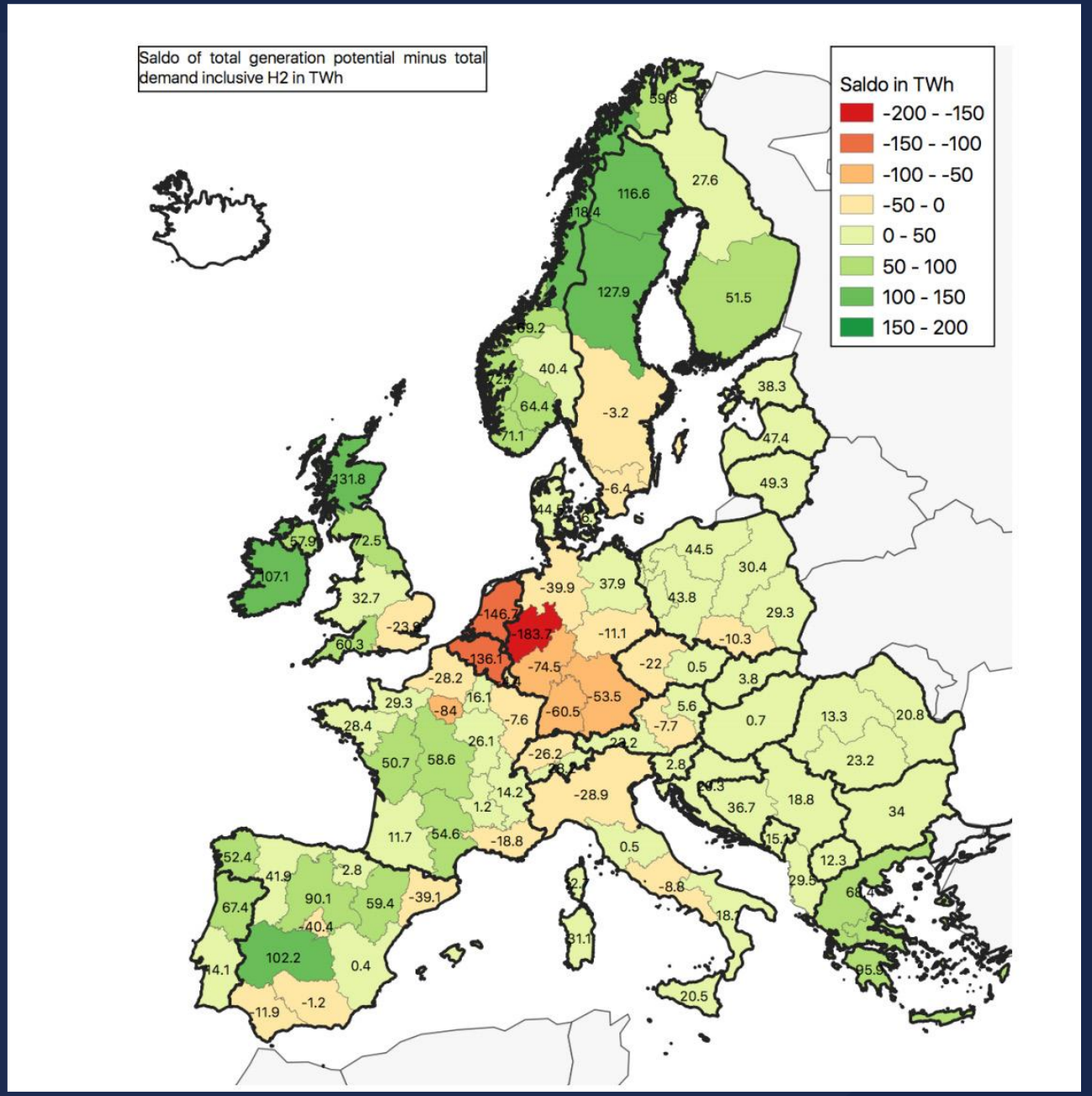
Why do we need this ammonia cracking technology?

Hydrogen “shortage” in Western Europe

Aside from the economics, Western Europe needs more energy than it can produce locally. In specific terms, the highly industrialized region of **Belgium-Netherlands-North-Rhine Westphalia** consumes much more energy than what can be provided locally or even regionally, as shown in the map right



Source: Report “Shipping sun and wind to Belgium is key in climate neutral economy” by the Hydrogen Import Coalition (2020)

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When do we need this technology?

Port of Rotterdam: "An initiative of 18 companies, led by the Port of Rotterdam Authority, has kicked off a study into the possible establishment of a large-scale ammonia cracker, which will enable imports of 1 million tonnes of hydrogen per year for the decarbonization of industry and mobility.
https://www.portofrotterdam.com/sites/default/files/2023-05/large-scale-industrial-ammonia-cracking-plant.pdf

By 2050, demand for this relatively clean energy carrier is expected to increase to 20 Mtonnes, around 18 Mtonnes of which will be imported."

Wilhelmshaven: Niedersachsen Ports, Uniper and Tree Energy Solutions will explore the feasibility of brand new, six-berth, "green gases" jetty infrastructure at Wilhelmshaven for future fuel imports. In parallel, Uniper will conduct a technical feasibility study that will eventually allow imports of around 2.6 million tonnes of ammonia per year at the German port. https://www.ammoniaenergy.org/articles/new-ammonia-import-infrastructure-under-development-across-europe-and-beyond/

Similar announcements for the Ports of **Antwerp, Hamburg, Rostock** and others

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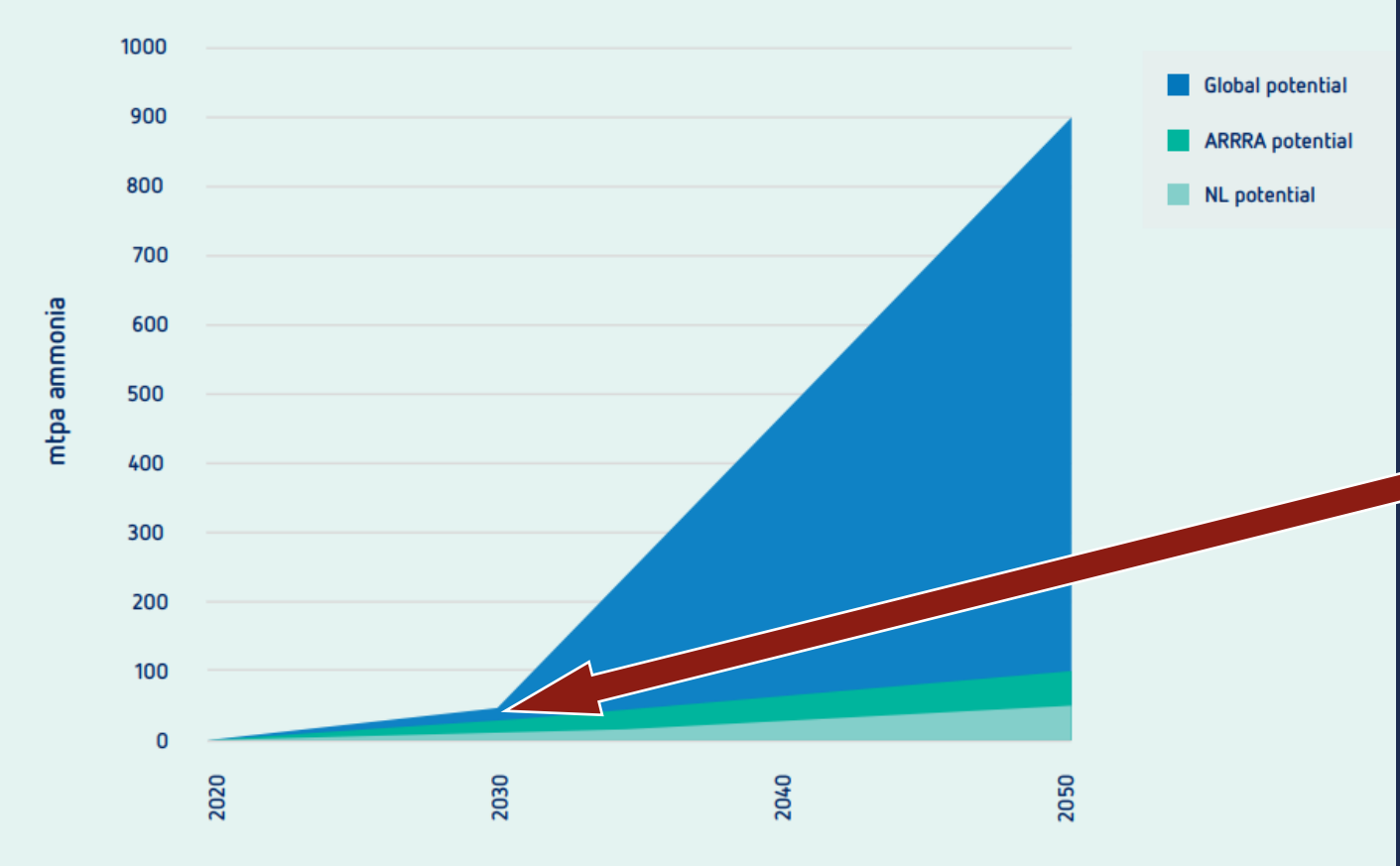
Potential development of ammionia demand in 2050



ARRRA =
Antwerpen-
Rotterdam-
Rijn-
Ruhr-
Area

in 2030:
" A suggested 10 mtpa of ammonia could be converted into about 1,5 mtpa of Hydrogen for domestic use"

Source: Clean Ammonia Roadmap from ISPT
https://ispt.eu/media/2024-ISPT-Clean-Ammonia-Roadmap-report_online-versie.pdf

Stoichiometric Controlled Oxidation (SCO): Proven Technology for Ammonia Combustion

Proven in industrial applications

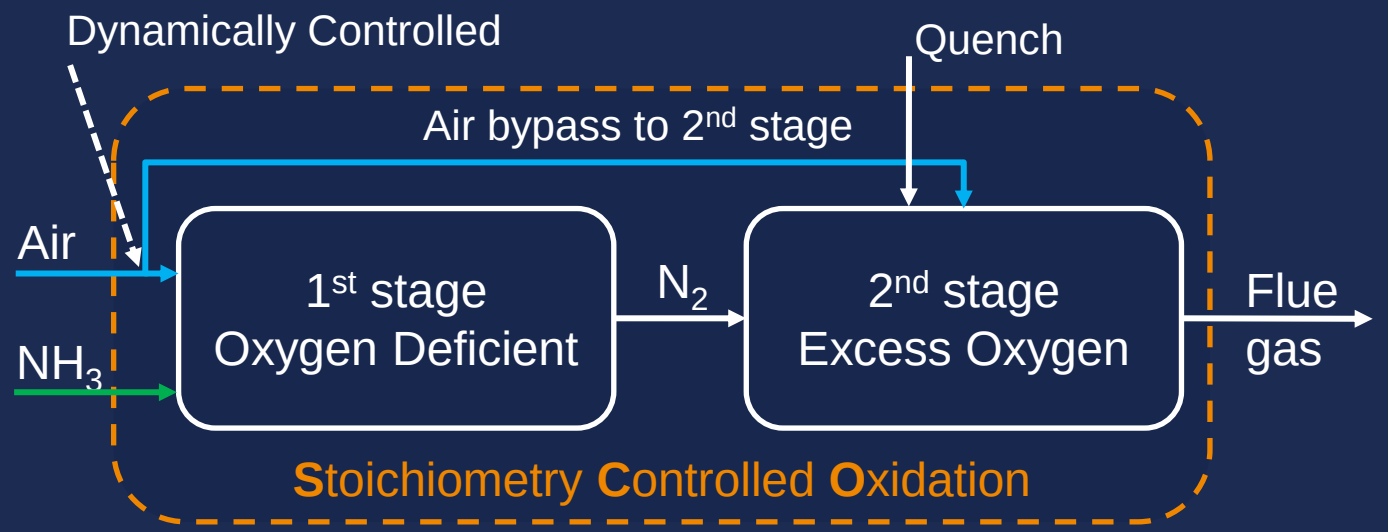
No CO_2 emissions

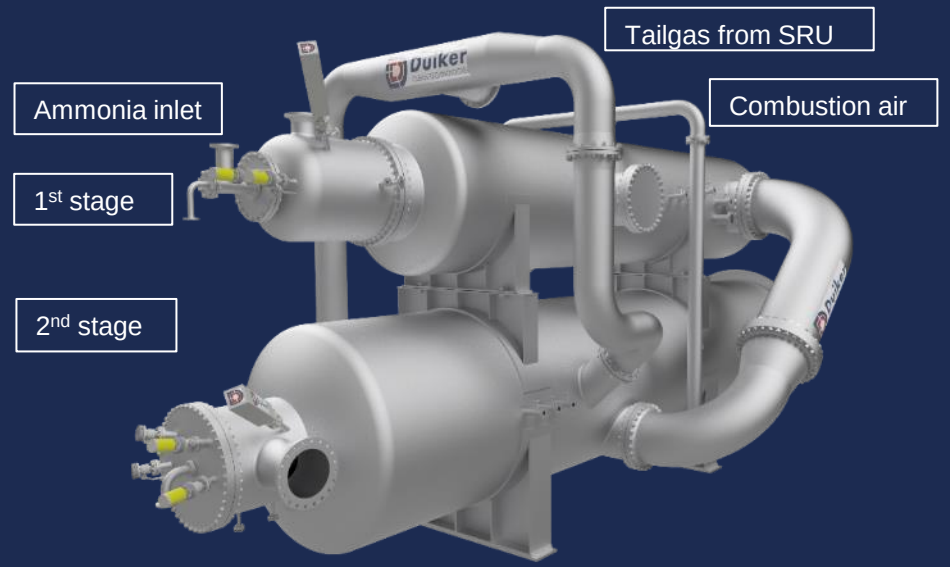
No soot or particulate emissions

Outlet NO_x: 50ppmv @ 3% O_2 dry

Inlet NH_3: 50%-100%

Patented Technology





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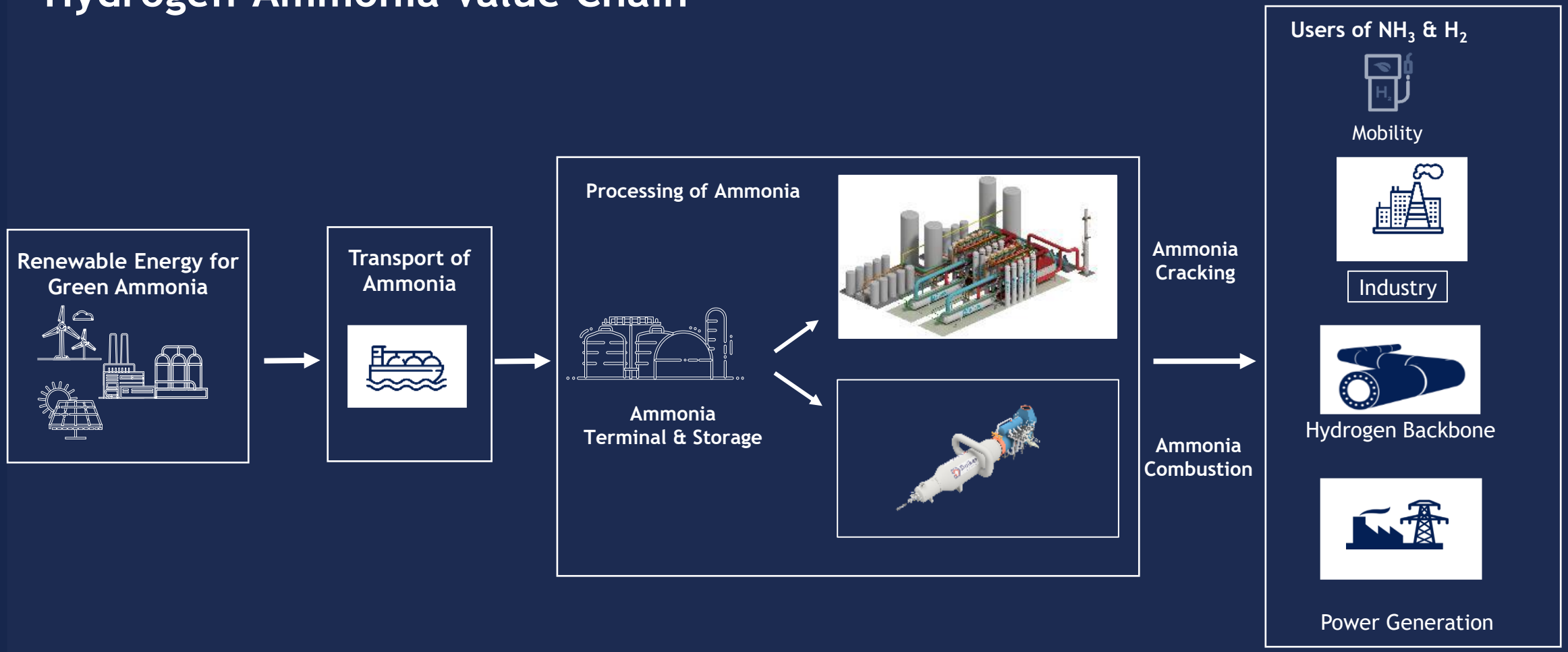
Stoichiometric Controlled Oxidation (SCO): Proven Technology for Ammonia Combustion

NO_x: 50ppmv @ 3% dry

Proven at commercial scale

Hydrogen-Ammonia Value Chain



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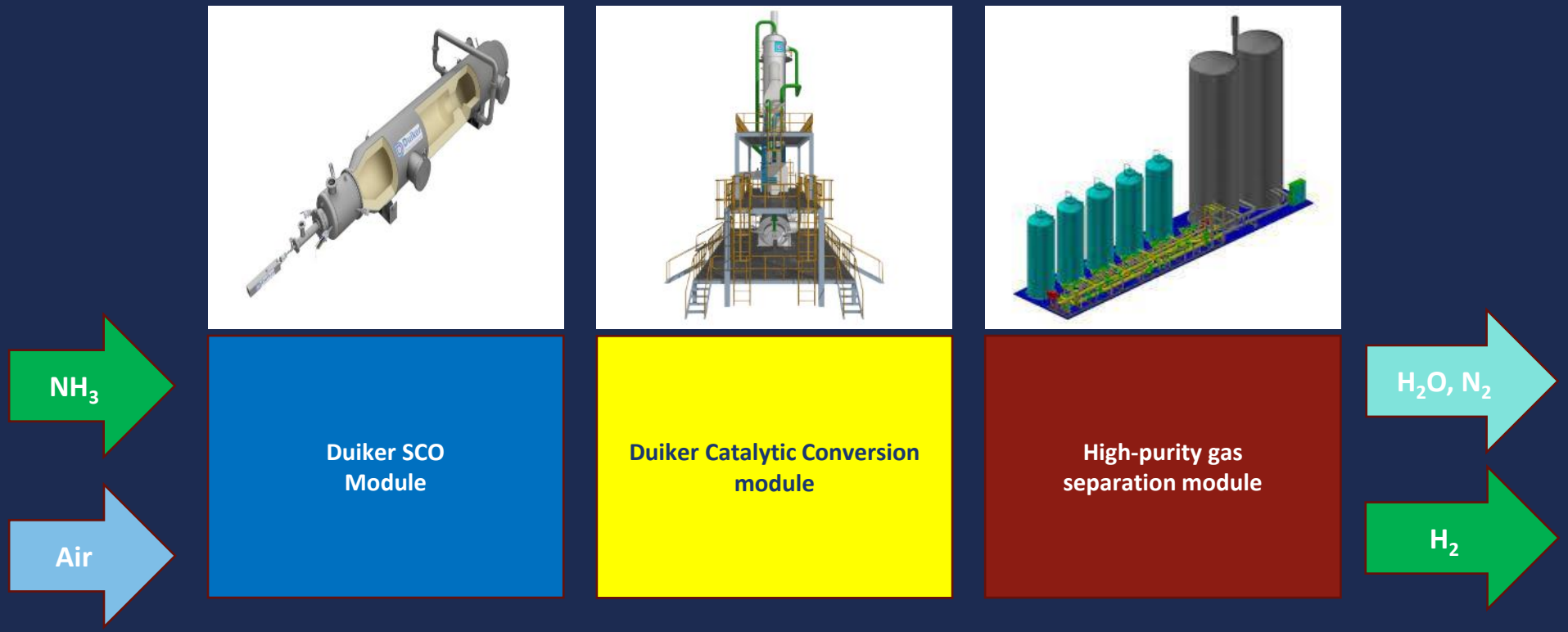
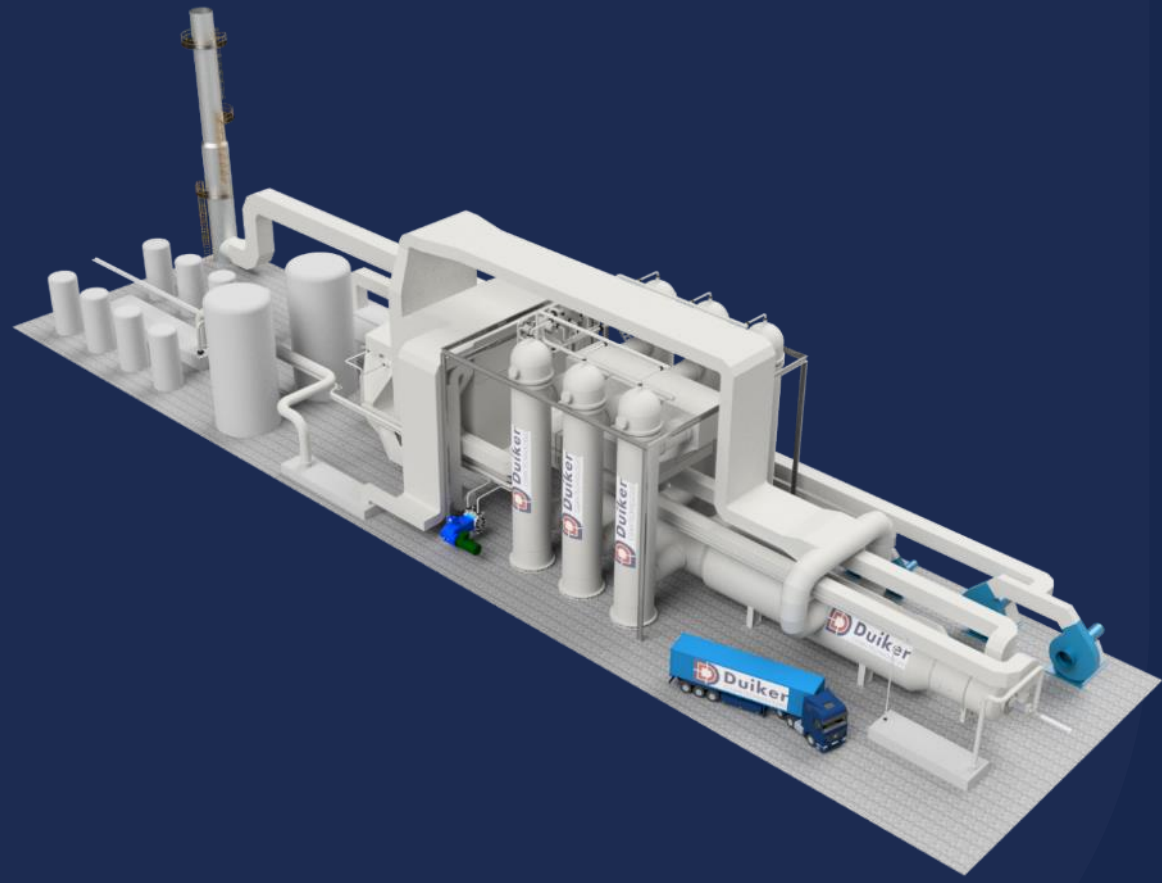
Basic principles Duiker Ammonia to Hydrogen Converter



Duiker AHC - Key Characteristics

- Efficient use of heat from NH_3
- H_2 product purity acc. ISO 14687:2019
- High yield conversion to H_2 (89%)
- Capacity: 7 – 700+ MTPD H_2 output
- Scalable to world scale needs
- Zero CO_2, NH_3 & low NO_x emissions
- Proven technology, patent pending
- Availability: commercially available

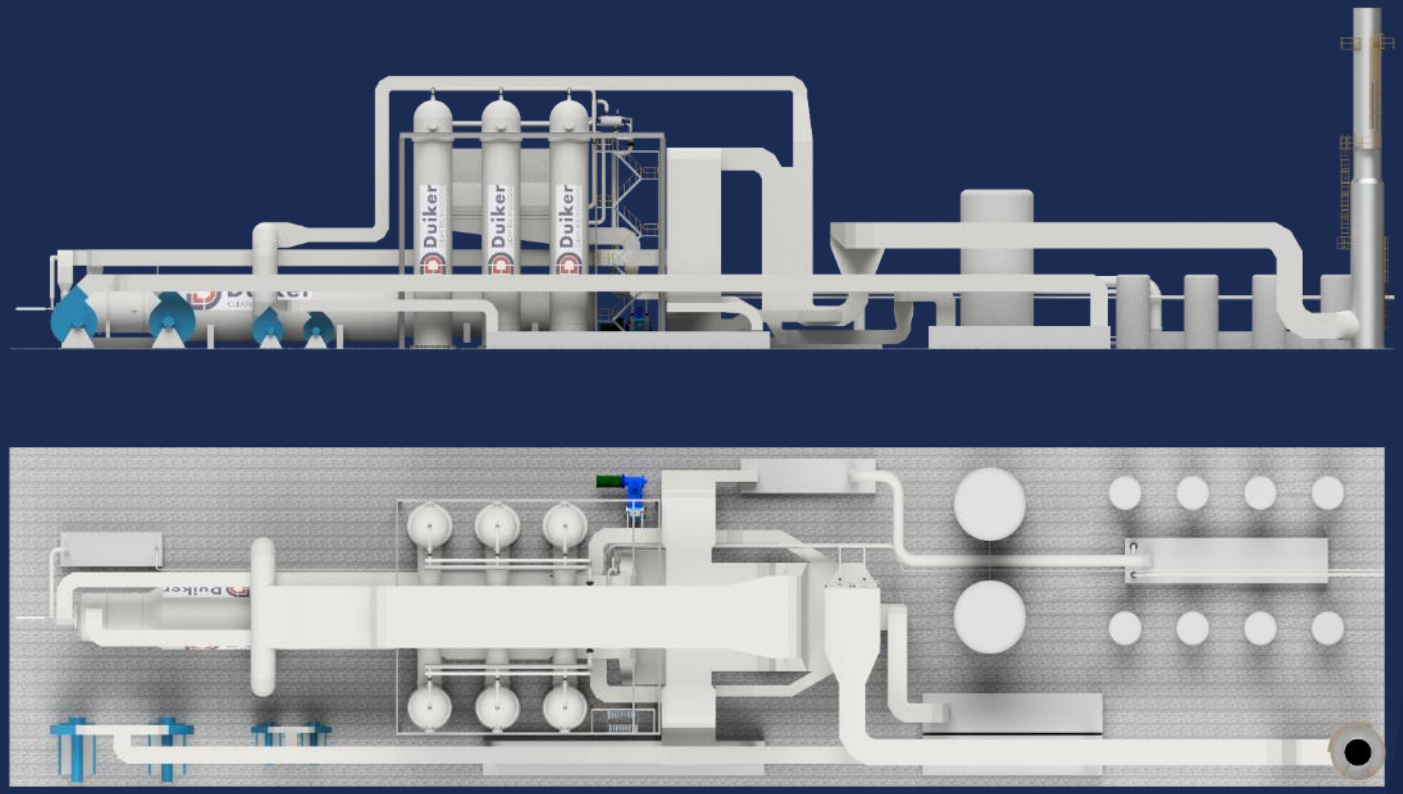


AHC – Maximum Train Size (economic optimum):

Hydrogen Production (@ H_2 purity of **99,97%**):
275 TPD ≈ 103.000 TPA H_2 ≈ **382 MW**

Hydrogen Production ((@ H2 purity of **98%**):
353 TPD ≈ 129.000 TPA H2 ≈ **382 MW**

Ammonia Consumption:
1.969 TPD ≈ 719.000 TPA NH_3



- Length: 122 m, width 30 m, plot 3.660 m^2

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Any Question?

Thank you for your attention!

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