Net-Zero: The Emergence of an Ammonia Economy in Asia

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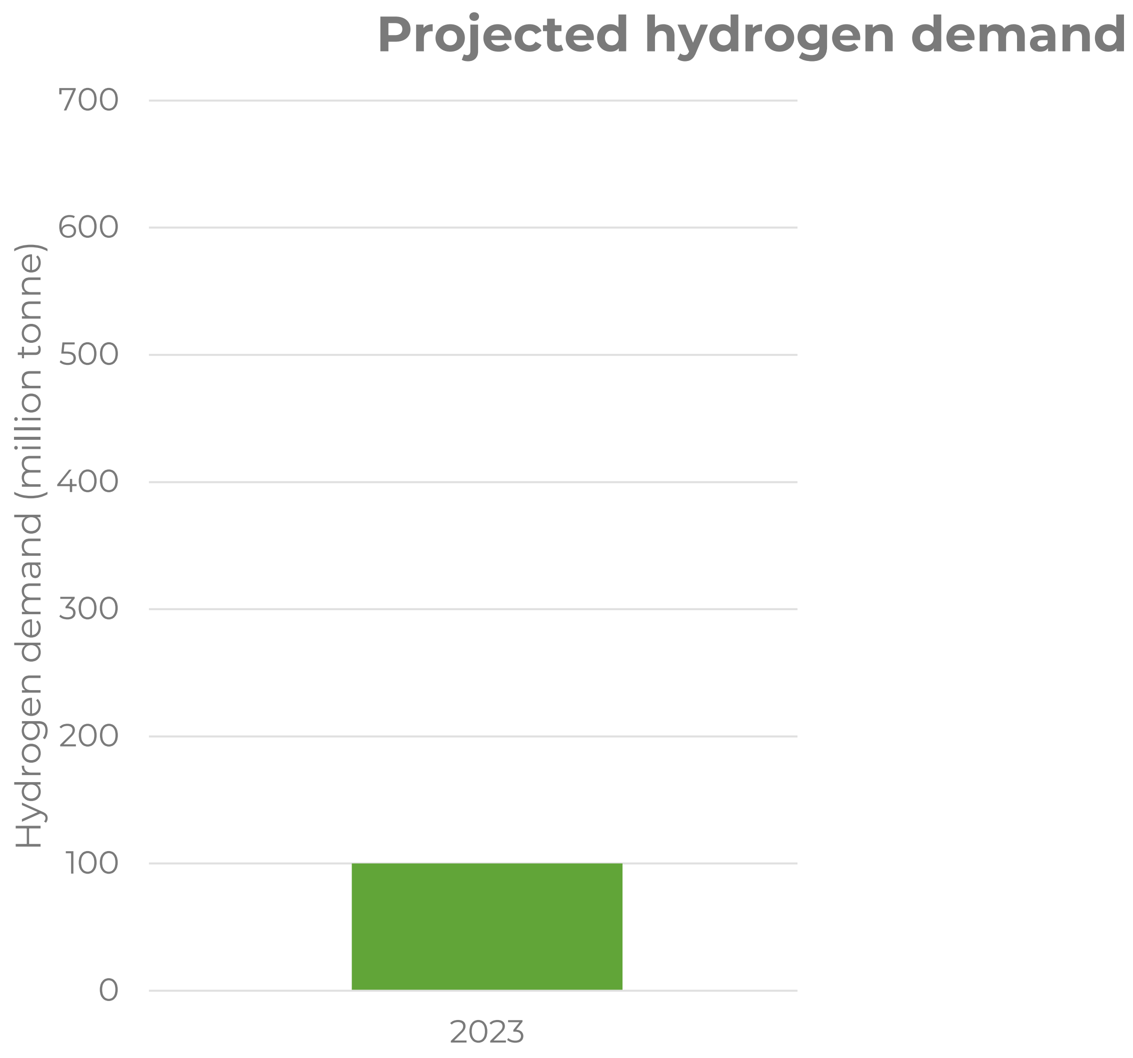
Principal Analyst

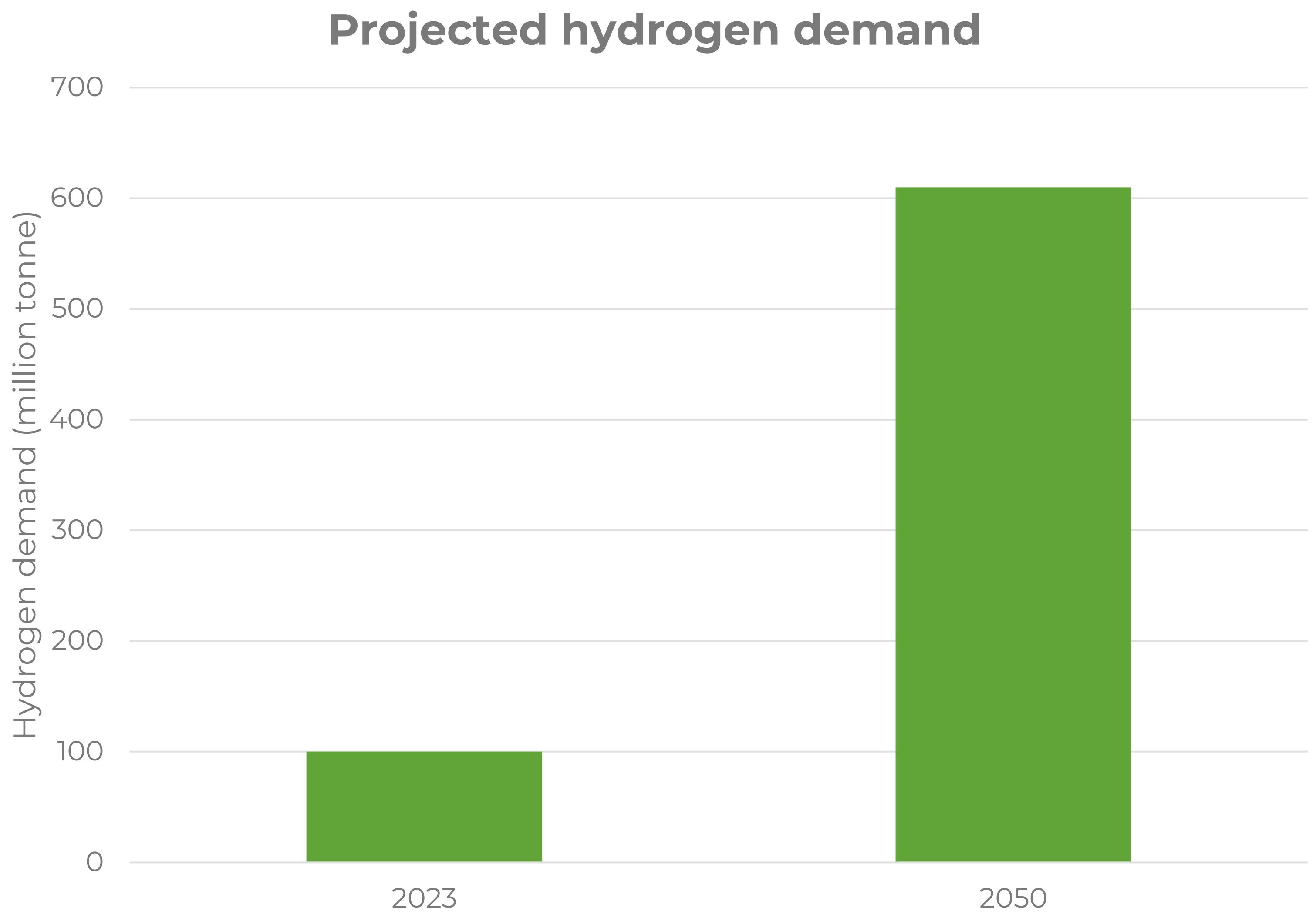
Lux MotivBase | The Deciding Factor

In 2023, the world requires 100 Mtonne of hydrogen



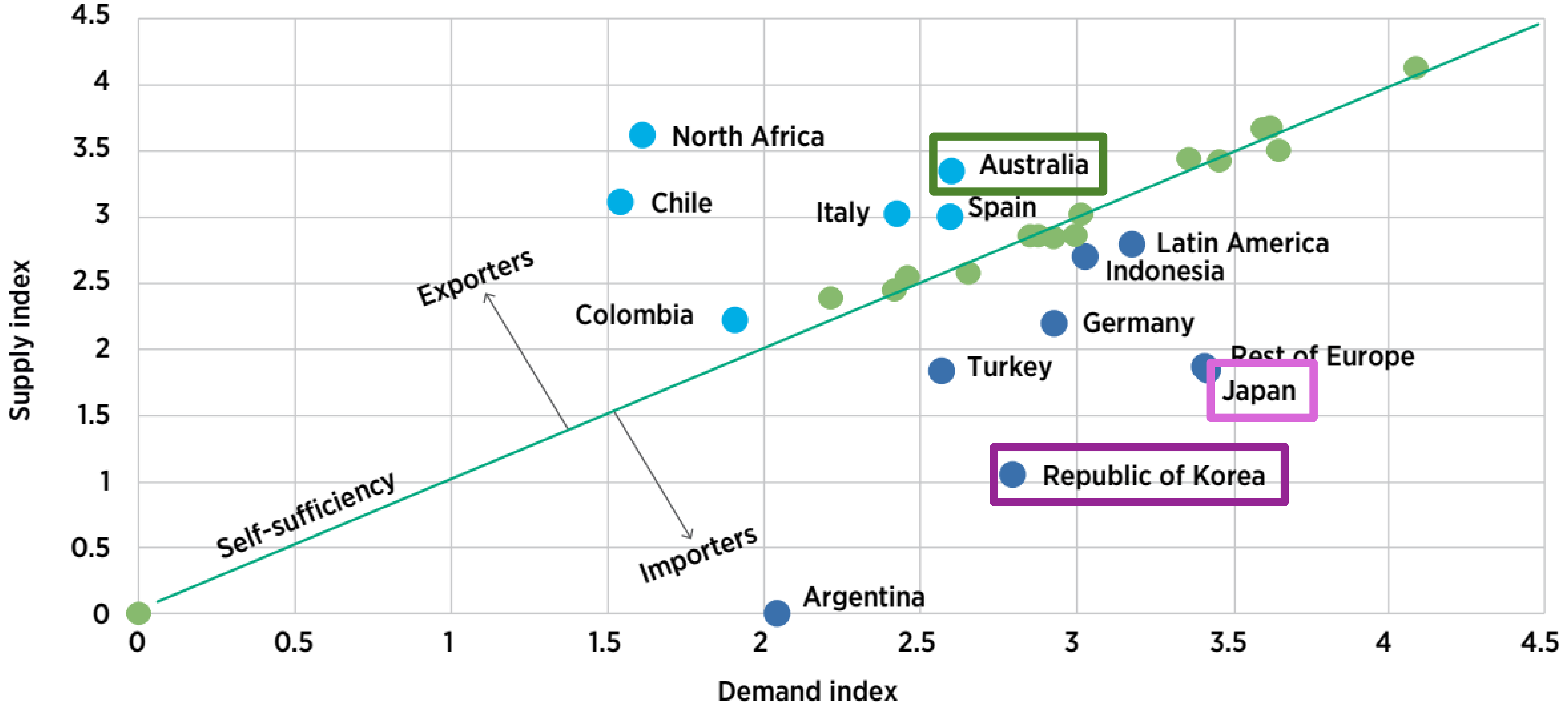
Most hydrogen today is used in oil refining and fertilizer production

By 2050, this grows to over 600 Mtonne of hydrogen



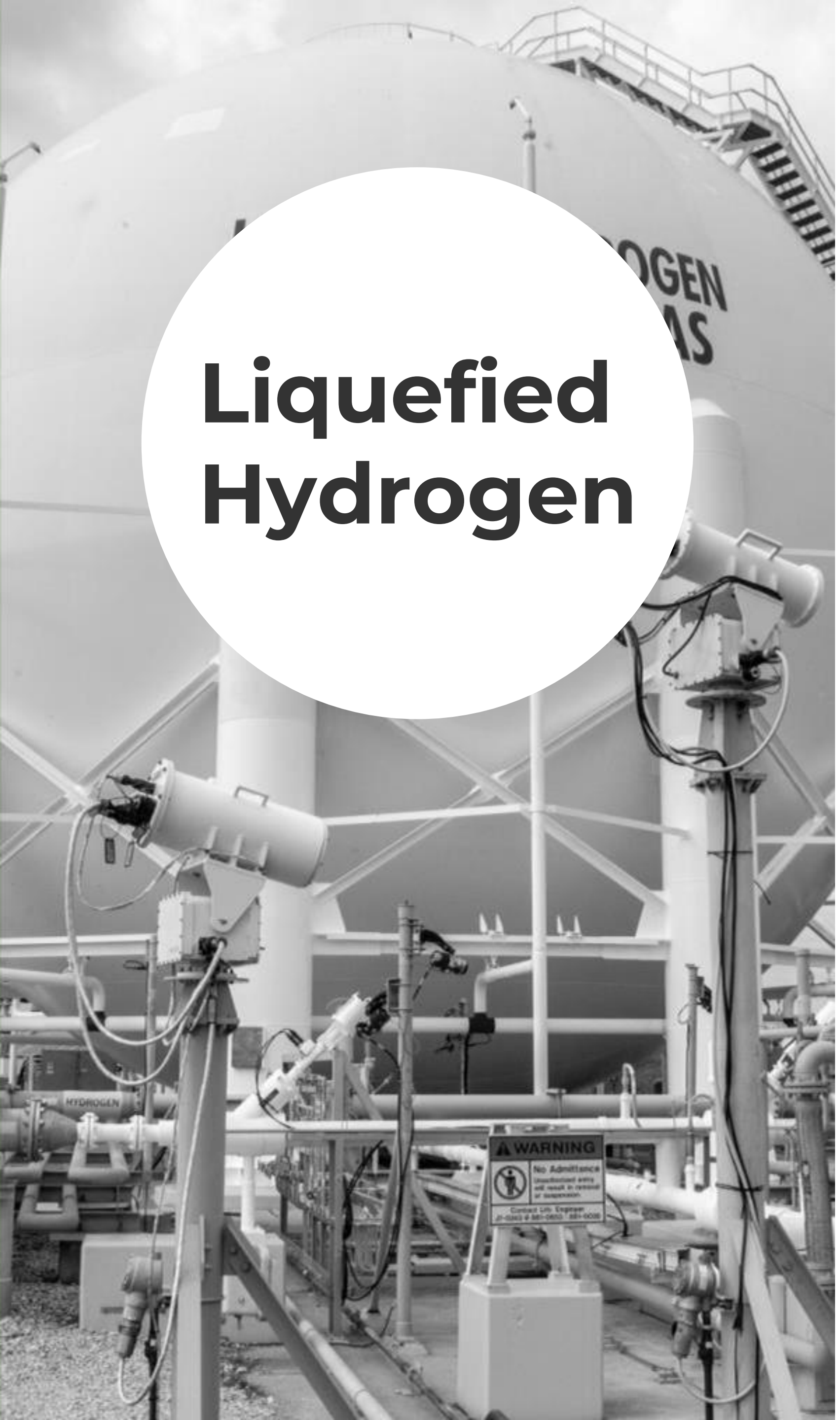
By 2050, hydrogen will be used for refining, fertilizers, steelmaking, power generation, and transportation

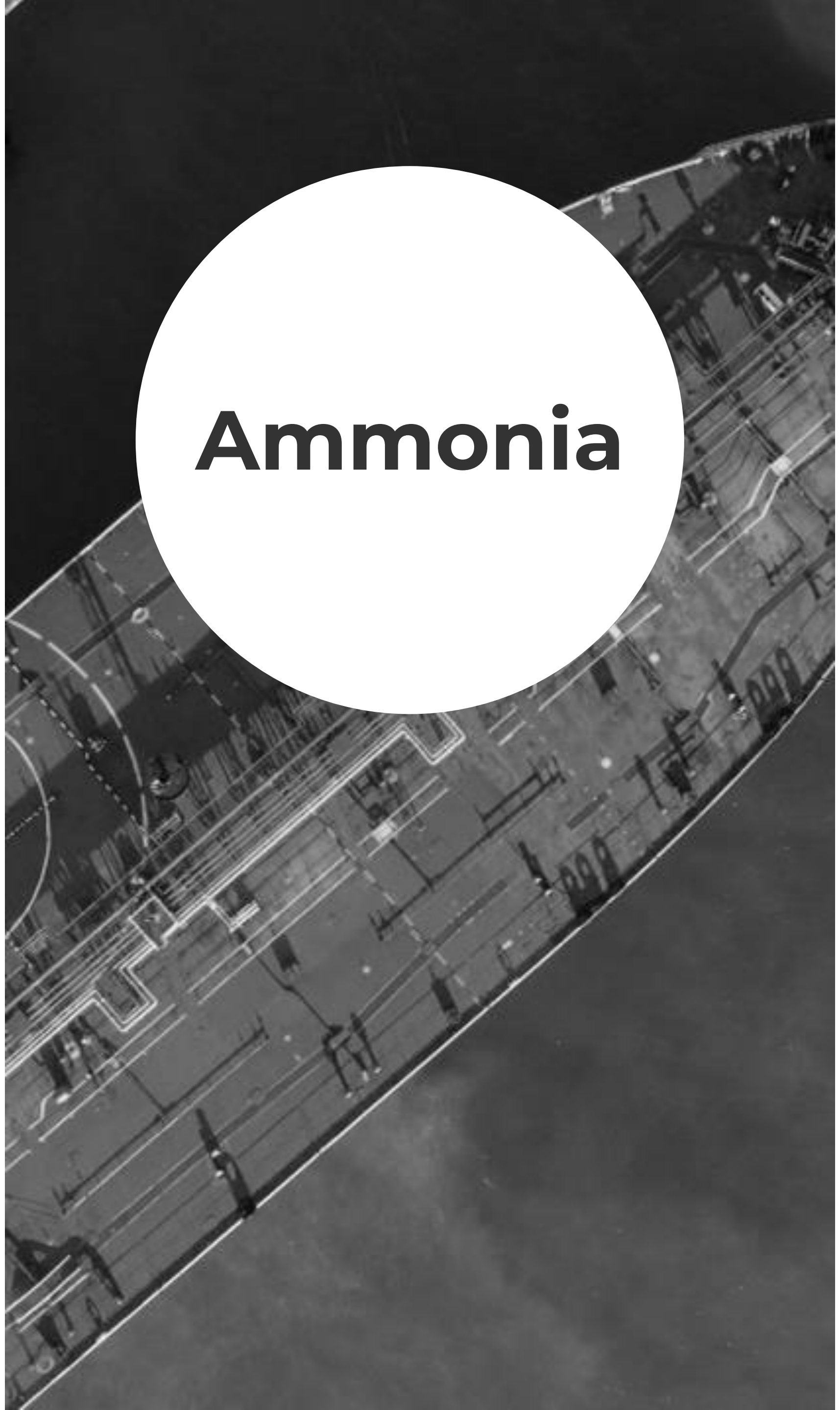
Not every country can be self-sufficient in their need for hydrogen



Source: International Renewable Energy Agency, "Global Hydrogen Trade To Meet The 1.5 °C Climate Goal (2021)"


5,000
nautical
miles





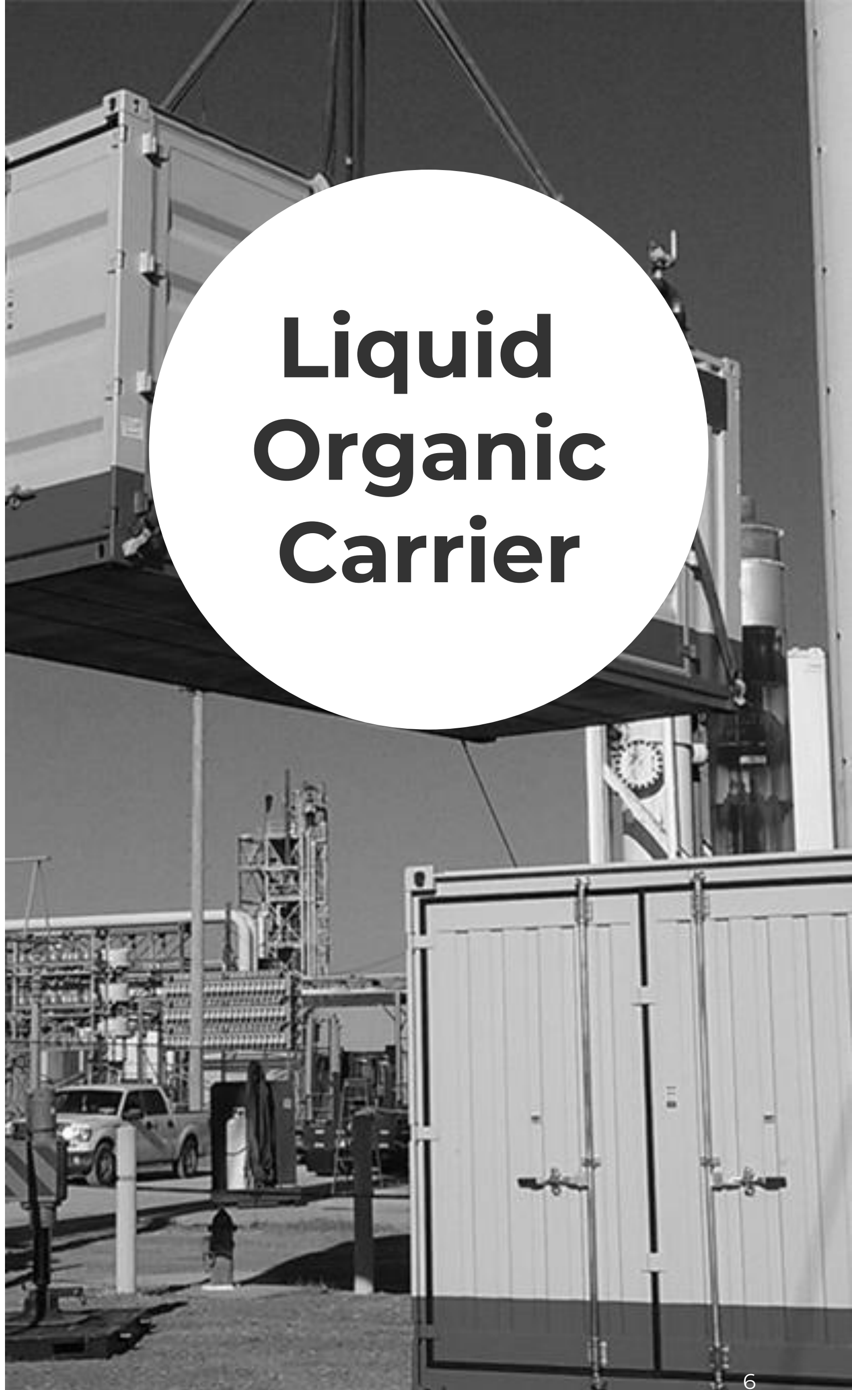


Image source: NASA, YARA, Hydrogenious LOHC Technologies

Liquefied hydrogen

Drivers:

- Liquefied hydrogen has a high hydrogen density of 66 kg H_2/m^3 and is stored at ambient pressure.
- Liquefied hydrogen is pure hydrogen and thus doesn't have contamination risks.
- Liquefaction technology is well understood and, while not widely adopted yet, can be scaled up quickly.

Barriers:

- The low temperatures needed for liquefaction require a high amount of energy and lead to high rate of hydrogen loss through boil-off.
- Liquefied hydrogen can't utilize existing liquefied natural gas infrastructure for transport and requires specialized tankers that aren't yet commercial.

Image source: NASA

The **Hydrogen Energy Supply Chain (HESC)** joint-venture demonstrated the transport of liquefied hydrogen from Australia to Kobe, Japan, in February 2022.

The project is now looking to scale to the commercial phase of producing 225,000 tonne of hydrogen per year.

Image source: Kawasaki

Ammonia

Drivers:

- In its liquid state, ammonia has an exceptionally high hydrogen weight fraction.
- Ammonia is a globally traded commodity chemical and thus benefits from an already mature supply chain.
- Ammonia can, in principle, be combusted directly in gas turbines, removing the need for hydrogen extraction.

Barriers:

- Ammonia is highly toxic, which limits its adoption to port-to-port use — inland distribution and consumption are unlikely.
- Hydrogen extraction from ammonia is immature, energy intensive, and can result in trace ammonia contaminants in the hydrogen product.

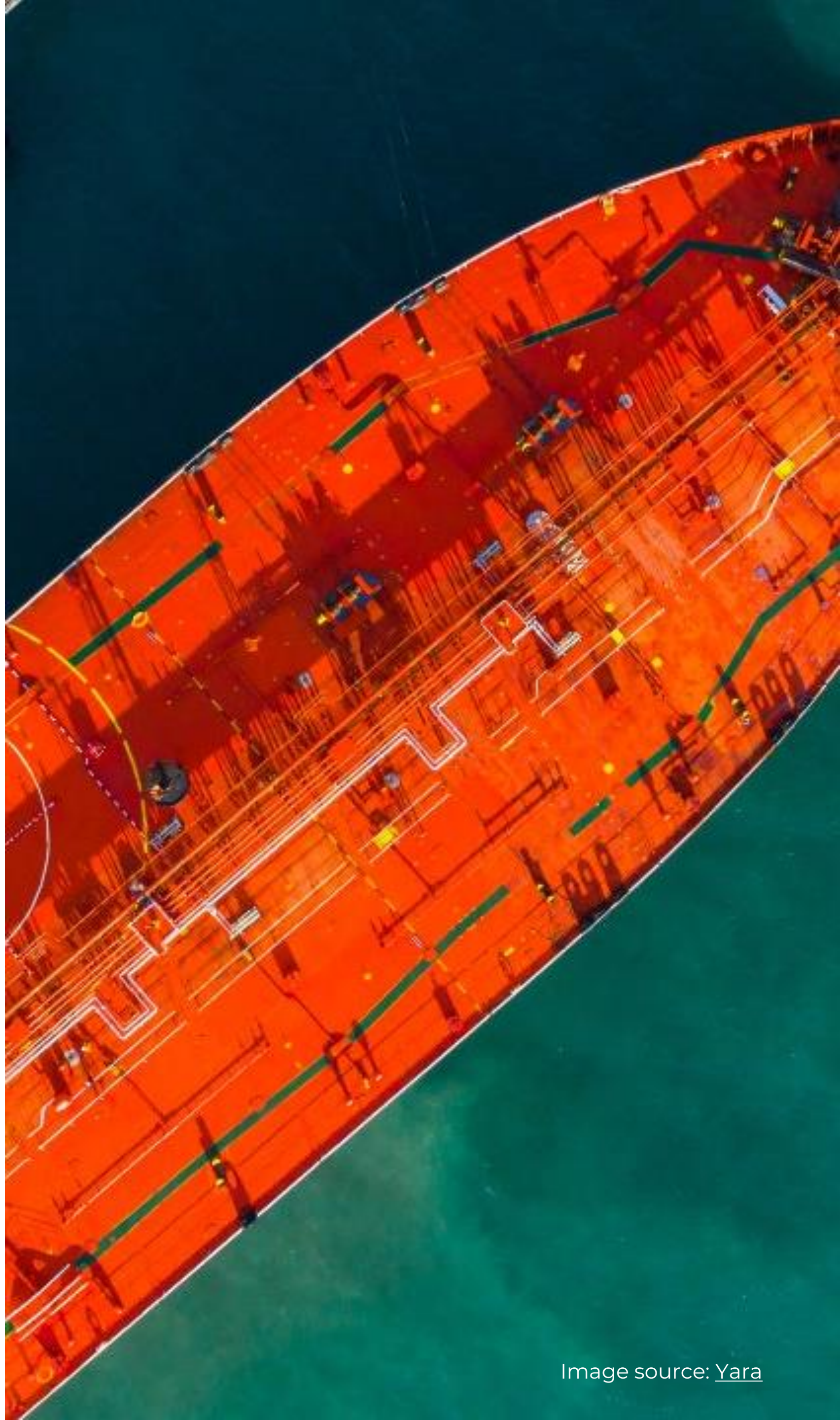


Image source: Yara

Korea Zinc, **Hanwha Impact Corp.**, and **SK Gas** formed the Han-Ho Hydrogen Consortium to build a 3-GW green energy project in Australia to produce and export ammonia to South Korea.

Final investment decision is expected by 2028.

Liquid organic carrier

Drivers:

- Liquid organic hydrogen carriers (LOHCs) remain in liquid state at ambient pressure and temperature, minimizing hydrogen loss through leaks.
- LOHCs are compatible with existing hydrocarbon infrastructure and don't require new equipment.
- LOHCs have mild toxicity and flammability and can be used for inland storage and transport with minimal safety precautions.

Barriers:

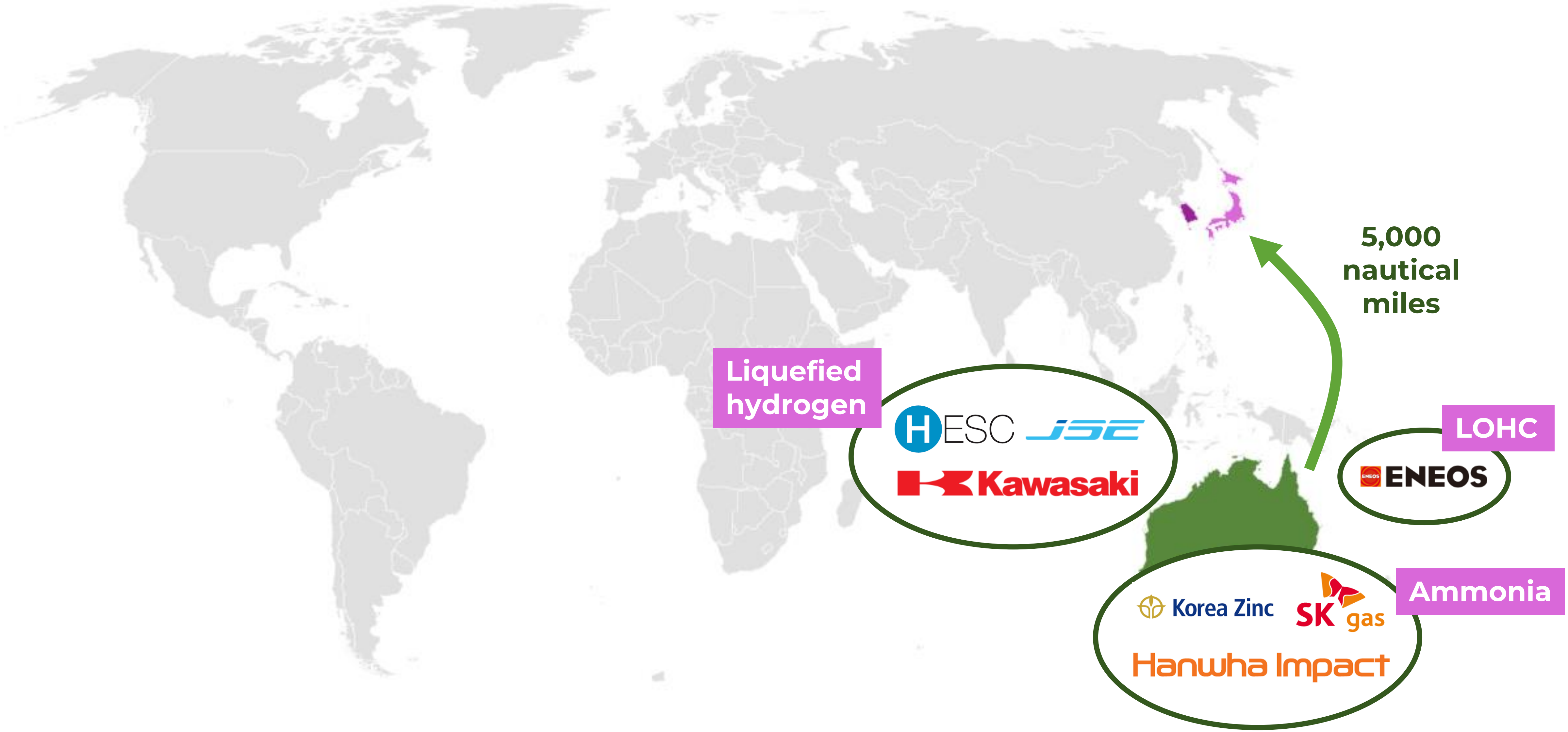
- LOHCs can't be used directly and require hydrogen extraction, which is energy intensive.
- LOHCs require a concurrent scale-up of the manufacturing of the carrier material.

Image source: Hydrogenious LOHC Technologies

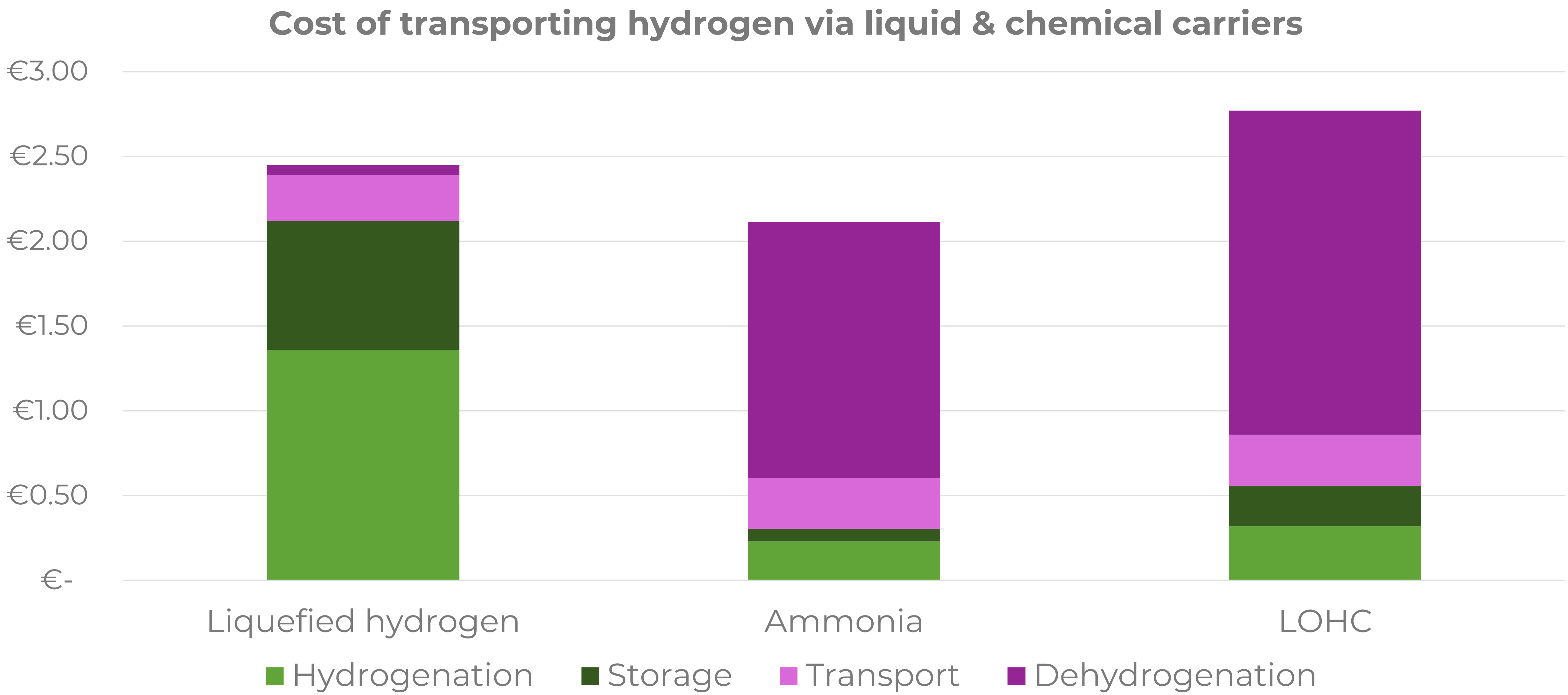
Eneos built a demo-scale LOHC plant in Brisbane, Australia, to demonstrate the use of methylcyclohexane (MCH) for transporting hydrogen to Japan.

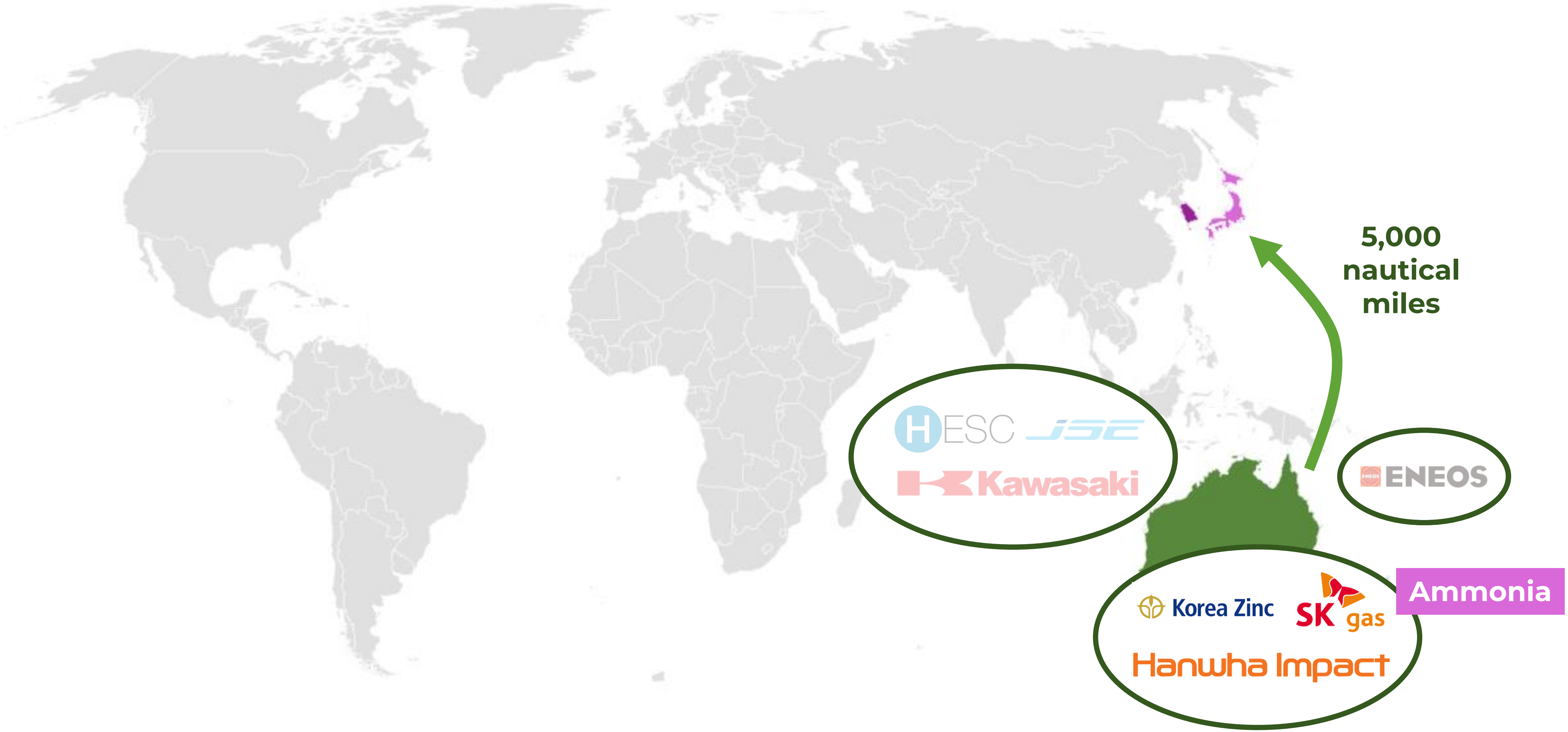
The demonstration project will last for one year.

Image source: ENEOSi


5,000
nautical
miles
Liquefied
hydrogen
HESC
Kawasaki
LOHC
ENEOS
Ammonia
Korea Zinc
SK gas
Hanwha Impact

International shipping of hydrogen will add USD 2.00 –USD 3.00/kg of hydrogen




5,000
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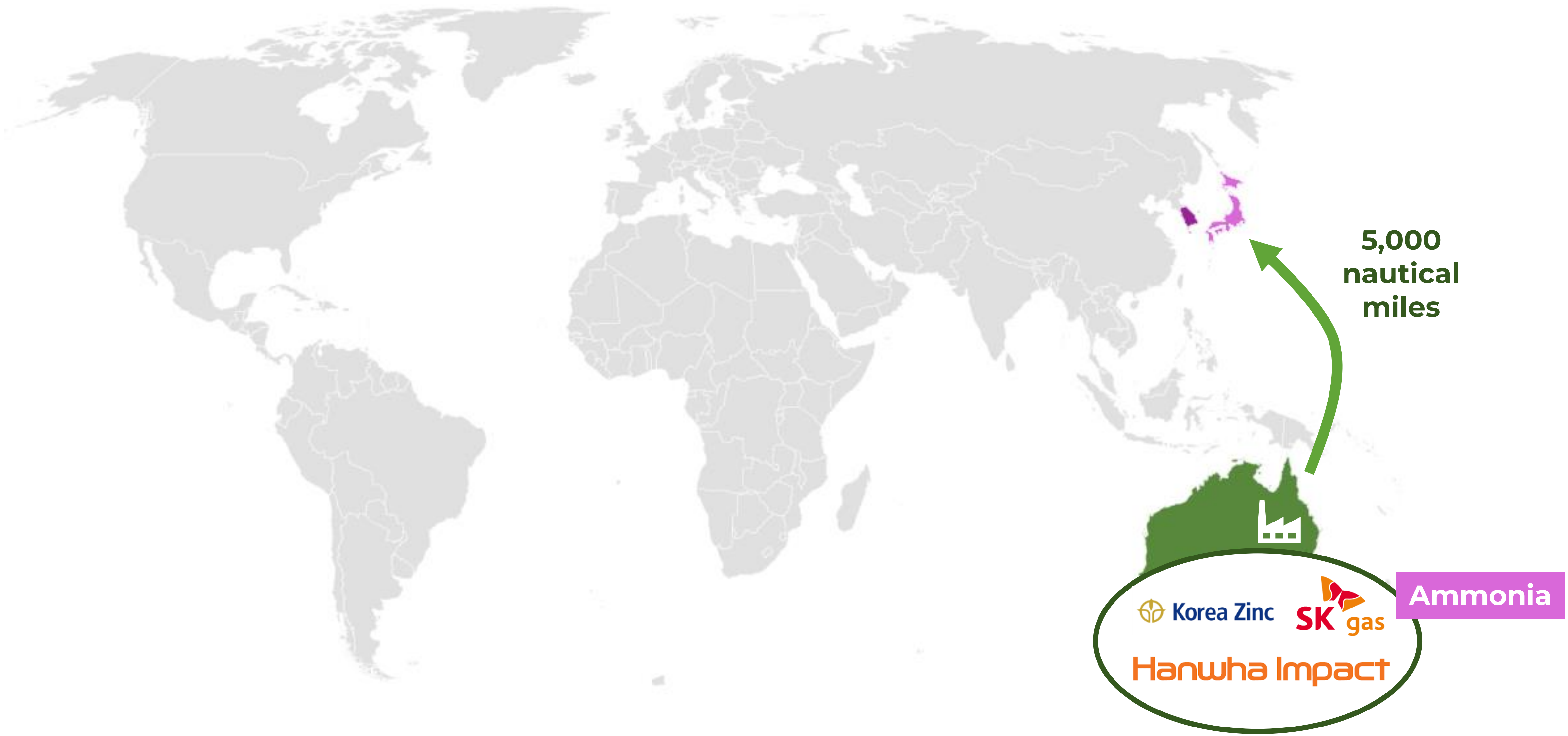
Ammonia


5,000
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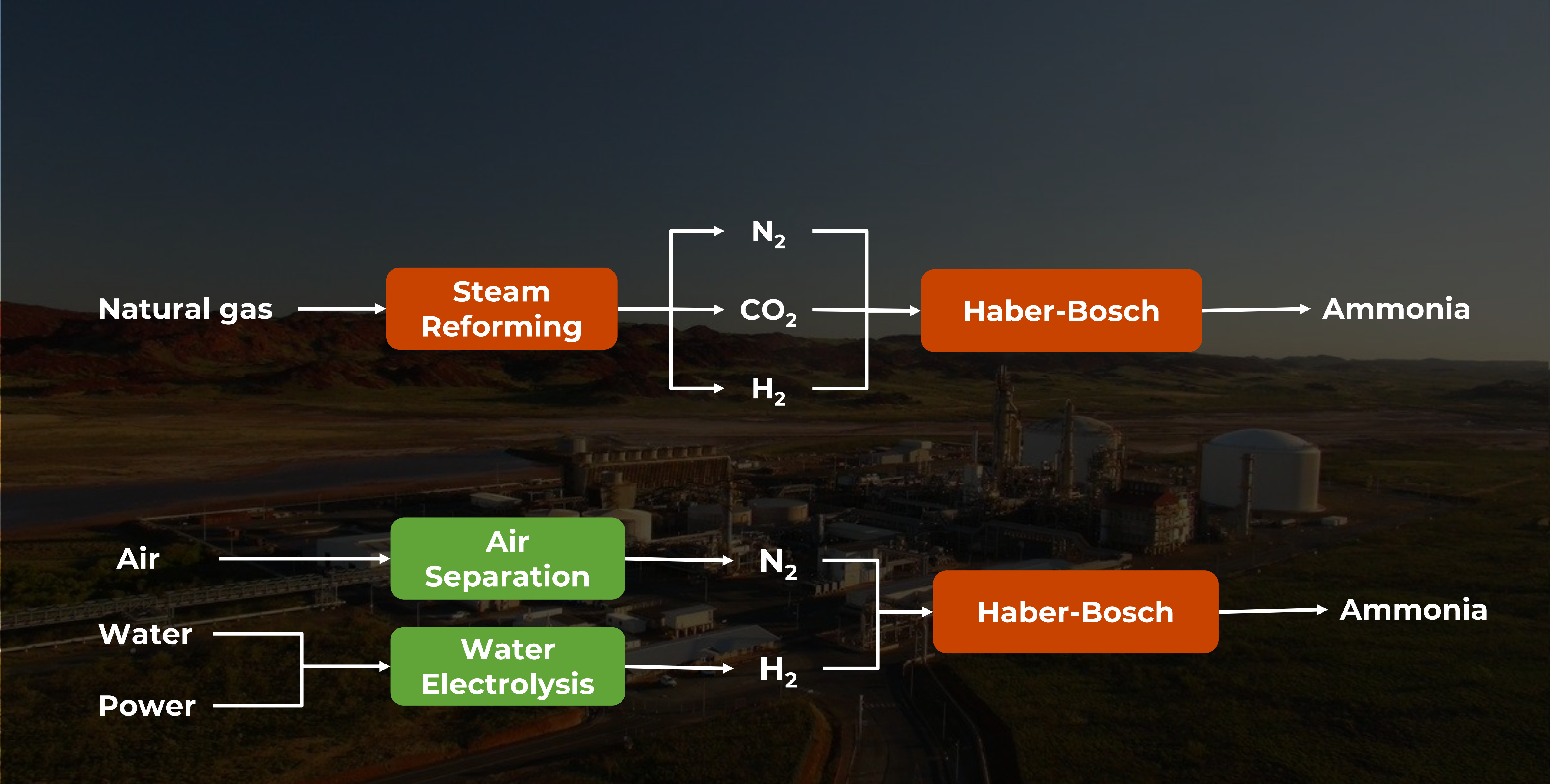
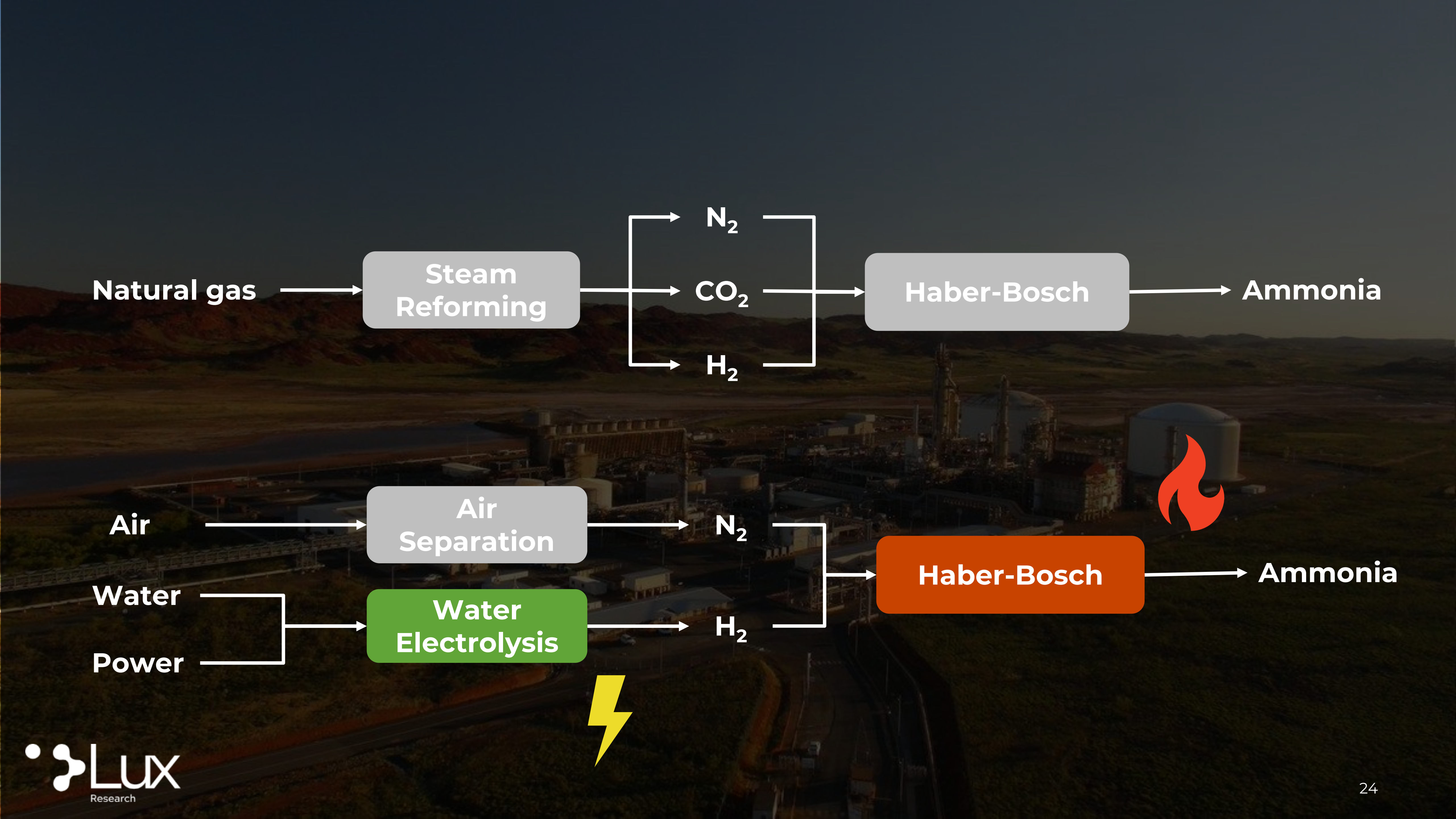


Natural gas
Steam Reforming
N_2
CO_2
H_2
Haber-Bosch
Ammonia
Air
Water
Power
Air Separation
Water Electrolysis
N_2
H_2
Haber-Bosch
Ammonia

Lux Research

AMMONIA GENERATION TECHNOLOGY LANDSCAPE

KBR	CASALE	thyssenkrupp	TOPSOE	CLARIANT
Stamicarbon	JM			
Starfire Energy	liquium	COPERNIC	FuelPositive	ReMo ENERGY
Tsubame BHB	AMMPOWER			


Natural gas
Steam Reforming
N2
CO2
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Haber-Bosch
Ammonia
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N2
H2
Haber-Bosch
Ammonia
Lux
Research

Topsoe, Vestas

Vestas TOPSOE

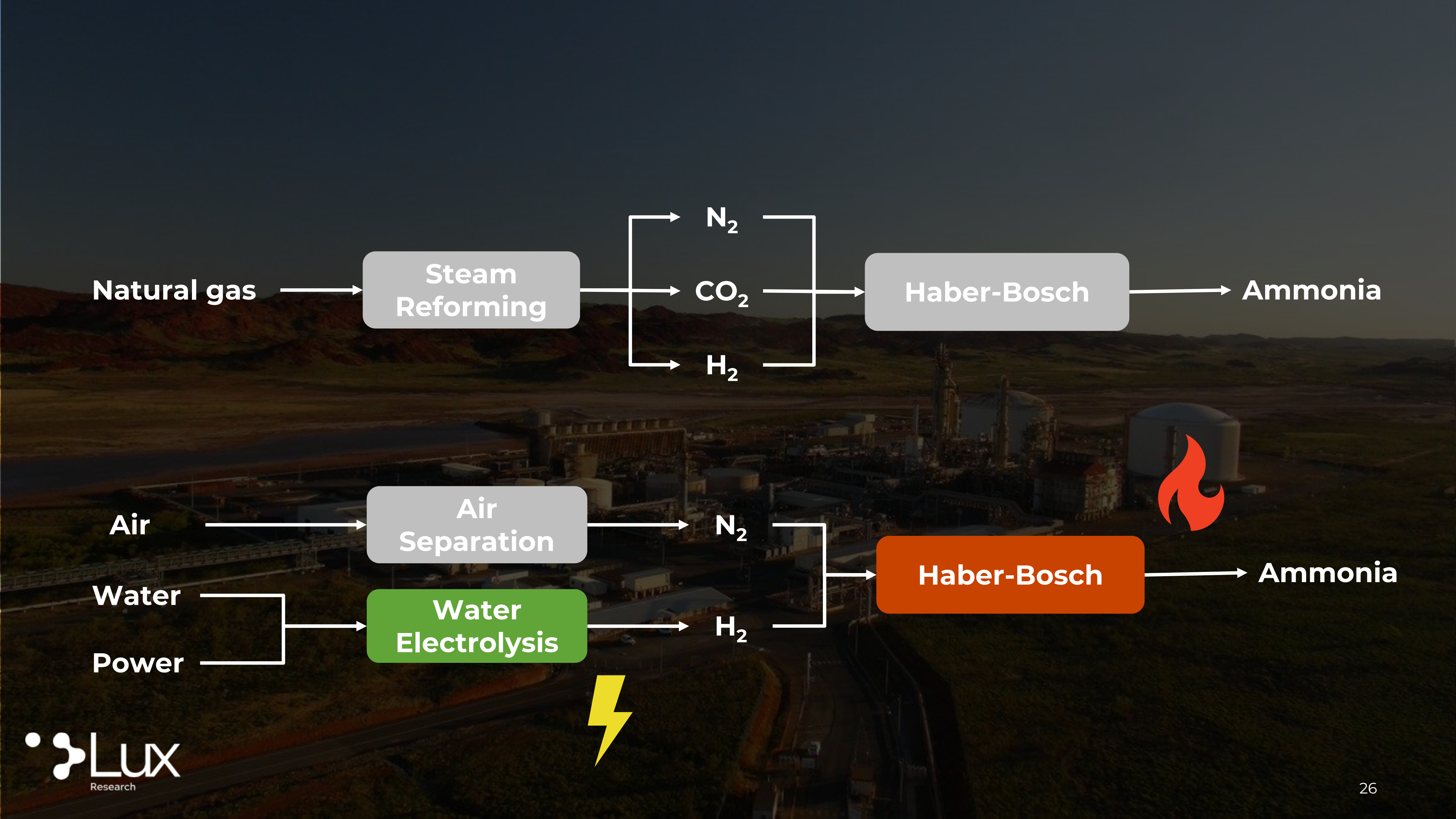
Dynamic green hydrogen production

- Vestas will connect the wind turbines and solar panels directly to an electrolyzer, removing the need for energy storage.
- Topsoe will design the Haber-Bosch process to handle fluctuations in hydrogen input.
- First 10-MW demo unit expected to come online by 2023; electricity supplied by 12-MW wind turbines and 50-MW solar panels.
- Raised EUR 11 million from Danish Energy Agency in June 2021.

Lux Take

The project will overcome a key barrier in green ammonia and may serve as the blueprint for future power-to-x industrial projects combining electrochemistry with thermochemical processes.

Image source: Vestas



Natural gas
Steam Reforming
N2
CO2
H2
Haber-Bosch
Ammonia
Air
Water
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Air Separation
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N2
H2
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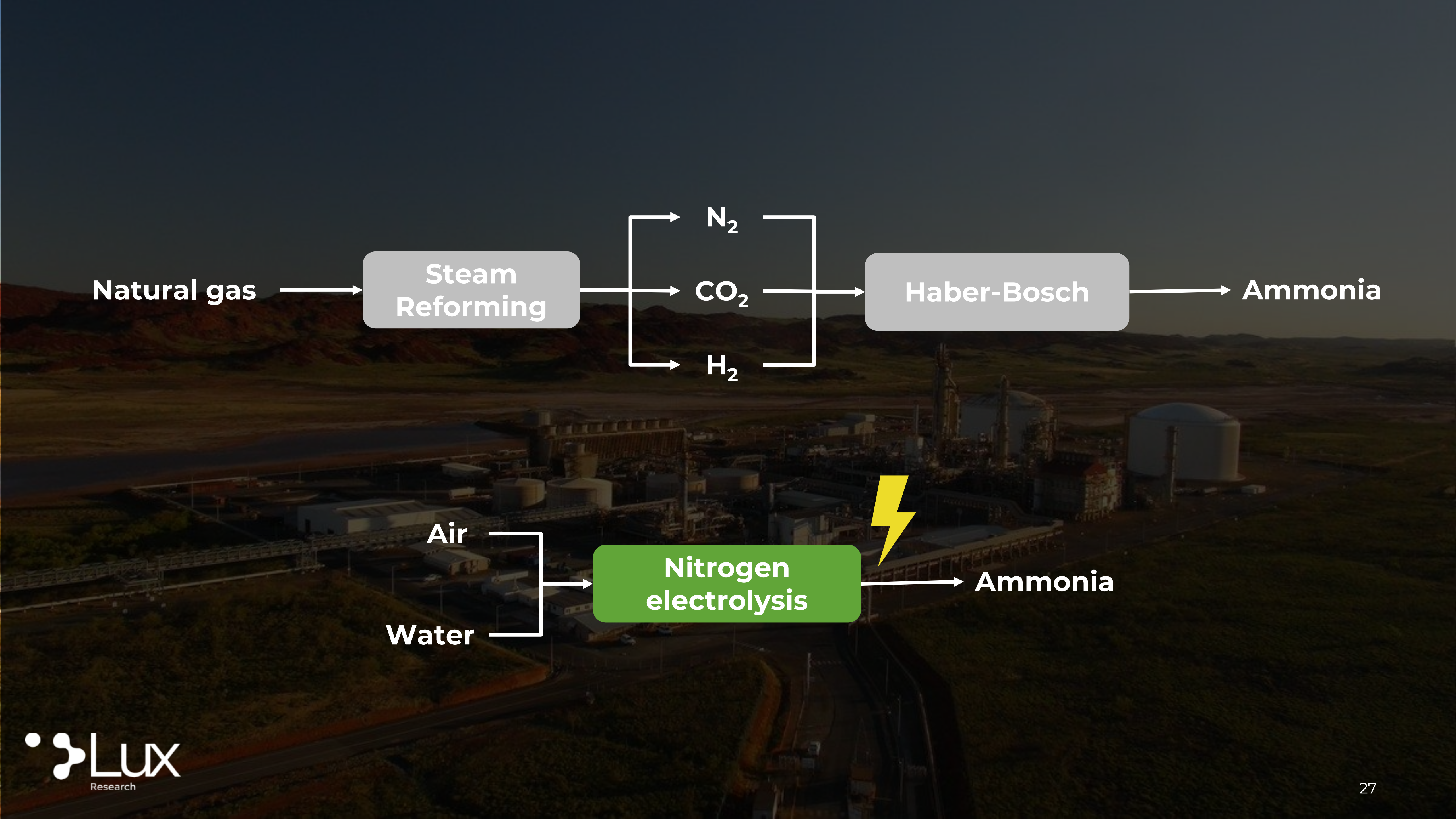

Natural gas
Steam Reforming
N_2
CO_2
H_2
Haber-Bosch
Ammonia
Air
Water
Nitrogen electrolysis
Ammonia
Lux Research

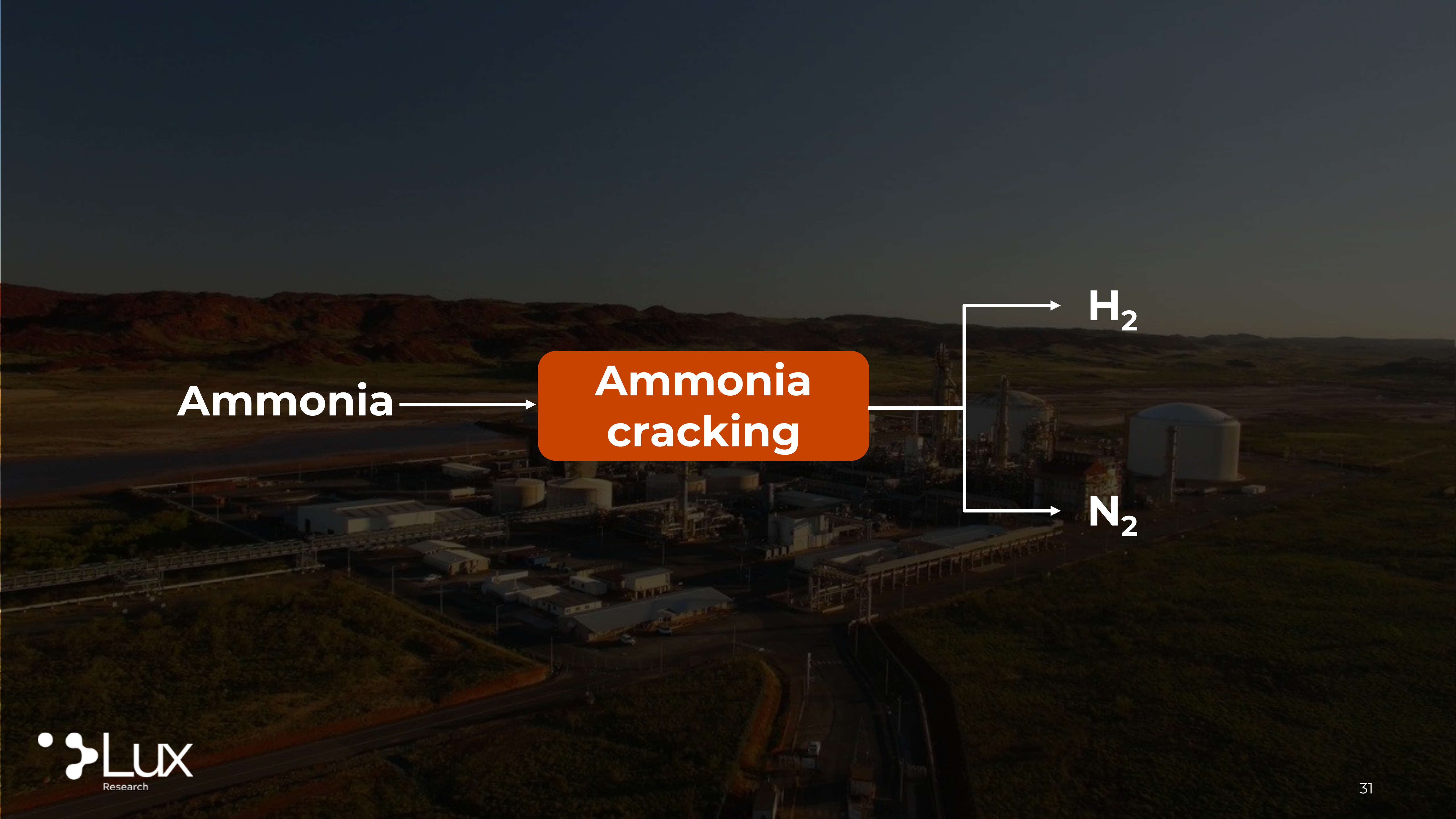
Jupiter Ionics produces ammonia by reducing nitrogen from the air and hydrogen extracted from water.

It uses a phosphonium salt in the electrolyzer.

JUPITER IONICS

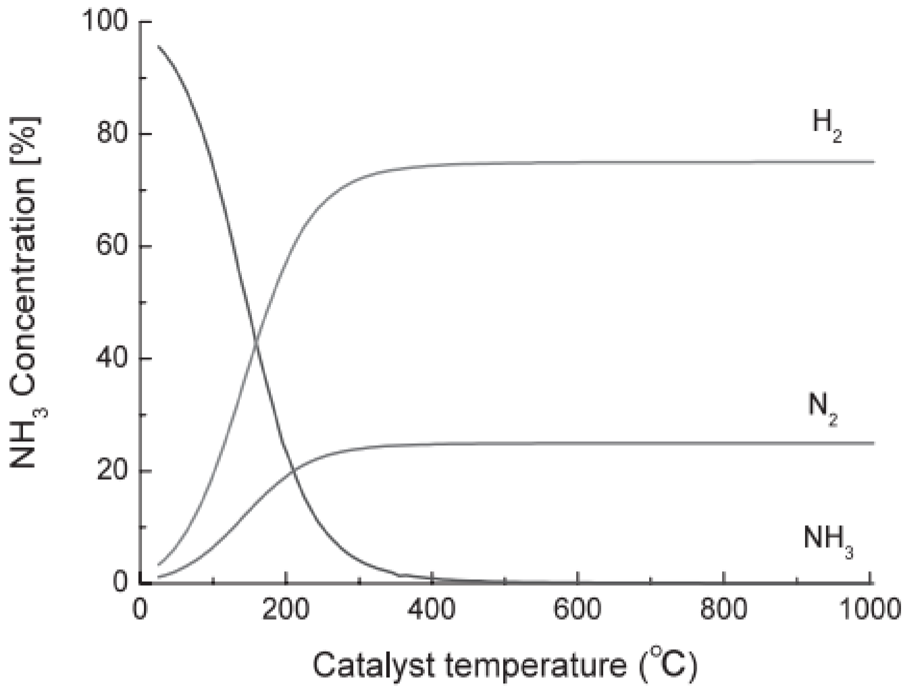

5,000
nautical
miles
Korea Zinc
SK gas
Hanwha Impact


5,000
nautical
miles
Korea Zinc
SK gas
Hanwha Impact


Ammonia
Ammonia cracking
H2
N2
Lux Research

Ammonia cracking requires a catalyst and high temperatures to overcome the slow decomposition rate

Ammonia can be cracked into hydrogen using a catalyst. Without a catalyst, the decomposition reaction is too slow. Once the reaction runs, it creates a thermodynamic equilibrium composition in the gas.



Equilibrium gas composition for ammonia at atmospheric pressure (vol. %).

Designing a good ammonia decomposition system requires:

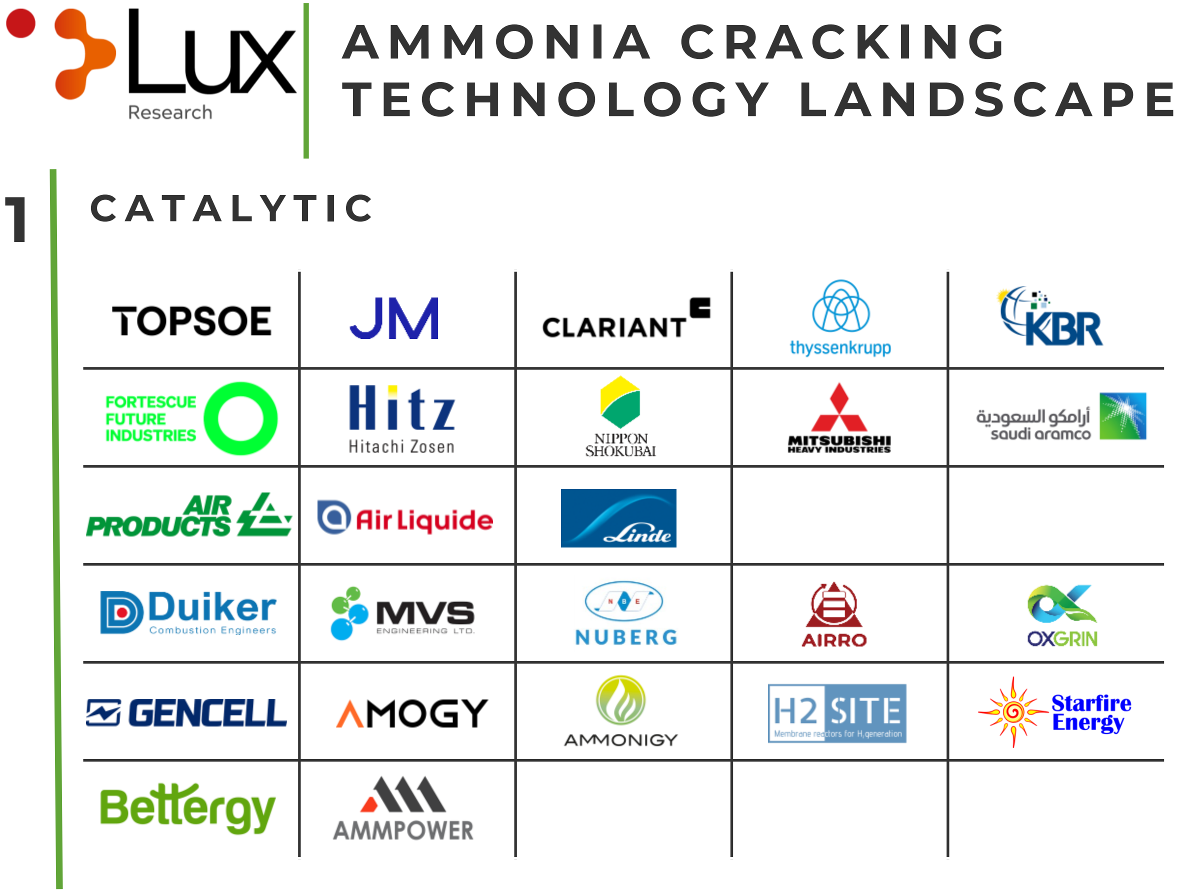
1. A cost-effective way of achieving high temperature
2. A cost-effective gas treatment to remove ammonia

The system design is a trade-off between energy costs for heating and costs of ammonia recovery.

Catalytic platforms will be the de facto technology for ammonia decomposition at industrial scale

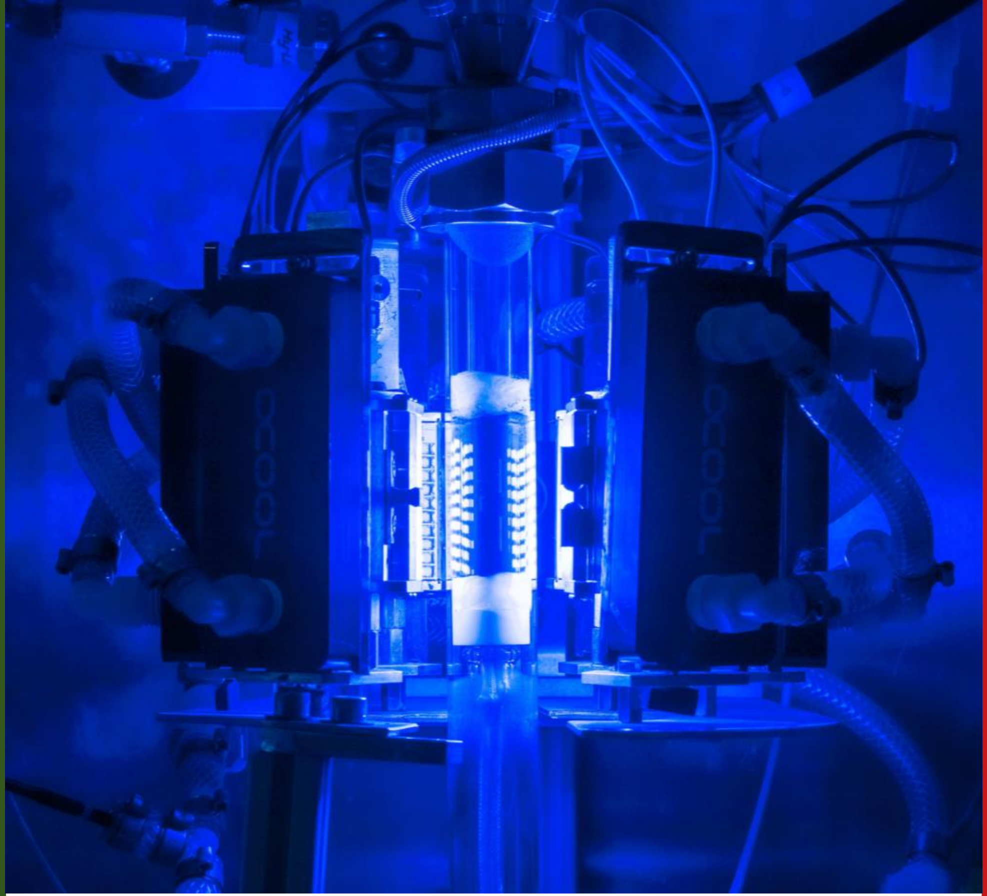
Commercial activity in ammonia decomposition is set to skyrocket in the near term. A full ammonia value chain isn't complete without decomposition, which means that increasing efforts in development and commercialization should be expected.

Competition will intensify in the near term as companies will want to establish a leadership position by being the first to deploy an industrial-scale facility.



Lotte Chemical, Sumitomo Corporation of Americas, and **Syzygy Plasmonics** will deploy a photocatalytic ammonia cracker at Lotte's HQ in Ulsan, South Korea.

The reactor is set to come online by 2024.

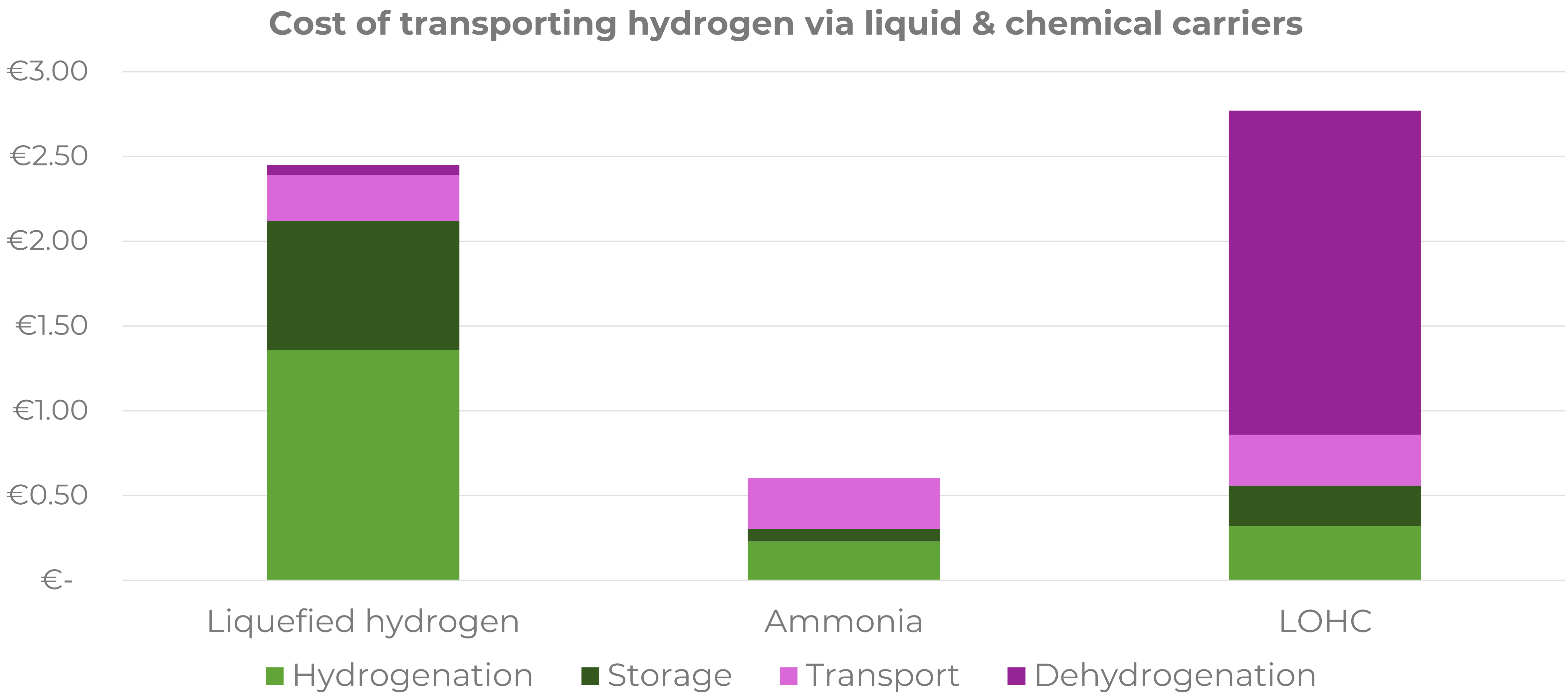


LOTTE CHEMICAL

SYZYGY PLASMONICS

Sumitomo Corporation of America

You don’t need to crack ammonia if you can use it directly



IHI is developing combustors to attain 100% liquid-ammonia-fueled firing in gas turbines.

It already reached 70% co-firing and aims to reach 100% by 2030.

Key Takeaways

1 There will be an imbalance in hydrogen within Asia

Hydrogen will have to be traded to fill in supply gap

2 Ammonia will be the main carrier for hydrogen

It’s the most cost effective and easiest to implement

3 It all starts at the port

The first hydrogen hubs in Asia will leverage port infrastructure

Thank you

A link of the webinar recording will be emailed within 24–48 hours.

UPCOMING WEBINARS

JUNE 8

Net-Zero: The Emergence of an Ammonia Economy in Europe

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