

Decarbonisation in ammonia production: An update from the Ammonia Energy Association

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AMMONIA ENERGY
ASSOCIATION



Ammonia Energy Association

- The Ammonia Energy Association (AEA) is a global industry association that promotes the responsible use of ammonia in a sustainable energy economy
- **Supply:** decarbonize ammonia production
- **Demand:** adopt ammonia in energy markets
- **Members:** global and cross-sectoral



AMMONIA ENERGY
ASSOCIATION

MEMBER LIST — May 2022

PLATINUM: bp, CF Industries*, CWP Global, Denbury Inc., The Hydrogen Utility*, InterContinental Energy*, KBR*, LSB Industries, Mitsui & Co., Monolith Materials, Nutrien*, OCI*, Starfire Energy*, Yara*. **GOLD:** AFC Energy, Airgas, Aker Clean Hydrogen, Asian Renewable Energy Hub, Casale*, Enaex, Engie, Equinor, Fortescue Future Industries, FuelPositive, Haldor Topsøe*, Hamilton Locke, Marnco, Mitsubishi Heavy Industries, Origin Energy*, Proton Ventures*, S&P Global Platts, Syzygy Plasmonics, thyssenkrupp Industrial Solutions*, Trammo, Trigon, Tri-State Generation & Transmission. **SILVER:** AES Gener, Air Products, Ammonigy, AmmPower, Amogy, Argus Media, BASF, Black & Veatch, Bureau Veritas, Burns & McDonnell, Casa dos Ventos, Consorcio Eólico, CRU Group, CS Combustion Solutions, Copenhagen Atomics, Cummins, EIFER, Enterprize Energy, Fertiberia, GenCell Energy, GTI Energy, Gunvor Group*, H2Site, Heraeus, Horisont Energi, HyFuels Holdings, IHI Americas, Inherent Solutions Consult, inodú, Intecsa Industrial, Johnson Matthey, Koch Fertilizer, Linde, Lotte Fine Chemical, Mabanaf, Maersk*, Mercuria, MineARC Systems, Mitsui OSK Lines, Nel Hydrogen*, Pacific Green Technologies, SagaPure*, Schoeller-Bleckmann Nitec, Shell, Skeiron, Sperre Industri, Stamicarbon, Talos Energy, Thorium Energy Alliance*, TotalEnergies*, Tsubame BHB, Universal H2, Wonik Materials, Woodside Energy. **MEMBERS:** AB Achema, Advanced Ionics, Advanced Thermal Devices, AHMON, Air Liquide, Airthium, Apex Clean Energy, Arizona Public Service, Ark Energy, Arranged, AustriaEnergy, Avaada Energy, Axetris, BLG, Brittany Ferries, C-Job Naval Architects, Carbon-Neutral Consulting*, CHZ Technology, ControlRooms, Cozairo, Cura IT, Danaos Shipping, Duiker Combustion Engineers, El-H2, Energy Estate, Eneus Energy, ESNA, Evergy, Exmar, George Propane, GESCA, Greenfield Nitrogen, GTT North America, Idemitsu Kosan, Incitec Pivot, Ingenostrum, IT Power Australia, JGC Holding Corporation, John Cockerill, Jupiter Ionics, Keppel Infrastructure, Koole, Mainspring Energy, MAN Energy Solutions, MicroEra Power*, Moda, Nebraska Public Power District, Neology, Netsco, New Energy Technology, NGLStrategy, Nordex, Northern Nitrogen, NovoHy, NYK Energy Transport (USA), Oceanic Vessels, Oiltanking, Osaka Gas USA, Renewable Hydrogen Corporation Canada, SAFCell, SBM Schiedam, Shrieve Chemical Company, Syntex, Terrestrial Energy, Tokyo Gas, Unconventional Gas Solutions, UPC\AC Renewables, Vahterus, Varo Energy, Vopak.



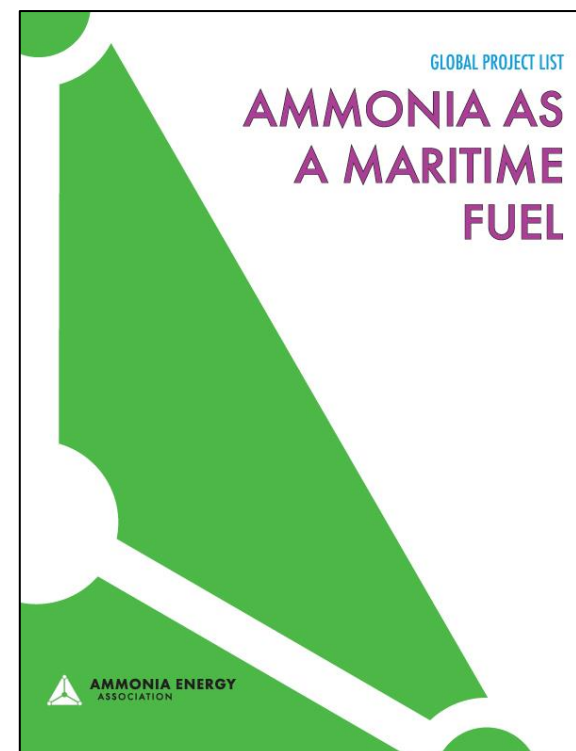
Ammonia Energy Association



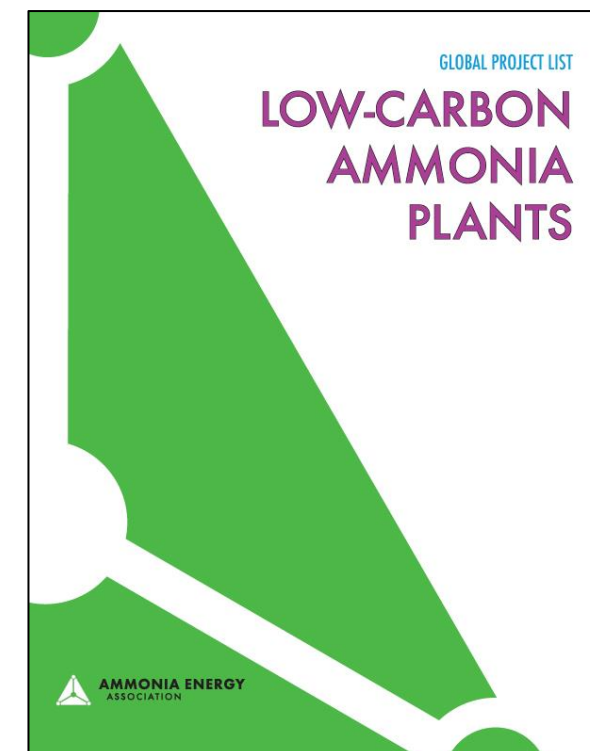
Develop certification
scheme for low carbon
ammonia



Innovation Outlook:
Renewable Ammonia.
(collaboration with
IRENA)

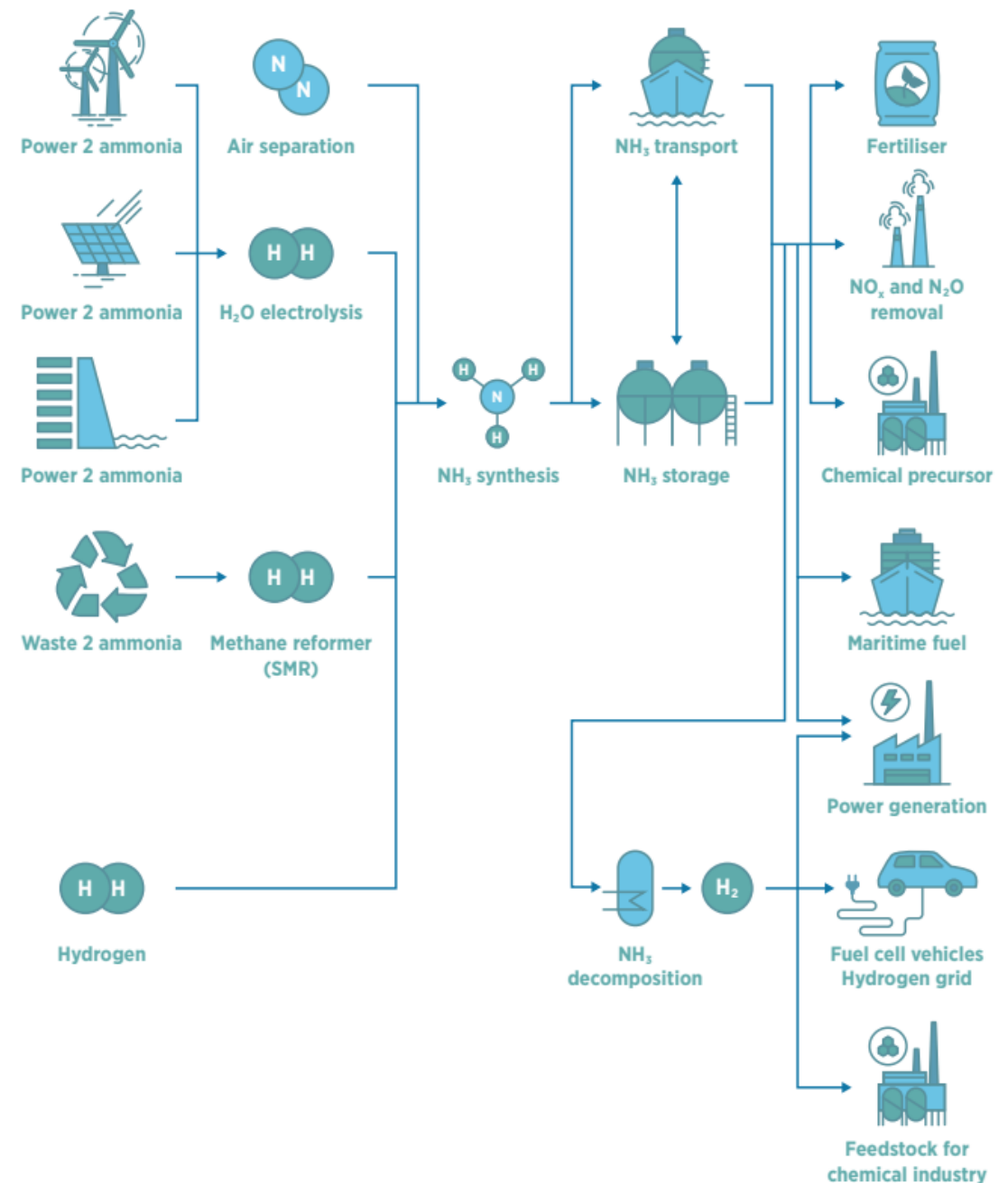
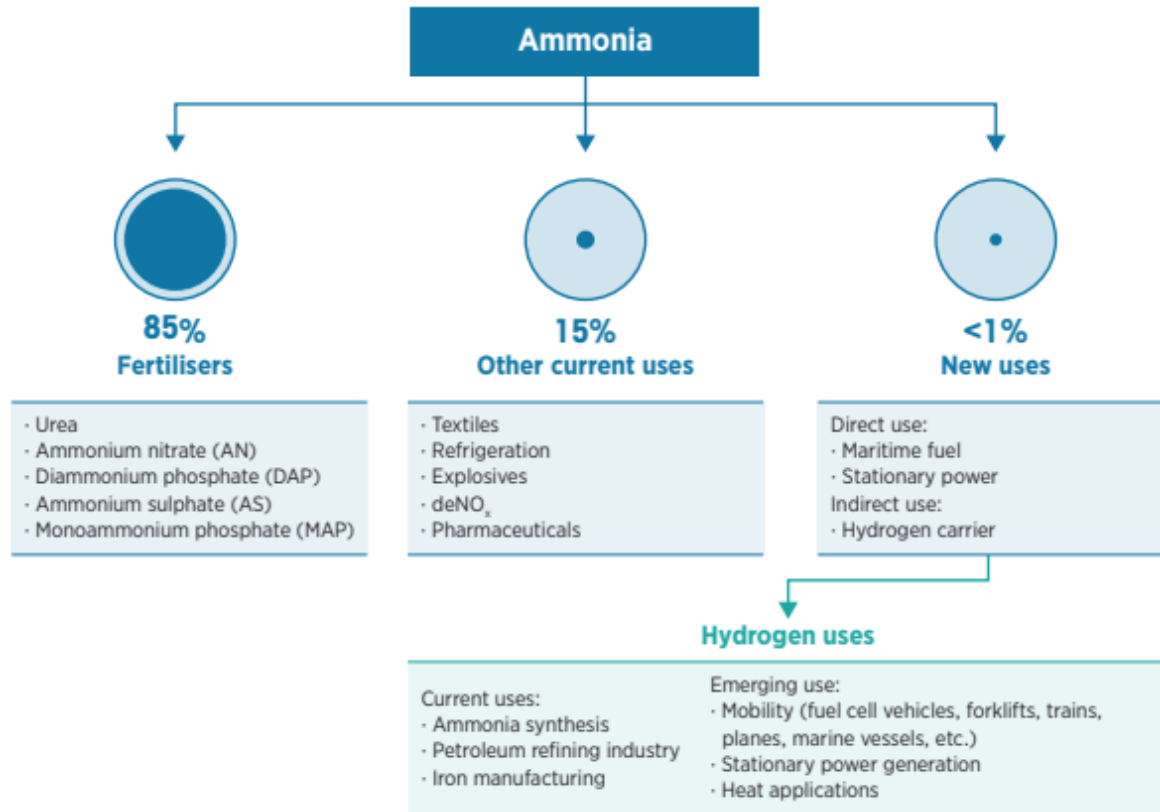


Mapping maritime
ammonia projects
(+ webinars)



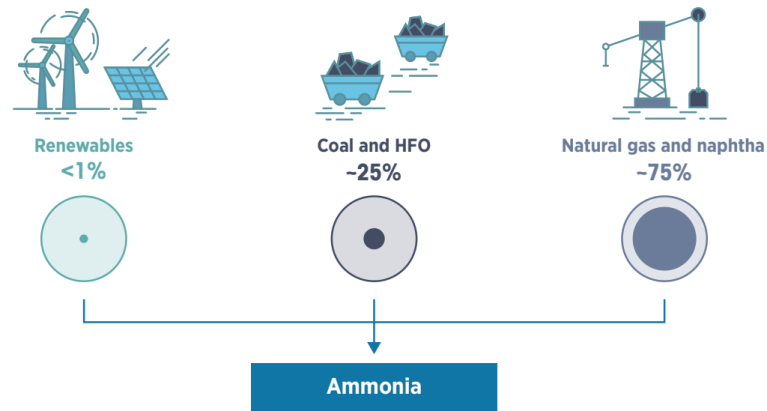
Mapping low carbon
ammonia plants
(+ webinars)

Why ammonia?

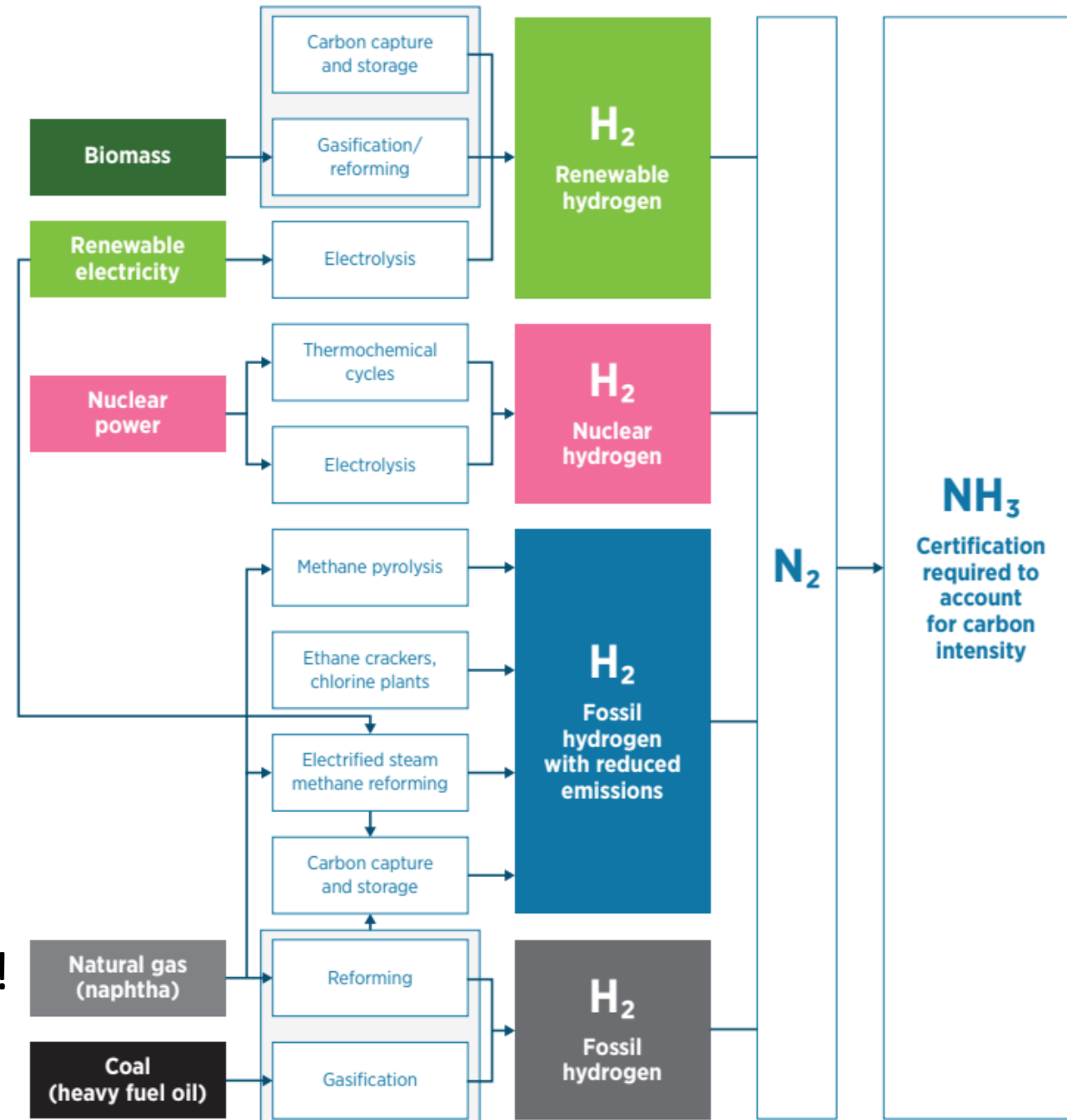


Production pathways

Current production (183 Mt) exclusively fossil:

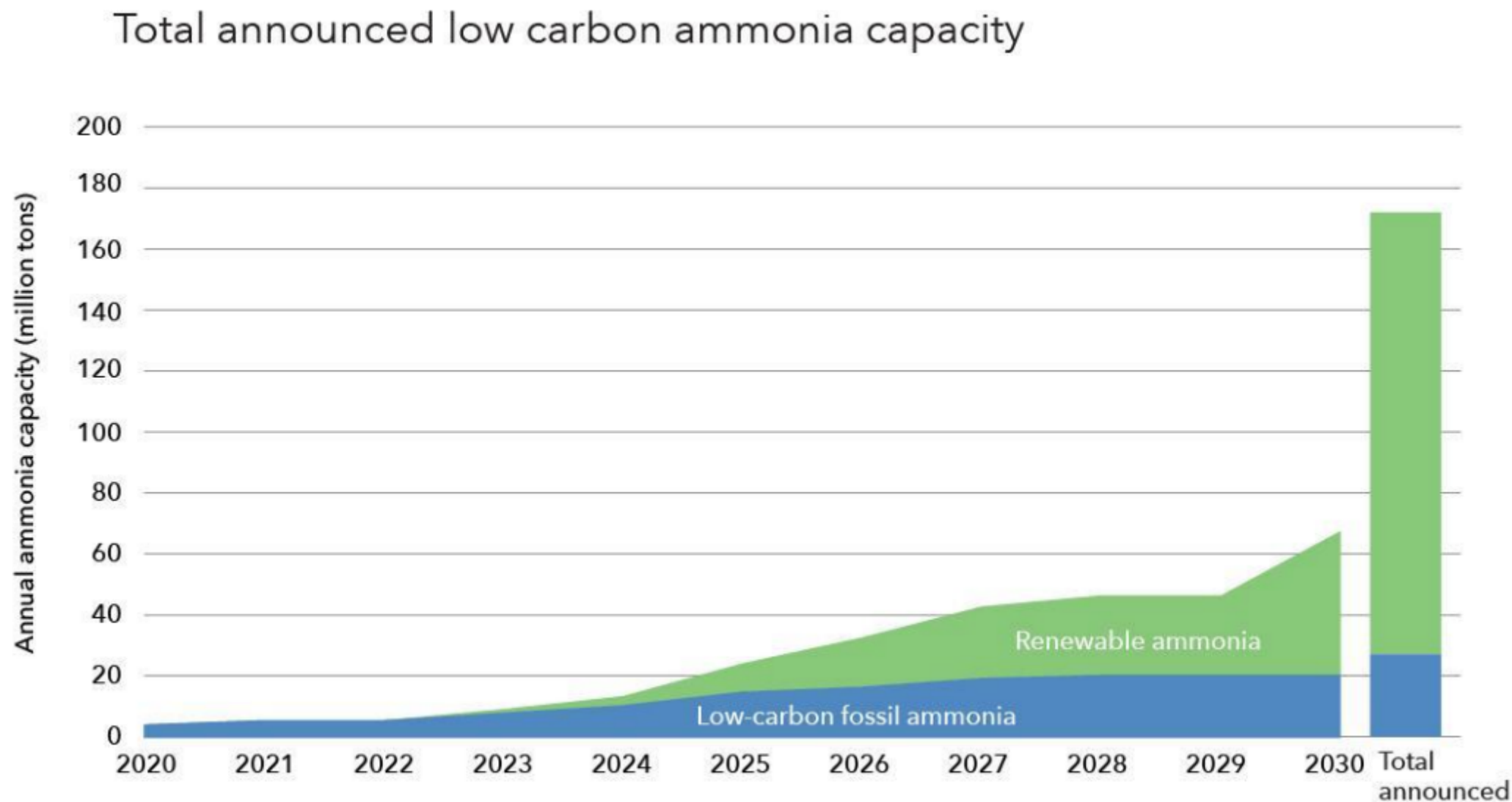


- About **90% of the energy input** for H_2 production, so determines CO_2 footprint!
- Colours of ammonia \neq carbon footprint, as depends on Scope 1-3 emissions





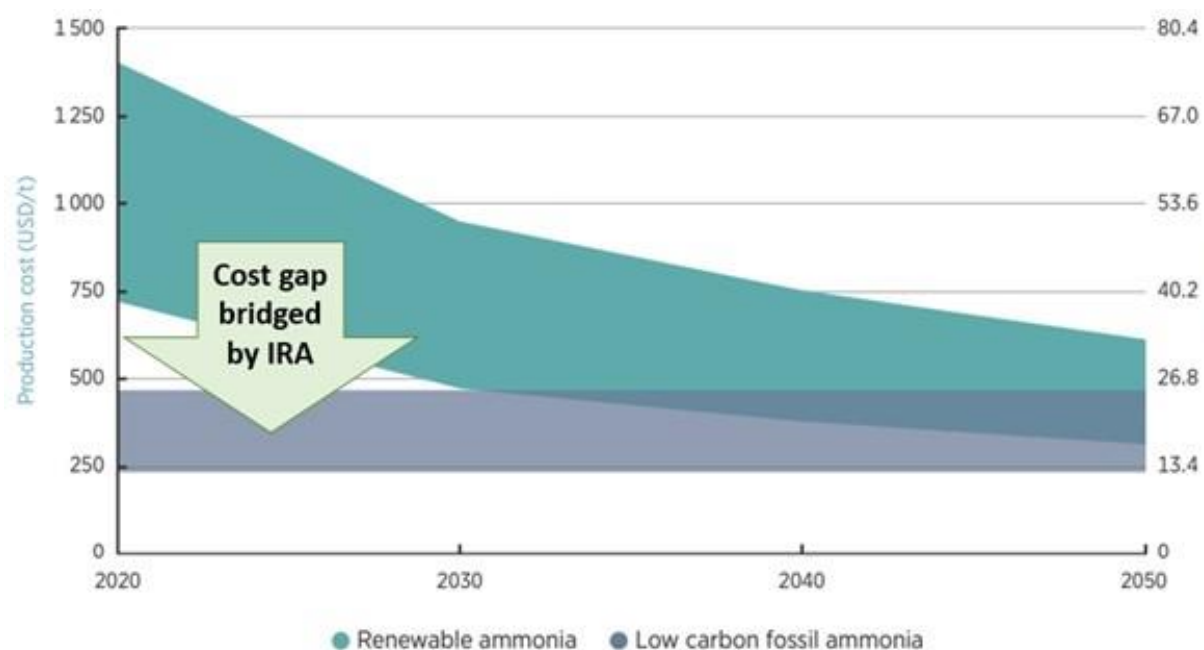
Decarbonising ammonia production





Recent policy developments

- **EU:** EU ETS & CBAM (Shipping fully introduced in ETS by 2026)
- **USA:** IRA up to 3 USD/kg-H₂ tax credit → 533 USD/t-NH₃
- Also, tax credit for CCS (permanent) now 85 USD/t-CO₂

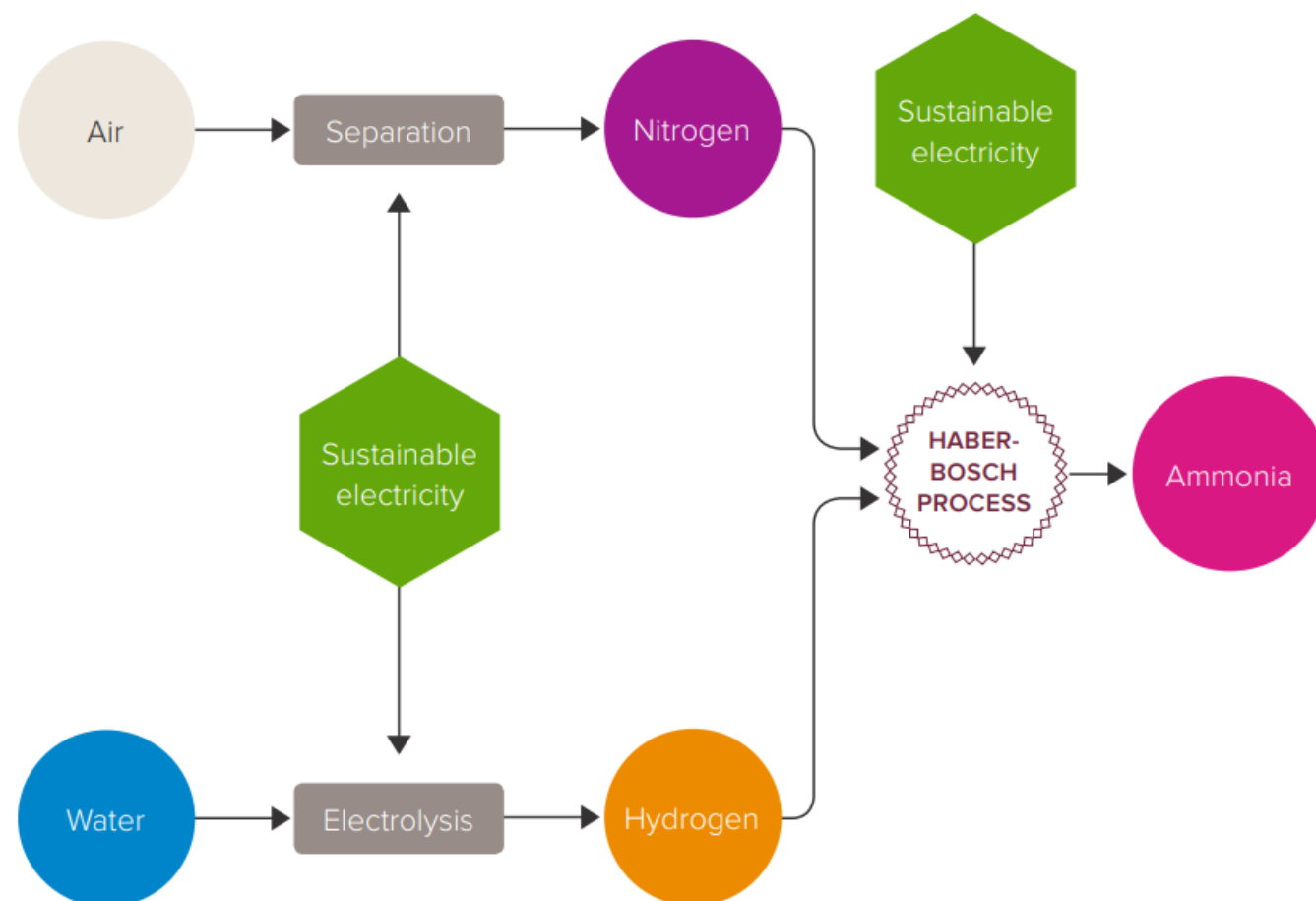


Renewable ammonia

- **Renewables:** electrolysis-based H_2 production (& N_2 production via PSA/ASU) + Haber-Bosch for NH_3 production
- **Electrolysis:** Alkaline & PEM commercial



100+ MW plants (<20 MW per module)
Hydropower + alkaline electrolysis



Industrias Cachimayo (Enaex)

Electrolysis-based ammonia (green ammonia grid connected)

- The oldest electrolysis-based ammonia plant still in operation is located in Cusco (Peru), starting operation in 1965. Enaex currently operates the plant, which has a capacity of about 32 KTPA ammonia.
- The main application of this grid-connected electrolysis plant is nitrate production, for example for the mining industry (explosives).

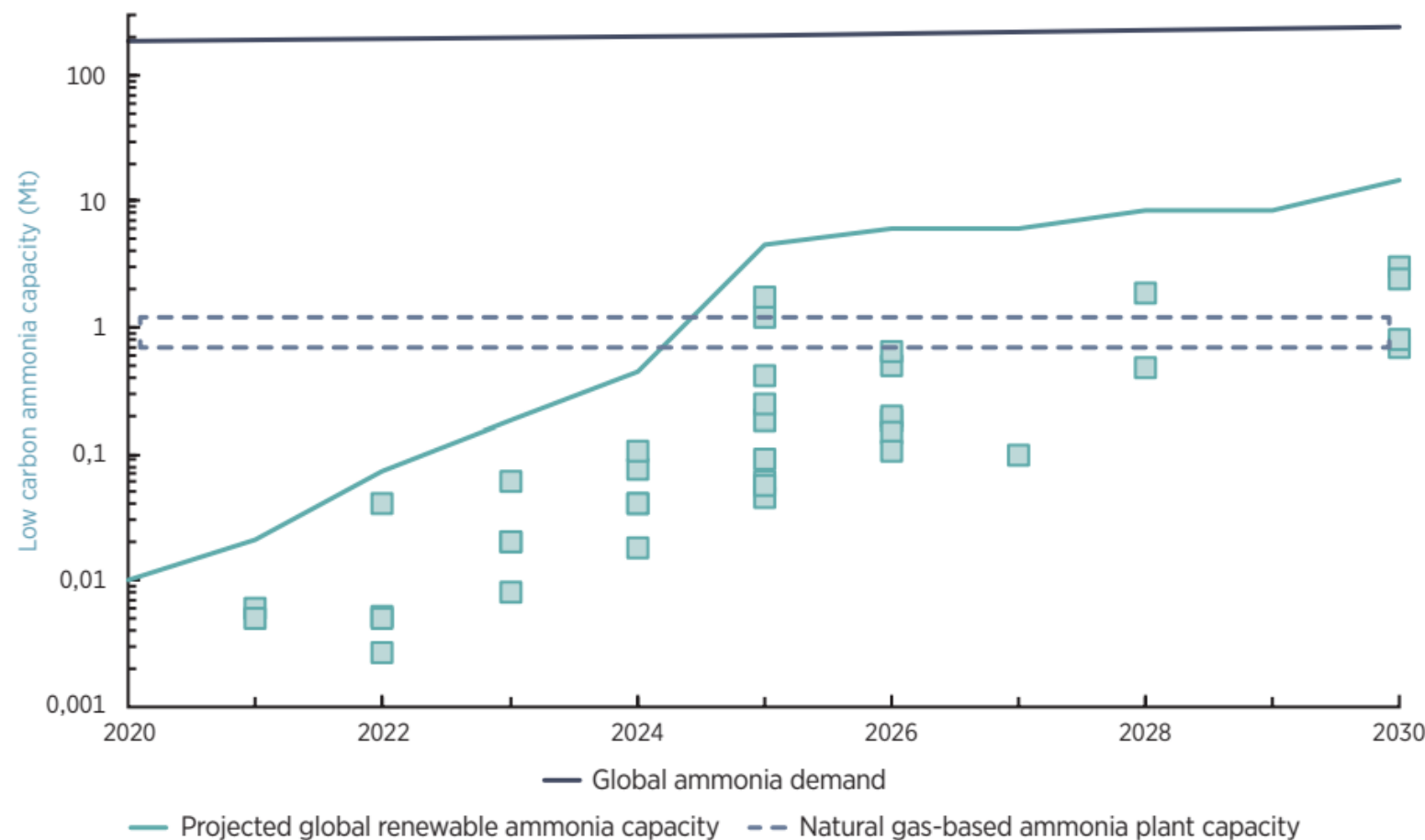


Key metrics

Location	Feedstock / Electricity	Hydrogen technology	Ammonia capacity	Year
Cusco Peru	Grid electricity Partly hydropower	35 MW Alkaline electrolysis	32 KTPA Newbuild	1965 Operational



Scaling-up intermittent renewable ammonia production

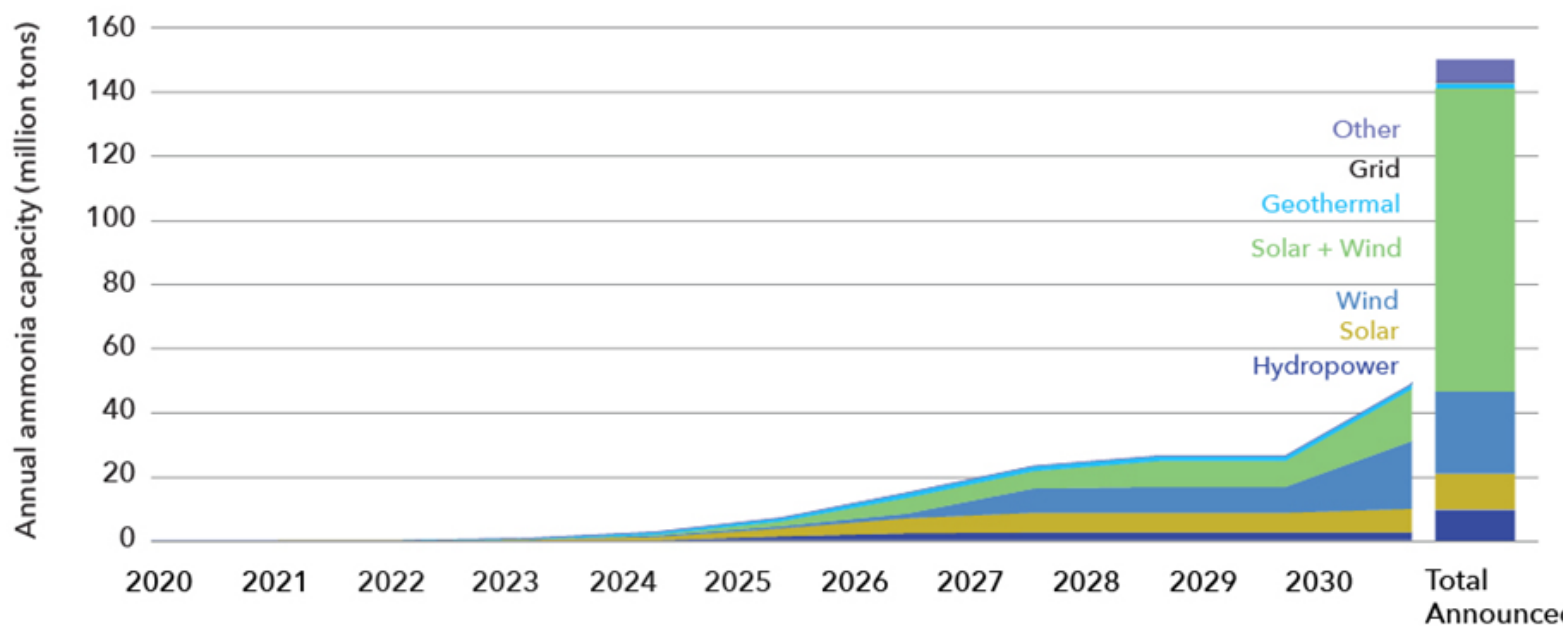




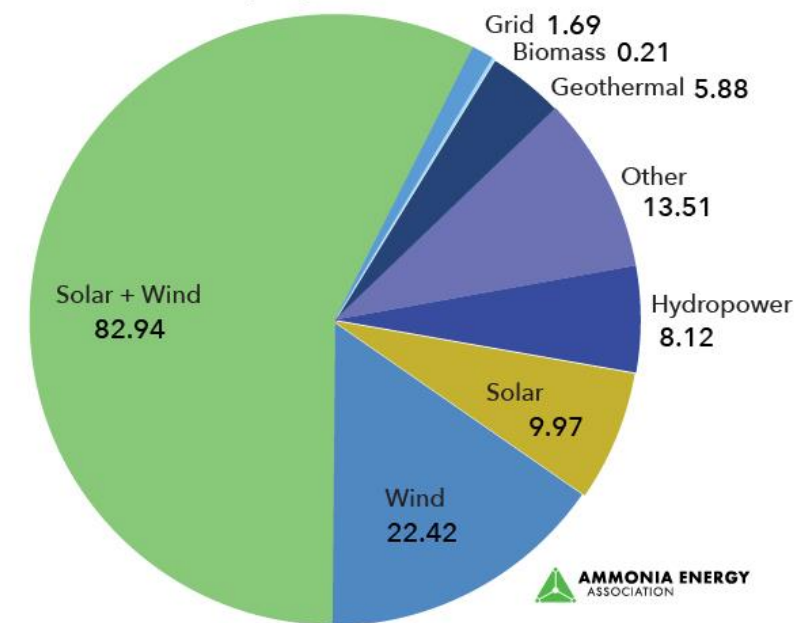
Renewable ammonia production feedstock

- Complementary solar & wind → high electrolyzer load factor

Announced renewable ammonia capacity, by technology



Total announced renewable ammonia capacity, by technology
Annual ammonia capacity (million tons)



Green Porsgrunn 1 (Yara)

Renewable ammonia (green ammonia grid connected partial revamp)

- In 2023, Yara will partially decarbonize its Porsgrunn ammonia plant in Norway with a 24 MW PEM electrolyzer, manufactured by ITM Power and to be installed by Linde Engineering. Electricity is derived from the hydropower-based Norwegian grid.
- Full electrification of the Porsgrunn ammonia plant, equivalent to 500 KTPA, is planned for 2026.



Key metrics

Location	Feedstock / Electricity	Hydrogen technology	Ammonia capacity	Year
Porsgrunn Norway	Grid electricity Mainly hydropower	24 MW PEM electrolysis	25 KTPA Partial revamp of 500 KTPA	2023 Construction

Link: <https://www.ammoniaenergy.org/articles/yara-selects-linde-engineering-to-build-electrolysis-plant-at-porsgrunn/>

Puerta Europa Puertollano 1 (Fertiberia)

Renewable ammonia (green ammonia partial revamp)

- In 2022, Fertiberia partially decarbonized its site in Puertollano with 17 KTPA renewable ammonia, to be utilized for fertilizer production. The renewable hydrogen is delivered by Iberdrola, which operates a 100 MW solar PV field, with 5 MW battery storage, 20 MW PEM electrolyzers, and 11 high pressure hydrogen storage tanks.



Key metrics

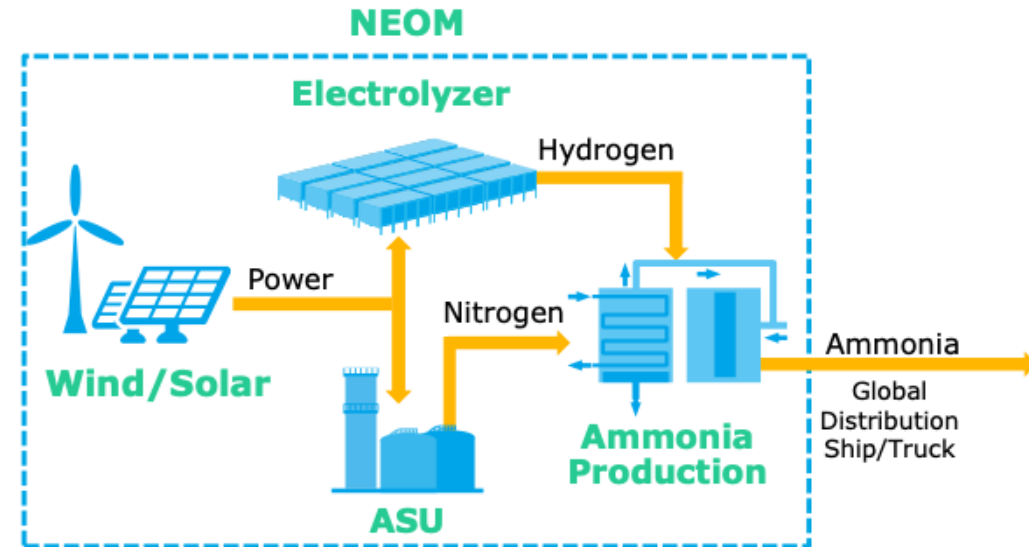
Location	Feedstock / Electricity	Hydrogen technology	Ammonia capacity	Year
Puertollano Spain	100 MW Solar PV & Grid	20 MW PEM electrolysis	17 KTPA Partial revamp of 200 KTPA	2022 Operational

Link: <https://www.iberdrola.com/about-us/what-we-do/green-hydrogen/puertollano-green-hydrogen-plant>

NEOM (Air Products, ThyssenKrupp, Topsoe)

Renewable ammonia (green ammonia newbuild)

- The NEOM project in Saudi Arabia is among the first world-scale greenfield renewable ammonia plants, which is set to produce 1200 KTPA by 2026, based on a \$6.5 billion investment. The plant consists of renewable electricity generation from wind and solar PV, alkaline electrolysis, an ASU, and an ammonia synthesis loop
- The aim is to export the ammonia as fuel or hydrogen carrier, for example to Northern Europe.



Key metrics

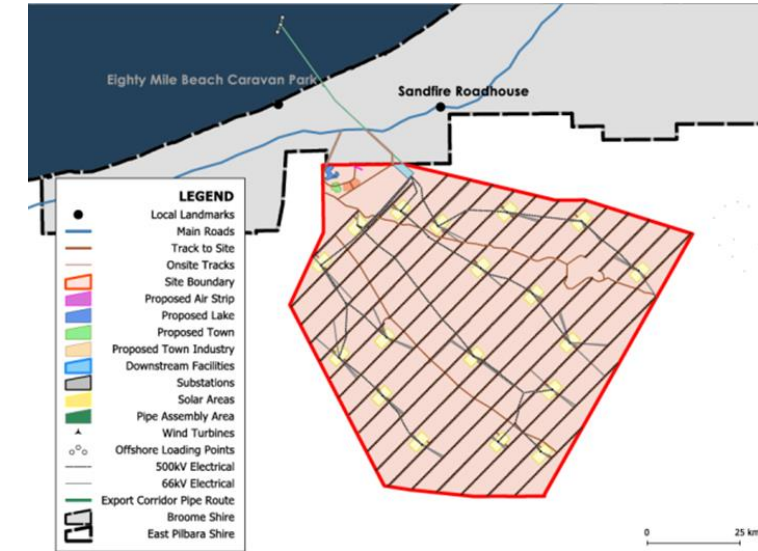
Location	Feedstock / Electricity	Hydrogen technology	Ammonia capacity	Year
NEOM Saudi Arabia	4 GW Solar PV & Wind	>2 GW Alkaline electrolysis	1200 KTPA Newbuild	2026 Planned

Link: <https://www.ammoniaenergy.org/articles/thyssenkrupp-to-install-2-plus-gw-of-electrolysers-for-neom/>

Australian Renewable Energy Hub (InterContinental Energy)

Renewable ammonia (green ammonia newbuild)

- The AREH developed by InterContinental Energy is a greenfield site in Pilbara (Australia) with the aim to produce 9900 KTPA from an area of 6500 km² by the mid 2030s. The key market is the Asian fuel market.
- FID is expected in 2025, and Oil & Gas major BP recently acquired a 40.5% equity stake in the project, to become the operator.



Key metrics

Location	Feedstock / Electricity	Hydrogen technology	Ammonia capacity	Year
Pilbara Australia	26 GW Solar PV & Wind	14 GW Electrolysis	9900 KTPA Newbuild	2035 Planned

Link: <https://www.ammoniaenergy.org/articles/bp-to-acquire-majority-stake-operatorship-of-asian-renewable-energy-hub/>



Thank you for your attention!

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