AMMONIA ENERGY ASSOCIATION

Low-Emission Ammonia Data (LEAD): Infrastructure

Executive Summary

April 2025

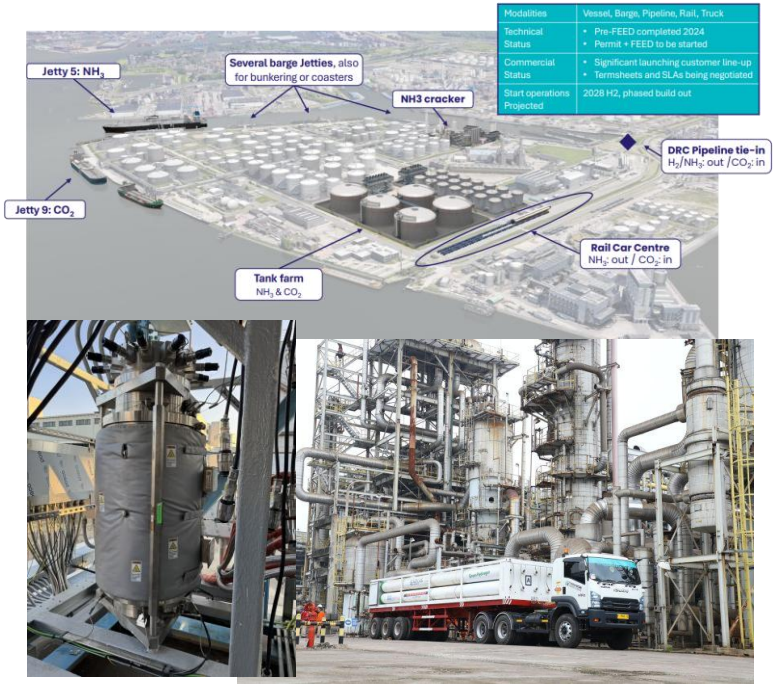
Ammonia Energy Association

Updates this quarter

Updated ammonia to power project list. Since the last update in January 2025, a more comprehensive list of ammonia to power projects is now available, with the AEA tracking 43 projects around the world (mostly in East Asia).

Capacity reservations for import terminals in Belgium and the Netherlands. Terminal operators are gaining confidence toward FID from "open season", with customers securing ammonia storage and handling capacity. Companies that have launched (and concluded) an "open season" for ammonia terminals include Advario & Fluxys, Chane, LBC Tank Terminals, and VTTI.

More demonstrations for ammonia infrastructure successfully completed. In January 2025, Syzygy Plasmonics completed trials for its fully electric 290 kilograms hydrogen per day ammonia cracker, at Lotte Chemical location in Ulsan (South Korea). In February 2025, the first 50 tons of renewable ammonia were produced at Pupuk Kujang Fertilizers in Indonesia, to be used for 8-hour ammonia co-firing trials at PLN's Banten Labuan power plant on Java's west coast.



Top: Chane's Rotterdam NH3 Import Hub.
Bottom Left: Syzygy Plasmonics' Rigel reactor cell.
Bottom Right: Renewable H_2 for ammonia production at Pupuk Kujang Fertilizers.

Maritime Ammonia Trade is ready to Scale-up

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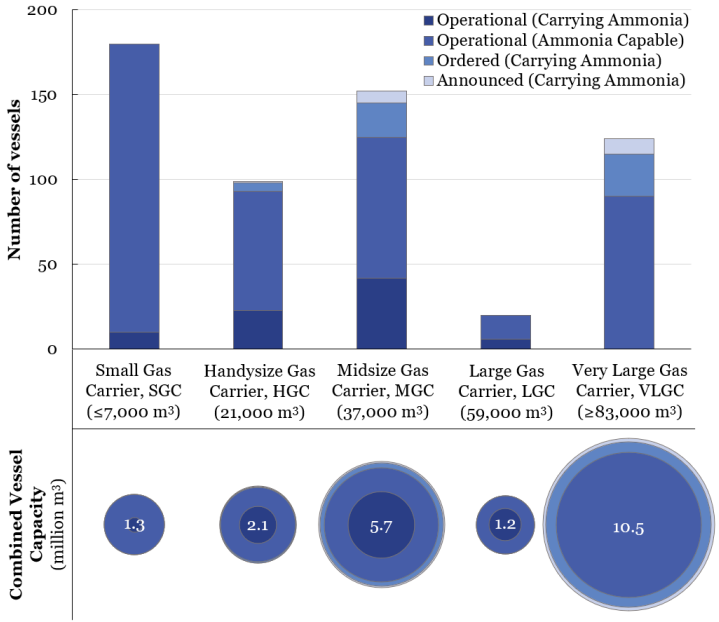
The existing fleet of ammonia carriers is capable of expanding in the near term. Around 17-20 million tons of ammonia is transported by vessels every year. The existing ammonia fleet consists of around 81 vessels, with most vessels in the MGC class (Midsize Gas Carrier, around 37,000 m^3 or 25.2 kT). However, around 508 ocean going vessels are capable of carrying ammonia, although most of these vessels carry LPG. Therefore, ammonia trade can expand significantly with existing vessels in the near term.

The ordered and announced ammonia carriers are Midsize Carriers and Very Large Gas Carriers. Around 63 new vessels have been announced (41 have been ordered). This is in anticipation of the increased ammonia trade for energy applications, and for current uses in energy import locations. Most of the orderbook for ammonia carriers consists of VLGCs (Very Large Gas Carriers, ≥83,000 m^3 or ≥56.6 kT), allowing ammonia trade to scale up for energy applications. Existing VLGCs for LPG trade can also be used for ammonia trade.

Existing and future fleet of ammonia carriers & ammonia capable vessels

Operational Vessel Data (April 2025): Affinity Research & Argus Media 2025 Q2



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Global Ammonia Terminal Capacity will expand

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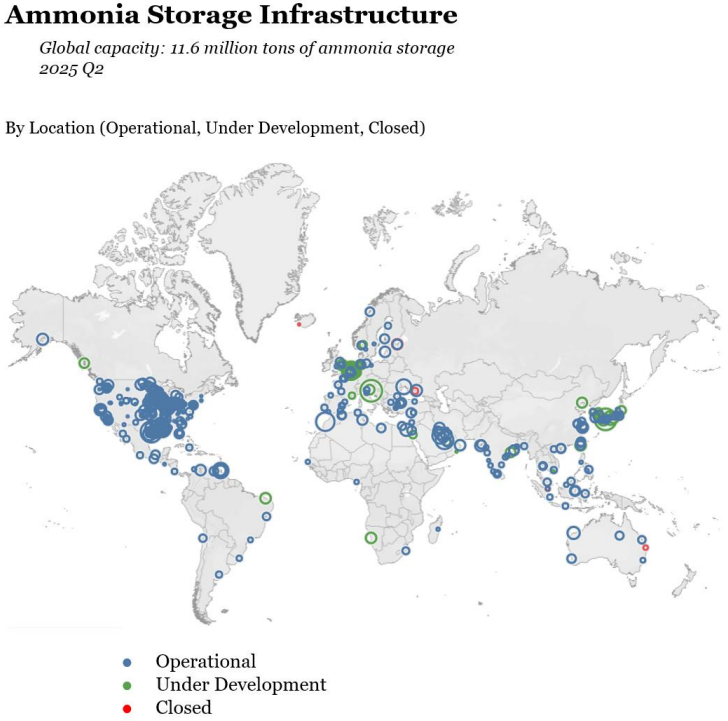
The AEA tracks 607 ammonia terminals, of which 298 are in industrial ports. Assuming 25 turnovers per year, and a similar distribution of importing and exporting terminals in industrial ports, around 96.5 MT can be transported annually. This exceeds the 17-20 MT of ocean-going transport each year, allowing for ammonia trade to expand.

The United States has many inland ammonia terminals and the largest existing capacity (6.5 MT of existing capacity, including 2.9 MT in coastal ports, and 3.7 MT inland), due to the direct use of ammonia as fertilizer in the US Midwest. This also implies significant inland ammonia transport and storage.

Around the rest of the world, ammonia storage terminals are mostly located in industrial ports, for ammonia import and for ammonia export. New export locations with multiple low-emission ammonia projects also announce centralized storage facilities, such as in Brazil and Namibia.



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Global Ammonia Terminal Capacity will expand in East Asia

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In East Asia, Japan and South Korea aim to import significant volumes of ammonia for energy applications, next to existing uses of ammonia in the chemical industry. Thus, ammonia storage facilities are Operational or Under Development in all industrial clusters.

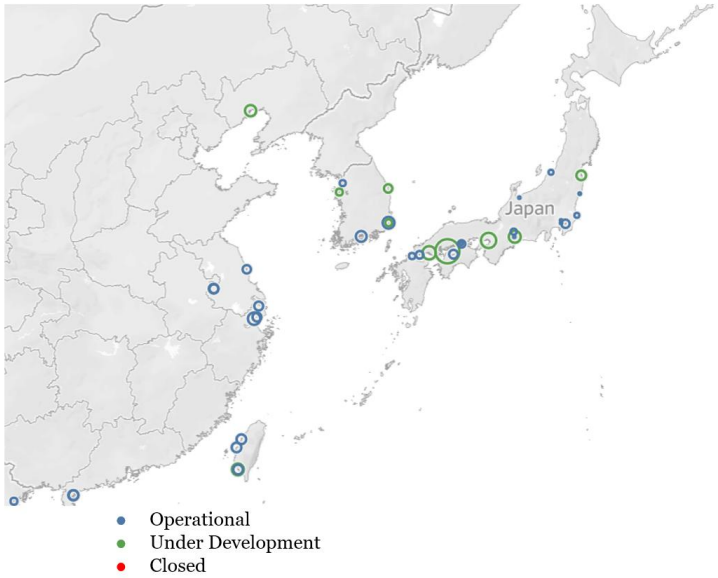
Japan aims to increase ammonia imports from around 0.2-0.3 million tons (MT) in the early 2020s, to 3 MT in 2030, and to 30 MT in 2050.

Assuming 25 turnovers per year, Japan's Operational ammonia storage capacity can process 6.0 MT. If the capacity Under Development is also included, about 17.6 MT of ammonia can be processed annually, indicating Japan is on track for its required ammonia import infrastructure.

Ammonia Storage Infrastructure in East Asia

2025 Q2

By Location (Operational, Under Development, Closed)



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Global Ammonia Terminal Capacity will expand in West Europe

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In West Europe, Belgium, Germany, the Netherlands, and the United Kingdom aim to import ammonia for energy applications. Also, the phase out of free allowances for CO_2 emissions in the European industry by 2034 will also result in the import of low-emission ammonia to Europe for existing markets.

Rotterdam (The Netherlands) is the largest port in Europe with 13% of all energy utilized in Europe passing through the Port of Rotterdam. Rotterdam is also a major bunkering hub for vessels.

New import capacity for hydrogen and derivatives has been announced. Assuming 25 turnovers per year, 14.3 million tons (MT) of ammonia throughput capacity is Under Development in the Port of Rotterdam. To account for increased ammonia volumes, the PGS-12 design code for ammonia storage and handling has been updated recently.

***Webinar**: Updated PGS-12 code: Preparing for increased ammonia imports to the Netherlands*
https://ammoniaenergy.org/webinars/updated-pgs-12-code-preparing-for-increased-ammonia-imports-to-the-netherlands/

Ammonia Storage Infrastructure in West Europe

2025 Q2

By Location (Operational, Under Development, Closed)

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Ammonia Cracking is Developing with Pilots Under Construction

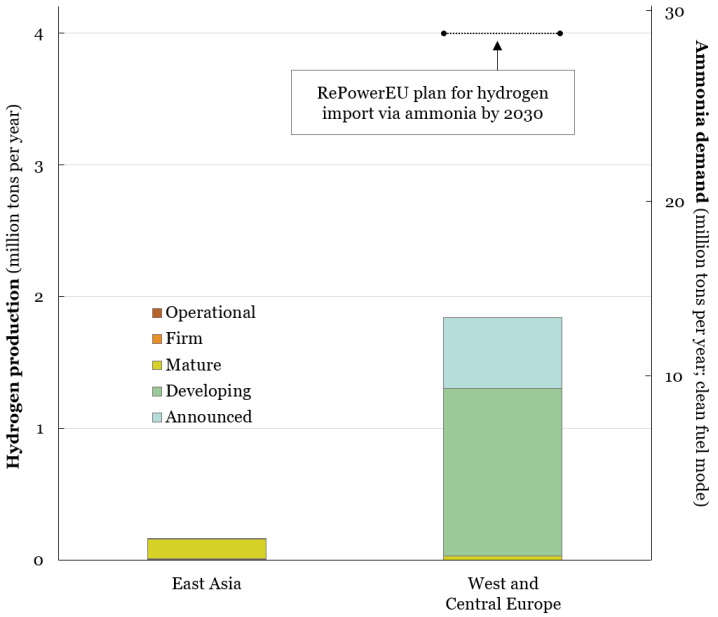
As of April 2025, at least 23 industrial-scale ammonia cracking projects are under development with 1.9 million tons (MT) of hydrogen capacity.

- Depending on the technology choice, this is equivalent to between 10.9 MT and 13.8 MT of ammonia feedstock.
- While most projects are in early stages of development, several pilot-scale crackers are under construction in locations that import energy. The three Firm and Mature projects in East Asia are focused on power generation and industrial hydrogen supply. The two Firm and Mature projects in West and Central Europe are focused on industrial hydrogen supply.

In 2022, the RePowerEU plan indicated 4.0 MT of hydrogen would be imported via ammonia by 2030. The ammonia cracking projects announced so far could supply around nearly half of this target. In addition, however, imports of ammonia for direct use (not cracking) may also be counted within the EU's target.

Ammonia cracking for hydrogen production

Global announced demand: 10.9-13.8 million tons of ammonia
2025 Q2



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Ammonia for Power is Demonstrated as Policies and Projects develop

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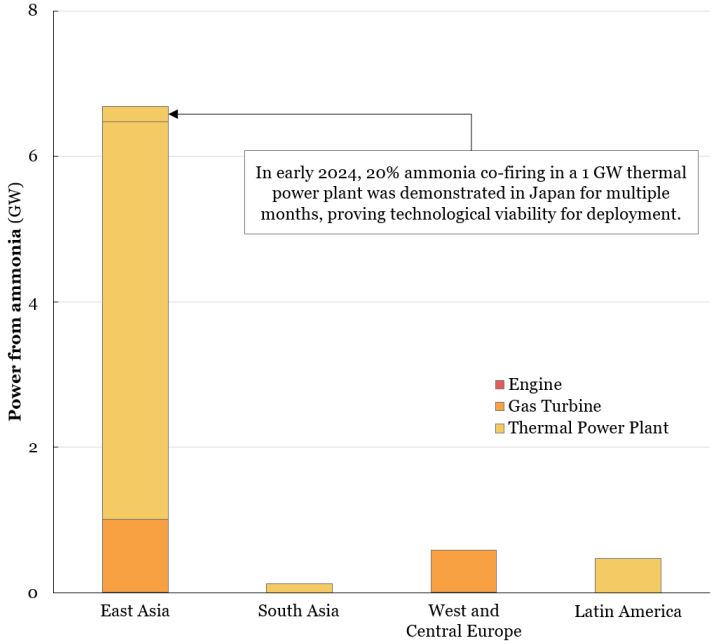
As of April 2025, at least 43 Ammonia for Power projects are under development, mostly based on ammonia-fueled gas turbines (10 projects) and ammonia co-firing in thermal power plants (31 projects). These projects have a combined power output of 7.8 GW from ammonia, and could represent up to 33.8 million tons (MT) of ammonia demand annually.

Most projects (38) are located in East Asia, with a significant focus on ammonia co-firing in thermal power plants (28 projects).

- In early 2024, 20% ammonia co-firing in a 1 GW thermal power plant was demonstrated in Japan. Japan aims to complete its Contract for Difference support scheme in the first half of 2025.
- South Korea announced the conclusion of its first ammonia for power auction in December 2024.
- The first commercial demonstration of an ammonia-fueled gas turbine will be a 60 MW pilot project in Jurong Port (Singapore).

Power generation from ammonia

Global announced demand: 33.8 million tons of ammonia
2025 Q2



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Assumptions

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Ammonia Terminals:

- The number of turnovers for an ammonia terminal is assumed to be 25 per year.

Ammonia cracking:

- The hydrogen yield for ammonia crackers is assumed to be 78 wt.% H_2 (or 0.1385 kg-H_2/kg-NH_3). This is based on "clean fuel mode", utilizing H_2 and/or NH_3 as a fuel for the ammonia cracker. Alternatively, an external fuel such as gas (CH_4) can be used for heating, increasing the hydrogen yield to about 96 wt.% H_2 (or 0.170 kg-H_2/kg-NH_3).

Ammonia for power:

- The energy efficiency of an Engine is 30%, on a Lower Heating Value (LHV) basis
- The energy efficiency of a Gas Turbine is 40% for simple cycle operation, on a Lower Heating Value (LHV) basis
- The energy efficiency of a Thermal Power Plant is 35%, on a Lower Heating Value (LHV) basis

Terms of Use

For more information or questions related to this material, please contact Kevin Rouwenhorst at krouwenhorst@ammoniaenergy.org, Technology Manager, Ammonia Energy Association.

The original data upon which this material is based is available to the members of the Ammonia Energy Association. If you are interested in joining the AEA, please visit ammoniaenergy.org/members for more information. The original data is based on publicly available materials.