AMMONIA ENERGY ASSOCIATION

Global Project List: Low-Emission Ammonia Plants (LEAP)

Executive Summary

November 2024 Version

Ammonia Energy Association

Project intelligence database

The AEA's project intelligence database has been available to members of the AEA since April 2022, and contains details on all the low-emission (and transitional) ammonia production plants that have been announced.

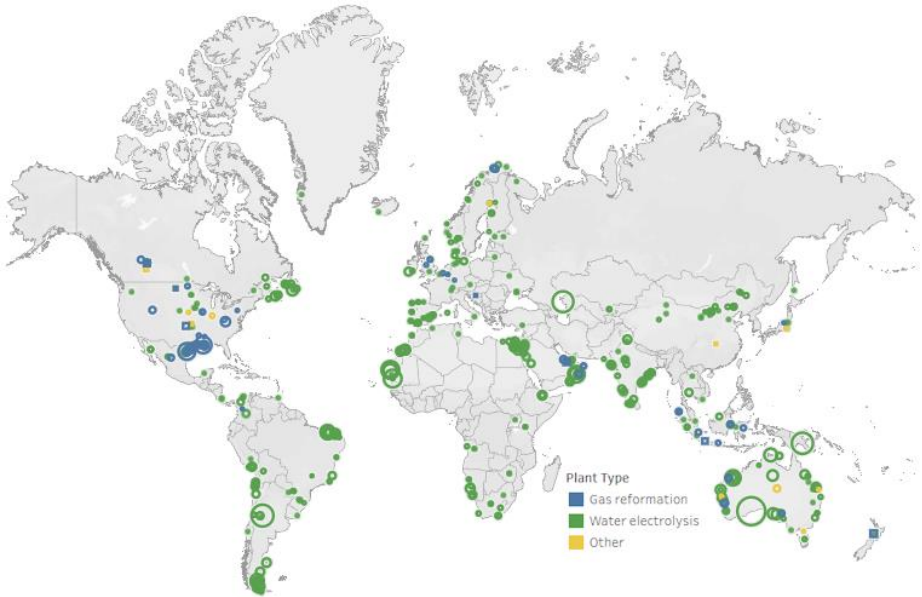
The database is growing quickly:

- December 2022: 103 projects
- November 2024: 464 projects (578 phases of expansion), for a total of 438.1 million tons

Even since the last update in August 2024, the capacity we are tracking has increased by 65.6 million tons.

Projects are categorized according to technology pathway:

- **Gas reforming** (CCS, CCU, EOR, biogas)
- **Water electrolysis** (renewable, grid, nuclear), and
- **Other** (pyrolysis, gasification, electrochemical, byproduct hydrogen, etc).



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ammoniaenergy.org/LEAD

Project updates this quarter

Updates on realized capacity:

- A gas reformation plant in Saudi Arabia installed partial CCS with offtake to Japan for energy applications; **44,000 tons of ammonia per annum**
- A flexible water electrolysis-based ammonia plant was inaugurated in Denmark (start-up in 2025 Q1); **5,000 tons of ammonia per annum**
- Biomass and biogas feedstocks were added to gas reformation plants in Germany to produce low-emission ammonia and derivatives

Updates on firm capacity:

- An ammonia plant in India with RFNBO compliant water electrolysis-based hydrogen production has reached FID; **1,000,000 tons of ammonia per annum**

Flexible renewable ammonia plant in Denmark

Low-emission ammonia projects

As of November 2024, 438.1 million tons (MT) of Low-emission and Transitional ammonia have been announced.

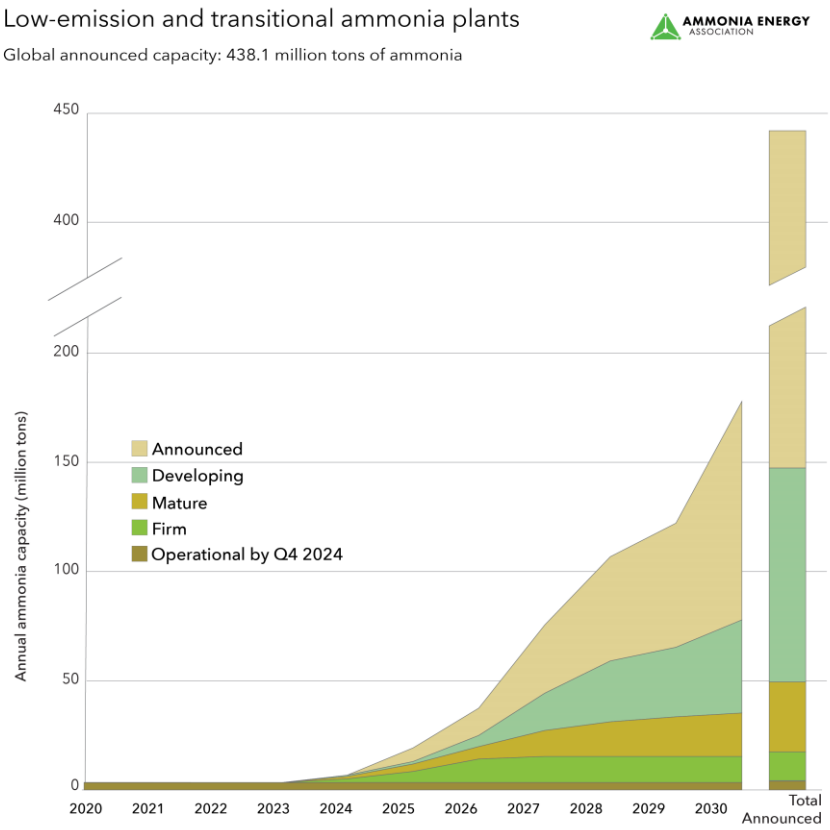
By 2030, we expect 35.7 MT to be operational

- 3.7 MT is Operational (up to Q4 2024)
- 11.8 MT is Firm (eg, construction / FID)
- 20.2 MT is Mature (eg, offtake / EPC)

In total, 295.1 MT is classified as Announced with few public details. Another 96.7 0 MT is Developing (eg, making clear progress to FID), of which 42.4 MT targets to start this decade.

Key conclusions:

- Within the large funnel of projects, a significant number of projects are maturing to meet the ammonia energy demand.
- Clear demand signals and regulatory certainty will be required to move more of these projects towards FID.



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Availability this decade

Looking only at Operational, Firm, and Mature projects, 35.7 million tons (MT) of Low-emission and Transitional ammonia capacity is expected to be Operational in 2030.

- 3.6 MT Transitional is already operational. We expect this to increase to 5.9 MT Transitional in 2030.
- 0.2 MT Low-emission is already operational. We expect this to increase to 29.8 MT Low-emission in 2030.
- About half of Low-emission capacity this decade comes from Gas reformation projects, totalling 17.7 MT in 2030.
- Water electrolysis projects begin operating at scale in 2025-2026, and reach 15.1 MT capacity in 2030.

Key conclusions:

- Transitional ammonia plants serve existing markets (fertilizers, chemicals), but are not expanding long-term.
- Gas reformation projects are developing at large-scale, especially at existing sites, while Water electrolysis projects are scaling toward the size of Gas reformation projects in the late 2020s.

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Plants by Region

Operational, Firm, and Mature projects:

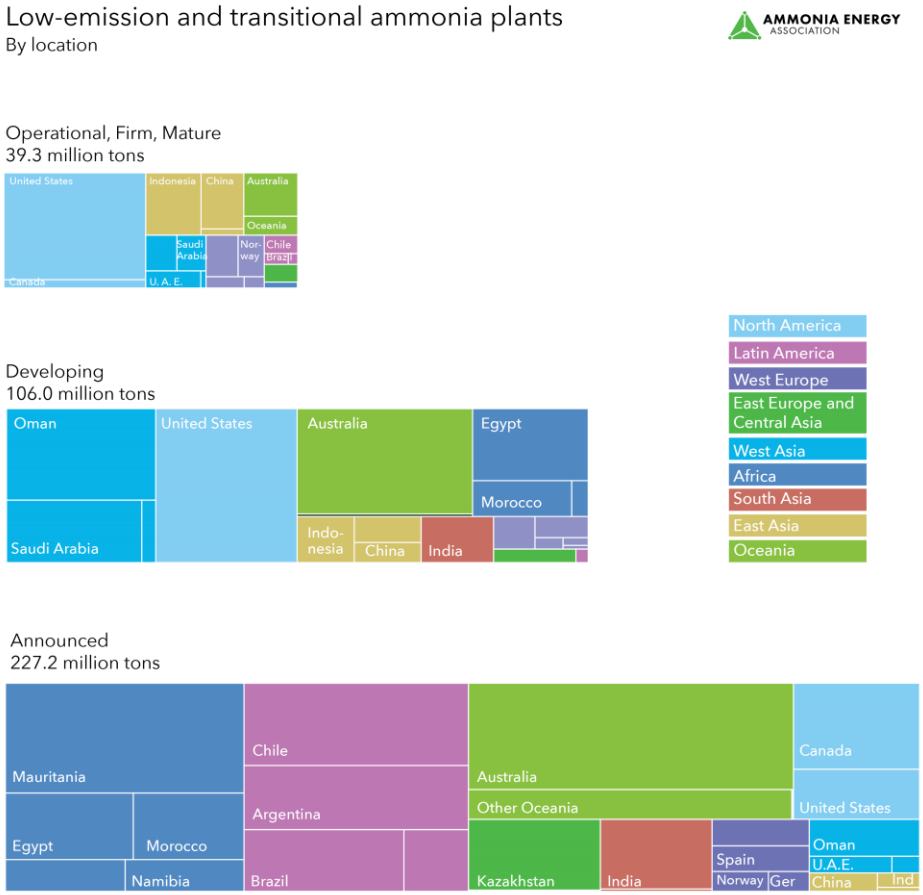
- Mostly in developed economies, at existing plants serving existing markets (fertilizers, industry) – with some notable first-mover offtakes into energy markets,
- But also new capacity, especially in China, Indonesia, Chile, Norway, and West Asia (Middle East).

Developing projects:

- Overwhelmingly in Australia, Egypt, Oman, Saudi Arabia, and the United States, largely focused on export markets,
- Replacing imports for domestic markets also visible, especially in India and Morocco.

Announced projects may suggest long-term view:

- Latin America, Africa, South Asia, and Oceania dominate the pipeline due to renewable potential. Clear challenges for de-risking investments, as focus is on premium ammonia energy markets.



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Plants by Technology

Operational, Firm, and Mature projects:

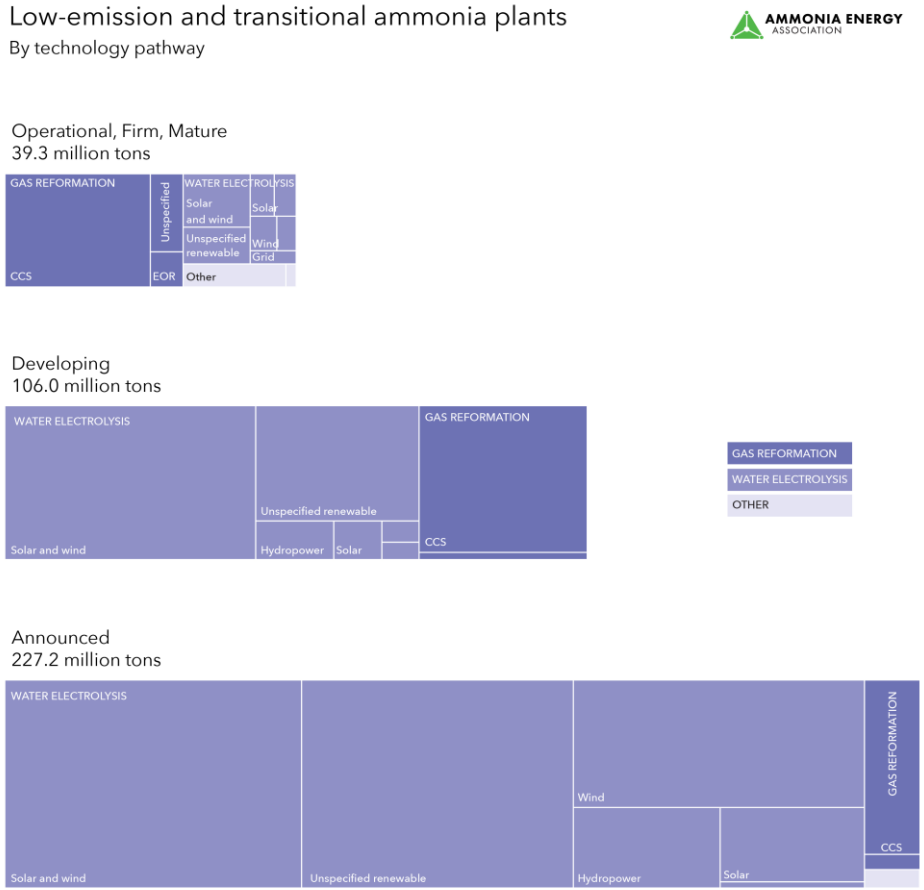
- Gas reformation projects dominated by CCS (carbon capture & sequestration), with some EOR (enhanced oil recovery).
- First-mover Water electrolysis projects use many inputs, including grid electricity and renewables.

Developing projects:

- Gas reformation pipeline dominated by CCS.
- Water electrolysis pipeline dominated by combined solar & wind, sometimes connected to the grid.

Announced projects:

- Water electrolysis dominates long-term pipeline.
- Challenges for de-risking technologies may be overcome by first-mover projects. Firm demand required to support such scale-up of supply.



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Evaluation of project maturity

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The AEA tracks project development indicators using nine criteria:

- FEED ongoing/completed
- existing ammonia complex
- existing operator (ammonia, chemicals, energy)
- existing infrastructure
- hydrogen technology vendor selected
- ammonia licensor selected
- plant operator selected
- offtaker selected
- financing / funding (pre-FID)

Using nine criteria, every project is assigned an objective status:

- **Operational**: the plant is operational
- **Firm**: the plant has reached FID or is under construction
- **Mature**: 5+ out of 9 criteria have been met
- **Developing**: 3+ out of 9 criteria met
- **Announced**: 2 or less out of 9 criteria met
- **Defunct**: the plant has closed, or the project is on hold, or not ongoing

Evaluation of project category

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The database include both Low-emission and "Transitional" plants.

Low-emission plants include a variety of technology pathways, including water electrolysis, gas reformation with permanent CCS, and methane pyrolysis.

Transitional plants includes projects with reduced emissions, but via pathways that may not be consistent with net-zero (for example, byproduct fossil hydrogen or enhanced oil recovery pathways).

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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.