Ammonia Energy

AURI, MN Renewable Energy Roundtable
Agriculture’s Opportunity in the Emerging Hydrogen Economy

September 10, 2020
Trevor Brown, Ammonia Energy Association
Ammonia Energy Association

A global trade association that advocates for the responsible use of ammonia in a sustainable energy economy.

ammoniaenergy.org
Ammonia Energy Association

Supply: decarbonize ammonia production.
Demand: adopt ammonia in energy markets.

ammoniaenergy.org
MEMBER LIST – September 2020

* indicates representation on Board of Directors


Low-Carbon Ammonia — Supply

Pilot plants, Revamps, Industrial Feasibility
**Enaex** — Cusco, PE (1962)
Capacity: 10,000 tpy ammonia (estimate). Feedstock: hydro power.
Note: Only remaining commercial electrolysis-ammonia plant (Uhde).

**Nutrien** — Joffre, AB (1987)
Capacity: 490,000 tpy ammonia. Feedstock: byproduct hydrogen.
Note: 25% reduction in carbon footprint, offsets company carbon tax liability.

Capacity: 60,000 tpy ammonia. Feedstock: waste plastic / natural gas.
Note: 65% of hydrogen comes from plastic; sells low-carbon deNOx fluid (Ecoann™) in protected market (“eco-friendly goods for procurement”).

**Yara / BASF** — Freeport, TX (2018)
Capacity: 800,000 tpy ammonia. Feedstock: byproduct hydrogen.
Note: 25% reduction in carbon footprint.
• “Green Ammonia” is not black and white, but shades of grey.
• Renewable hydrogen (wind / solar) is one feedstock. Other hydrogen sources include recycled waste, nuclear power, industrial byproduct, biomass / biogas, or fossil fuels without carbon emissions (eg: pyrolysis, CCS).
• “Low-Carbon Ammonia” is available today at industrial scale, but is not yet marketed as such.
University of Minnesota — Morris, MN (2014)
Note: Small-scale, distributed model, driving chemical engineering / economics research.

Siemens — Harwell, UK (2018)
Capacity: 10 tpy ammonia. Feedstock: wind power
Note: Haber-Bosch + intermittent power, informs electricity business cases.

Note: Catalysts optimized for low pressure Haber-Bosch. Also: ammonia combustion (gas turbine).

OCP — Jorf Lasfar, MA (date TBD)
Capacity: TBD. Feedstock: solar power.
Note: Collaboration with Fraunhofer IMWS (Germany).
Enaex — Antofagasta, CL (date TBD)
Capacity: 20,000 tpy ammonia. Feedstock: solar power.

Proton Ventures / Siemens / Yara — Goeree-Overflakkee, NL (date TBD)
Capacity: 20,000 tpy ammonia. Feedstock: wind / tidal power.
Note: Regional "green hydrogen" economy.

Siemens Gamesa — Skive, DK (date TBD)
Capacity: TBD. Feedstock: wind power.
Note: Upstream industry, developing downstream markets.

Ballance Agri-Nutrients — Kapuni, NZ (date TBD)
Capacity: 5,000 tpy ammonia (estimate). Feedstock: wind power.
Note: 16 MW wind turbines, NZ$50 million budget.
Queensland Nitrates — Moura, AU (date TBD)
Capacity: 20,000 tpy ammonia. Feedstock: solar power.
Note: Feasibility; partners include Incitec Pivot / Wesfarmers JV; partners Neoen, Worley.

Dyno Nobel — Moranbah, AU (date TBD)
Capacity: 60,000 tpy ammonia (estimate). Feedstock: solar power.
Note: Feasibility; proposal is for 210 MW solar / 160 MW electrolyzer.

Yara — Pilbara, AU (2006 / TBD)
Capacity: 25,000 tpy ammonia. Feedstock: natural gas / solar power.
Note: 850,000 tpy current capacity. Addition of 100 MW solar, 50-60 MW electrolyzer; future hydrogen tie-in already completed during 2018 turnaround. Engie feasibility.

H2U / thyssenkrupp — Port Lincoln, AU (TBD)
Capacity: 20,000 tpy ammonia. Feedstock: wind / solar power.
Note: Business case demonstration for renewable energy exports (“Hydrogen Hubs”), with two under development in South Australia and Queensland (up to 3 GW).
**Enaex** — Antofagasta, CL (date TBD)
Capacity: 350,000 tpy ammonia. Feedstock: solar power.

**Fertiberia** — Puertollano, SP (2021)
Capacity: 4,000 tpy ammonia (estimate). Feedstock: solar.
Note: 100 MW solar, 20 MW electrolyzer, EUR 150 million investment by Iberdrola. Decarbonizes about 2% of total ammonia plant capacity of 200,000 tpy.

**Haldor Topsøe** — Foulum, DK (2025)
Capacity: 300 tpy ammonia (estimate). Feedstock: wind power.
Note: Solid oxide electrolyzer, no ASU, modular. Energy efficiency estimated at 7.2 MWh (26 GJ), equal to best available technology (world-scale SMR-Haber Bosch).

**Yara** — Porsgrunn, NO (2022)
Capacity: 2,500 tpy ammonia (estimate). Feedstock: hydro power (grid).
Note: 5 MW electrolyzer drives manufacturing scale-up, reduces unit capex. Electrifies 1% of plant capacity, so existing Haber-Bosch plant will produce 500,000 tpy of 99% fossil ammonia but, with certification, can market 5,000 tpy of 100% green ammonia.
Wabash Valley Resources — Terre Haute, IN, United States (date TBD)
Capacity: 550,000 tpy ammonia. Feedstock: pet coke.
Note: US Dept of Energy funding for CCS. 45Q tax credits (carbon sequestration), and LCFS credits (reduction in ethanol fuel carbon intensity).

NEOM / Air Products — Neom, Saudi Arabia (2025)
Capacity: 1.2 million tpy ammonia. Feedstock: wind & solar power.
Note: 4 GW scale, $5 billion investment from NEOM, Air Products, ACWA Power. Additional $2 billion investment by Air Products to distribute 100% of offtake ammonia into hydrogen transportation markets (fuel cell trucks and buses).

Asian RE Hub— Pilbara, Australia (2028)
Capacity: 3-4 million tpy ammonia (estimate). Feedstock: wind & solar power.
Note: 15 GW, AU$ 22 billion investment (US$ 16 billion), 6,500 square kilometer site, export oriented for international fuel markets.
• “Green Ammonia” is happening
• This transition is not driven by fertilizer economics.
Low-Carbon Ammonia — Markets

Low-Carbon Fertilizer, Hydrogen Carrier, Maritime Fuel
Low-Carbon fertilizer demand

Back of an envelope illustration #1:

- Gasification with CCS: emits 0.18 tons CO2 per ton ammonia (GHG index 8.9 v 100 SMR baseline).
- Carbon Intensity of ethanol (fertilizer impact): ~10 down to ~4 g/MJ
- LCFS credits equate to ~$450 premium per ton low-carbon ammonia
Low-Carbon ammonia demand

Back of an envelope illustration #2:

- CA hydrogen fuel retail @ ~$14 / kg H2
- CA ammonia fertilizer retail @ ~$500 / metric ton NH3
- Switch value from N to H ...
- CA hydrogen fuel retail @ $1,891 / metric ton NH3

Assumes 24.1% loss during cracking and purification, thus 135 kg H2 per ton NH3.
Hydrogen fuel demand

http://investors.airproducts.com/static-files/b0595961-b2ac-45ff-89c5-7d9d8837a363
Maritime fuel demand

Annual ammonia demand could increase by 670 to 946 million tonnes and represent a potential $5 USD trillion market up by 2050.

Growth in ammonia for shipping could represent +400% capacity increase relative to 2018 global ammonia production capacity.


Ammonia Energy — what’s next?

Demand certainty will drive production scale-up.

Ammonia Energy Association spearheading Low-Carbon Certification initiative to support market premium.

Will the Mid-West export renewable energy using molecules? What role for Ag-producers in bio-ammonia?
Thank you

tbrown@ammoniaenergy.org
ammoniaenergy.org