



Biorenewable Insights: Green Ammonia

Green Ammonia is one in a series of reports published as part of NexantECA's 2022 Biorenewable Insights program.

Overview

The ammonia industry is the single largest source of direct emissions in the chemicals sector. To meet goals of carbon neutrality by 2050, the sector must radically reorient itself towards sustainable ammonia technology and equally rapidly deploy it.

Green ammonia will certainly be part of the coming wave of investment into the industry. However, key questions about technology availability, readiness, and competitiveness remain.

- What technologies are available for rapid deployment, and what will be ready in the near future?
- Amid sluggish government support for decarbonization and potential threats from blue ammonia, can green ammonia hold its own as an investment?
- Is the oft-touted benefit of intermittent operation for e-ammonia production enough to justify investment?
- What is the residual carbon intensity of blue ammonia, and how does it compare as a decarbonization tool to green ammonia?

Technologies

NexantECA's report covers key technologies necessary for all aspects of ammonia production, focusing not only on hydrogen production and the converter but also air separation, carbon capture, and geological sequestration. Key technologies covered by sector include:

- Ammonia Conversion: Haber-Bosch Process, Lithium-Mediated Electroreduction, Electrically Promoted Haber-Bosch Synthesis
- Hydrogen: Reforming (ATR and SMR), Electrolysis (alkaline, PEM, and SOEC), Gasification, Thermolysis
- Nitrogen: Cryogenic, Adsorptive, Indirect ATR

Process Economics

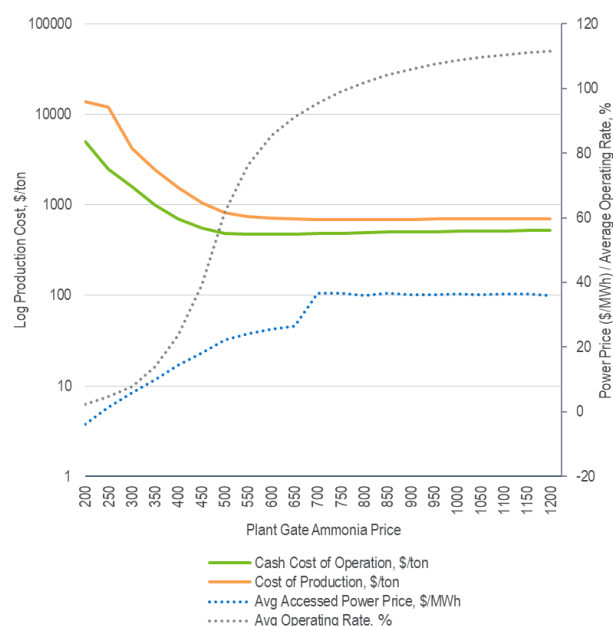
This report benchmarks two key green ammonia technology options, PEM Electrolysis with the Haber Process and Lithium-Mediated Electroreduction, against

competing blue ammonia processes on both an economic and carbon intensity basis. Blue ammonia competitiveness is not only examined in primary scenarios in the U.S. Midwest and Northwest Europe but takes into account sensitivities to geological sequestration costs based on geography. Green ammonia is evaluated based on both a maximized production basis and using a Monte Carlo simulation of optimal production behavior taking advantage of spot electricity pricing in the U.S. Midwest and Northwest Europe, with sensitivity to plant-gate ammonia pricing.

Commercial Impact

This report offers comprehensive coverage of planned and current green ammonia capacity as well as a critical analysis of current and future impacts on the conventional ammonia industry. It critically evaluates claims made by industry decarbonization plans and examines the scope for future investment vis-à-vis current investment activity.

Figure: Log-Linear Plot of Unit Production Costs of E-Ammonia vs. Plant Gate Ammonia Price, with Operating Rate and Effective Power Price¹



¹ Mean operating rates above 100 percent reflect periods where electrochemical systems are operating above their nominal rated capacity



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Technology and Costs comprises the Technoeconomics – Energy & Chemicals (TECH) program, the Biorenewable Insights program (BI), and the new Cost Curve Analysis. These programs provide comparative economics of different process routes and technologies in various geographic regions.

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