LCRI LOW-CARBON RESOURCES INITIATIVE

EPRI GTI ENERGY

EXECUTIVE SUMMARY

DECARBONIZING AMMONIA

Ammonia is the second most produced chemical in the world and the largest energy consumer in the chemical industry. More than 97% of ammonia production relies on fossil fuels, which emits 1–2% of CO_2 generated in the global energy system. About 70% of ammonia is consumed in the agriculture sector as synthetic fertilizer, and the rest is used in various industrial applications. Owing to its high volumetric energy density, ammonia is also considered a carbon-free, energy-dense liquid fuel and hydrogen carrier. With the continuous growth in population and affluence, it is expected that the demand for ammonia increases in the 21st century. Hence, it is critical to continue supplying ammonia, but with less impact on the environment.

The focus of this report is to review the technologies for decarbonizing ammonia manufacturing, which is acknowledged to be a vital steppingstone toward Net Zero 2050. Particularly, sustainable technologies with a higher technology readiness level (TRL) that can be deployed at scale within the next 2–3 decades are considered.

Key findings from this report include:

- Decarbonization of ammonia falls into two major categories: zero-carbon manufacturing and reduced-carbon emissions via intensified manufacturing.
- While numerous green ammonia manufacturing projects are under construction around the world, green ammonia manufacturing capacity is projected to only account for 3% of the total production by 2030.
- Despite currently being utilized primarily as a feedstock for fertilizer, experts predict use of ammonia as a low-carbon fuel and/or energy storage mechanism which could potentially improve the economic competitiveness of green ammonia.
- Retrofitting fossil-based ammonia manufacturing facilities with carbon capture and sequestration is considered to be among the most viable pathways to high volume production of low-carbon ammonia in the near-term.
- Intensification of the conventional Haber-Bosch process by lowering the temperature and pressure in the synthesis loop is another intriguing proposition to reduce emission and has received significant attention for distributed manufacturing. These technologies are being demonstrated at lower TRL, and some are in transition to be deployed at actual system conditions.
- While in its early stages of development, distributed green ammonia is a promising pathway to improve the sustainability of ammonia production. This approach would provide fertilizer users with increased accessibility to ammonia in remote areas and would also more easily enable use of carbon-free ammonia as a fuel for heavy industrial applications such as farm equipment.
- Though distributed green ammonia is not currently economical relative to today's ammonia production and distribution model, economies of scale in manufacturing distributed ammonia production systems shows promise for potential future cost reduction.

The full report provides an overview of ammonia's value as a low-carbon energy carrier, approaches to decarbonizing ammonia through zero-carbon manufacturing and reduced-carbon emissions via intensified manufacturing, and potential future directions to decarbonizing ammonia manufacturing.

The Low-Carbon Resources Initiative

This report was published under the Low-Carbon Resources Initiative (LCRI), a joint effort of the Electric Power Research Institute (EPRI) and GTI Energy addressing the need to accelerate development and deployment of low- and zero-carbon energy technologies. The LCRI is targeting advances in the production, distribution, and application of low-carbon energy carriers and the cross-cutting technologies that enable their integration at scale. These energy carriers, which include hydrogen, ammonia, synthetic fuels, and biofuels, are needed to enable affordable pathways to economy-wide decarbonization by mid-century. For more information, visit www.LowCarbonLCRI.com.

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