LCRI LOW-CARBON RESOURCES INITIATIVE

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EXECUTIVE SUMMARY

EXTRACTION OF GREEN AMMONIA FROM ANAEROBIC DIGESTION

Shifting from current methods of producing ammonia that are based on natural gas to alternative methods that are not based on fossil fuels and do not emit carbon dioxide helps facilitate a green energy economy by decarbonizing this energy-intensive chemical product.

Current attempts at producing "green ammonia" use electrification of the process. The switch to electrification has the potential to decrease emissions by one-third, despite decreasing efficiency. Electrifying the phases prior to the ammonia synthesis loop provides positive environmental impacts through reduced greenhouse gas emissions. Specifically, replacing steam methane reforming with electrolysis increases the efficiency of the subsequent stages. However, the average energy cost of electrolysis is approximately 3.5 to 4.5 times higher than steam reforming, further increasing production cost. This substitution of electrolysis for steam reforming is not sufficient, as it does not fully realize a carbon-neutral ammonia production process. To achieve a truly decarbonized ammonia production process, other methods of ammonia production need to be explored.

This work addresses alternative ammonia production from livestock manure using anaerobic digestion in a near-carbon-free ammonia process. The work evaluated poultry layer, dairy milking, and finishing swine manures to assess ammonia recovery potential and evaluate ammonia recovery and purification technologies for these applications.

Key findings from the full report include:

- Poultry layer manure and milking dairy manure can produce commercially-viable combined renewable green ammonia and renewable natural gas (RNG). Based on the ammonia recovery technologies, the poultry industry scenarios were found to have a higher ammonia production and a lower capital cost, compared to the dairy farming options.
- New builds at poultry locations should include ammonia recovery systems, given the additional value of green ammonia that can be recovered, compared to the expected additional capital and operational expenses.
- For existing milking dairy manure digesters, ammonia technology can be added as a "bolt-on" technology for the additional ammonia recovery. Based on the criterion evaluated in this report, follow-on work to select locations for this system and conduct an in-depth front end engineering design report is recommended. This would increase the precision and confidence in the engineering design and profitability of the proposed systems.
- Recovering ammonia from anaerobic digestion processes that is otherwise nitrified offers several practical and economic benefits. It lowers the water treatment energy, offers the ability to more readily apply sludges produced in the process (since it has lower ammonia content), and produces an ammonia-rich product stream (depending on the chosen recovery process) that can be sold as green ammonia. Anaerobic digestion also is enhanced, producing more methane (RNG) and lower sludge volumes (since more sludge is converted to methane).
- These processes are compatible with existing CO_2 capture technologies and would allow direct capture from the exhaust gases (currently estimated to be ~97% CO_2).

This report describes an assessment of technology suitable for ammonia recovery from anaerobic digestion. This assessment was conducted by reviewing the existing literature and engaging leading professionals in the water anaerobic digestion community, as well as other professionals in the industrial, consulting, and academic communities. The goal was to gather information on current technologies under investigation and the current state of those investigations. A technology scoring criteria and scoring matrix was created to rank the full set of technologies and to define a screening-level core list of high-potential technologies. The net ammonia yield and associated trade-offs (loss of methane, for example) were calculated for each core list technology. A high-level process flow for each core list technology and associated process flow diagrams and descriptions were developed.

The Low-Carbon Resources Initiative

This report was published under the Low-Carbon Resources Initiative (LCRI), a joint effort of the 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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