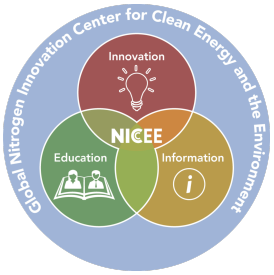

The Global Nitrogen Innovation Center for Clean Energy and the Environment (NICCEE)

Improving our understanding of the impact of nitrogen and "green ammonia" on climate change and the environment

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Green Ammonia in US Agriculture: Policy Pathways to Decarbonize Fertilizer Production and Empower Rural Communities

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Executive Summary

Ammonia is essential to modern agriculture, but its production currently relies on natural gas, exposing farmers to volatile energy markets and global conflicts. Ammonia production currently accounts for about 2% of global carbon emissions due to the current reliance on fossil fuels. Green ammonia, produced using renewable electricity and hydrogen from renewable sources, offers an opportunity for farmers to take local control of fertilizer availability and lower their exposure to volatile and unpredictable international markets. While current production remains limited due to high capital costs, access to renewable energy, and current policies supporting large industrial producers, emerging systems and technologies demonstrate potential for on-farm and cooperative-scale deployment. By expanding programs through the USDA, DOE, EPA, and state agencies, and ensuring financial incentives that specifically benefit smaller farms and co-ops, the US can make strides toward clean energy and climate goals while supporting farmers.

Context and Rationale

Green ammonia refers to ammonia generated using renewable energy and hydrogen from renewable sources. With no carbon dioxide (CO_2) emissions during the production process, it is significantly less environmentally damaging than **grey ammonia**, which is produced in centralized, industrial facilities using fossil-fuel-derived power and hydrogen. **Blue ammonia** has also emerged as a transitional alternative, but it still relies on fossil fuel power and methane-derived hydrogen with relatively unproven large-scale carbon capture and storage (CCS).

About 80% of current global ammonia production is used to synthesize fertilizers, with the other 20% used for munitions, plastics, and synthetic fibres and dyes. Grey ammonia is the historical form that remains the most widely used currently, in part due to technology "lock-in" from decades of use, and also due to its lower cost compared to green or blue ammonia. Despite the initial higher cost, green ammonia is expected to become cost-competitive in the near future, and implementing green ammonia technology has the potential to benefit farmers and the environment in ways that grey ammonia cannot. These include independence from fossil fuels, resilience to global market shocks, and local control of fertilizer production. For example, when Russia invaded Ukraine, fertilizer markets surged, leading to prices increasing by over 200%.[1] Moreover, green ammonia supports decarbonization in the agricultural sector, while contributing to national environmental goals. Due to the potential benefits, green ammonia can be competitive in the fertilizer market without the detrimental CO_2 emissions or other fertilizer types.

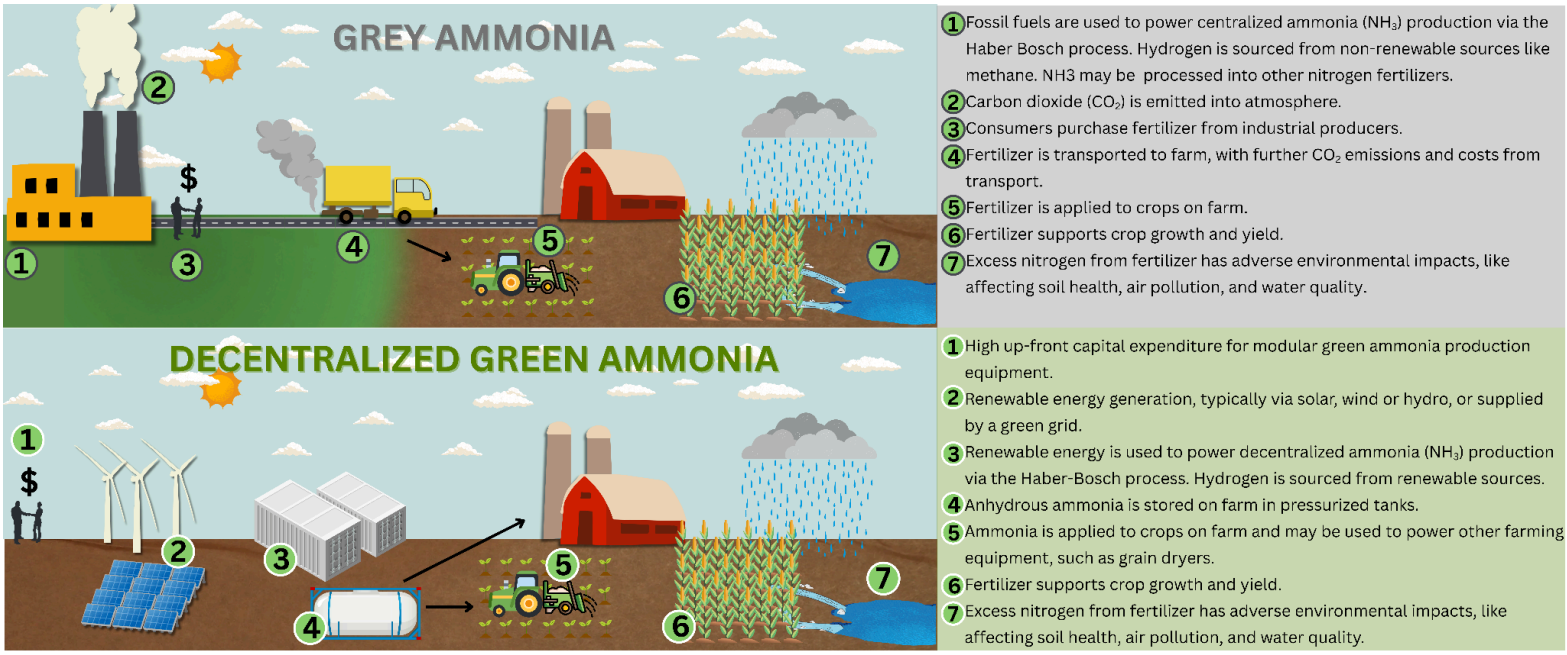

Figure made by Sophie LeClaire, 2025. Contact sarah.garvey@umces.edu for use.

Experiences on the Ground

There are two main pathways for current commercial green ammonia production: centralized and decentralized.

- **Centralized** green ammonia production involves large-scale plants that rely on access to substantial sources of renewable energy and, as with centralized grey ammonia production, requires ammonia transport from factory to farm. An example of this is **CF Industries**, the world's largest producer of ammonia, founded by nine US Midwestern farm co-ops, which operates both green and blue ammonia plants. Originally, a grey ammonia production company, CF Industries has made strides to decarbonize its ammonia production process. They are investing in green ammonia, both for the environment and financial benefits through tax incentives and credits, providing them a significant return profile.
- **Decentralized** production involves small-scale, modular green ammonia units that can be deployed on-farm and offer local autonomy, economic resilience, and alignment with rural clean energy goals. For example, **TalusAg** is a private, US-based company that has piloted modular, distributed green ammonia systems that allow co-ops and farmers to produce fertilizer locally. They have a successful installment in Kenya, a developing program in Iowa, and are anticipating significant continued growth.

The US renewable energy landscape is well poised to enable the transition to green ammonia. The current landscape for renewable energy generation shows a large amount of renewable energy in progress. Nearly 12,000 projects representing 1.6 gigawatts of capacity are currently in the "interconnection queue" (list of power generation projects waiting to be connected to the power grid), and 95% of those are solar, wind, or energy storage. The federal government is pulling back support for many of these projects, but even if only a fraction, *e.g.*, 20 – 40%, of these projects were completed, the resulting increase could nearly double electricity generation.[2]

Risks and Barriers to Adoption

Green ammonia offers the potential to decarbonize fertilizer production, but several economic, technical, and policy challenges complicate its adoption at the farm level. Green ammonia production technology remains capital-intensive, ranging from 1-5 million USD for 1-2 tons of ammonia production per day, and depends on reliable access to renewable energy. Different financial models, such as co-ops or long-term offtake agreements, can alleviate this barrier. An example of this is seen between TalusAg and Landus. Landus is an Iowa-based farmer cooperative that entered a fixed-price offtake agreement for a commercial green ammonia installation from TalusAg with a corresponding production capacity of about 300-600 tonnes per year.

Economies of scale often favor large industrial producers, and smaller agricultural stakeholders can face steeper financial barriers to entry for new technologies. Uncertainty and perceived risks of technology performance and long-term economic returns can also deter green ammonia adoption, particularly for small and mid-sized farms. Without targeted support, these dynamics could exacerbate existing inequities in the agriculture sector by accelerating farm consolidation, as larger operators with greater capital access could scale faster than smallholders. Over time, this could deepen structural inequalities, reducing rural employment opportunities and threatening local livelihoods.

The current main product of the green ammonia distributed unit is **anhydrous ammonia**, which is highly concentrated ammonia stored under pressure. Anhydrous ammonia is used on-farm in some parts of the US, mostly in the Midwestern corn belt, and accounts for about 24% of total nitrogen fertilizer use nationally. Farmers without the infrastructure to store and use anhydrous ammonia would incur significant additional expenses to adopt its use. Safety concerns related to anhydrous ammonia must also be considered for on-farm adoption. Anhydrous ammonia is hazardous to manage, as even minor skin or respiratory exposure carries health risks, and it requires specialized storage and application equipment. Experience handling anhydrous grey ammonia should be transferable to anhydrous green ammonia, but local production and storage add some additional challenges.

Green ammonia can also be solubilized in water, known as **aqua ammonia**. Aqua ammonia is not widely used by farmers today, but because it is a liquid, it might be feasible for farmers to adopt in lieu of other forms of liquid fertilizers currently in use (e.g., urea ammonium nitrate, or UAN). Research is needed to determine if green aqua-ammonia could be applied with the same equipment widely used to apply UAN and other forms of nitrogen fertilizer. Converting green ammonia into other fertilizer forms would add complexity and expense at small scales, and on-site conversion using distributed units is largely in the development phase.

Environmental impacts also persist despite decarbonized production. Fertilizer use, regardless of production method, contributes to emissions of nitrous oxide and nutrient leaching from croplands. Increased fertilizer access and potentially reduced costs from on-farm green ammonia production could unintentionally drive higher total nitrogen use, particularly in unregulated regions like the U.S. Midwest, and even in regulated areas, it could incentivize expansion of nitrogen-intensive crops such as corn. These dynamics could heighten regional nitrogen losses and lead to unforeseen risks and environmental hazards. On the other hand, green ammonia fertilizers produced on-farm, year-round, could also allow farmers to time their fertilizer applications to more effectively match crop demands, which could increase efficiencies and reduce nitrogen losses. Research and on-farm experience will be needed to guide optimal use of green ammonia as it becomes more available.

Relevant Current Policies

- **Department of Energy Hydrogen Hubs**: network of hydrogen infrastructure, with some limited green ammonia integration.
- **Tax Credit 45V, Clean Hydrogen Production**: Tax credit for green hydrogen for facilities beginning construction before Jan 1, 2028.
- **Fertilizer Product Expansion Program (FPEP):** grants to increase or expand fertilizer manufacturing.
- **Rural Energy for America Program (REAP):** loan financing and grant funding for use of renewable energy systems or energy efficiency improvements in agriculture.
- **USDA's Partnerships for Climate-Smart Commodities**: finances partnerships to support production and marketing of climate-smart commodities
- Farm bill programs, such as **USDA NRCS's EQIP** program: cost share on pre-approved conservation practices for farms.
- Complementary state-level programs, such as the **Green Fertilizer Grant Program**, which provides funding to agricultural and rural electric cooperatives to invest in green fertilizer production facilities located in Minnesota.[3]

Policy Recommendations and Opportunities

Financial support for small-scale deployment

- Establish dedicated **USDA, DOE,** and **EPA grant programs** for farmer coops to deploy small-scale green ammonia systems.
    - Provide financial support for **construction** of green ammonia production units
    - Provide funding for **R&D** on production and application of green ammonia products in forms other than anhydrous ammonia
- Expand existing partnerships and programs, such as **FPEP, REAP, Partnerships for Climate-Smart Commodities** and **EQIP**, to include benefits for producing, utilizing, or promoting green ammonia.

Tax credits & incentives

- Revise **Tax Credit 45V** to extend the eligible construction date back to 2032 and ensure coverage of green ammonia infrastructure
- Offer **tax credits** and other financial incentives for the use of curtailed (*i.e.,* excess) rural **renewable energy** in ammonia production.
- **Incentivize** farmers' use of green ammonia through **tax benefits**, improving cost-effectiveness

Training & technical assistance

- Develop **farmer training programs** focused on ammonia handling and new technology adoption.

Market & regulation

- Establish clear **regulations for buying, selling and transporting** green ammonia at local and national scales to ensure safety, transparency and market development
- Restore funding and integrate green ammonia into all **Department of Energy Hydrogen Hubs**

Conclusion

Green ammonia offers a promising opportunity to decarbonize fertilizer production, strengthen rural economies, and advance clean energy and climate objectives. While these climate objectives are not in

favor with the current U.S. administration, green ammonia also potentially offers farmers important economic benefits and resilience, which may create demand from the bottom up. Technological, historical, financial, and policy barriers currently limit widespread adoption, particularly for small and mid-sized farms, but targeted policy intervention can help overcome these challenges. Strategic investment in decentralized production systems, tailored incentives for farmer cooperatives, and expanded support through existing USDA and DOE programs (*e.g.,* grants for small producers, tax credits for renewable-powered systems, farmer training programs) would not only accelerate green ammonia deployment but also ensure equitable access across agricultural scales. By investing in on-farm and community-scale production, the US can give farmers greater control over their fertilizer supply while cutting emissions and promoting agricultural economies. The transition to green ammonia is not only an environmental objective but also an economic and strategic opportunity to secure a more self-sufficient agricultural future.

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Prepared by:

Sophie LeClaire, Sarah M. Garvey, Eric Davidson, David Kanter, Matthew Houser, Xin Zhang
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