Electrified production of climate-smart nitrate fertilizer is key to a decarbonized future

GREENHOUSE GAS EMISSIONS FROM NITROGEN FERTILIZERS

Nitrogen is an essential crop nutrient that plays several roles for plant growth: it is a key component of chlorophyll (the molecule that allows plants to absorb energy from the light) and amino acids. Farmers can find several forms of N fertilizer in the market to support their farming practices. However, N fertilizer production and field application emissions account for roughly 7% of all greenhouse gas (GHG) emissions worldwide (Figure 1). These emissions contribute to the greenhouse effect, trapping heat in the Earth's atmosphere and leading to increased global temperatures and climate change.

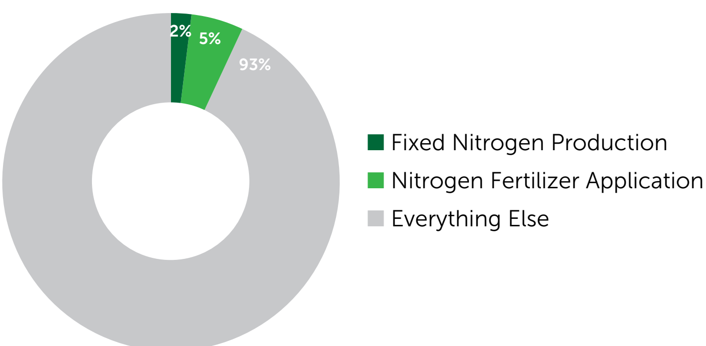

Figure 1. Global GHG Emissions from nitrogen fertilizer production and field application.

Popular N fertilizers include urea, ammonium nitrate (AN), urea ammonium nitrate (UAN), and calcium nitrate (CN). In nearly all of the existing markets, N fertilizer production starts with ammonia produced via the Haber-Bosch (HB) process. This process uses dinitrogen (N_2) and hydrogen (H_2) as feedstocks. The H_2 molecule comes from burning fossil fuel and results in significant carbon dioxide (CO_2) emissions. Once ammonia is produced, it is usually transformed into other products or fertilizers through chemical processes that result in additional GHG emissions.

It is estimated that for every ton of fixed nitrogen produced as ammonia, there is an emission of 2-4 tons of CO_2-equivalent from the production process due to the use of fossil fuels (Chen, 2018). In addition to these resulting CO_2 and methane (CH_4) emissions, nitrous oxide (N_2O) is another common GHG emitted during the production of N fertilizers. Nitrous oxide is a potent GHG with a global warming potential 265 times that of CO_2 (EPA). Nitrous oxide is commonly released during nitric acid production via the Ostwald process, resulting in 5 tons of CO_2-equivalent emissions for every ton of N produced as nitric acid. An even larger release of N_2O comes from the application of N fertilizers in the field, averaging 7 tons of CO_2-equivalent emissions for every ton of N applied. In fact, N fertilizer application represents 78% of all nitrous oxide (N_2O) emissions in the United States (Figure 2). Nitrous oxide emissions are particularly potent as they deplete the ozone layer, leading to more damaging UV radiation reaching Earth's surface. The fertilizer industry must adopt cleaner production methods and technologies to minimize CO_2, CH_4, and N_2O emissions, in order to minimize harmful climate impact.

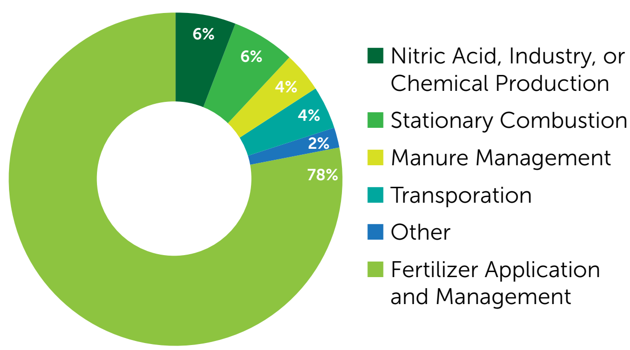

Figure 2. Sources of N_2O emissions in the United States.

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Nitrate-based fertilizers (e.g., calcium nitrate, potassium nitrate) are an important solution to protect the climate. Studies show that the use of nitrate-based fertilizers can reduce field application emissions by 2-10x over ammonium-based or ammonium-forming fertilizers (e.g, ammonia, urea) in non-flooded conditions (Burger, 2016; Wolff, 2017). Switching from ammonium-based to nitrate-based fertilizers could significantly reduce GHG field emissions associated with fertilizer application. However, nitrate-based fertilizers still have some GHG emissions associated with their production.

NITRICITY'S TECHNOLOGY CAN REDUCE EMISSIONS

Nitricity is developing a technology that avoids almost all of the emissions from production, distribution, and application: 1) CO_2 and CH_4 emissions from industrial N fixation, 2) N_2O emissions from nitric acid production, 3) emissions from distribution of fertilizers, and 4) N_2O emissions from fertilizer field application.

Nitricity's process imitates natural lightning N fixation by using renewable electricity and plasma reactor technology to break down the N_2 molecule. The cracked N_2 reacts with oxygen to form NO and NO_2, which then chemically react with water in absorption columns to produce nitric acid. Electrification of this process and use of renewable electricity reduce the production emissions to near zero. Importantly, the Nitricity's plasma technology produces an undetectable amount of N_2O to fix nitrogen as nitric acid, unlike the traditional ammonia (Haber-Bosch) and nitric acid (Ostwald) productions processes that are important emitters of N_2O (Figure 3). These data show that for every ton of nitric acid produced via the incumbent process, there are 1.26 tons of CO_2-equivalent emissions released into the atmosphere. Nitricity's systems are designed to scale up or down, bringing production closer to point of use and minimizing distribution emissions. Nitricity's "green" nitric acid can be combined with other substances to create valuable nitrate-based fertilizer products. Calcium nitrate is a great example with a lower field-emissions profile compared to ammonium-based fertilizers, such as anhydrous ammonia or urea.

Alternative sustainable technologies such as "green" ammonia (water electrolysis) and "blue" ammonia (CO_2 capture) address the GHG emissions associated with N fixation. However, the ammonia produced from these technologies still needs to go through the same industrial processes (e.g., Ostwald process), distribution, and field application as conventional ammonia, which results in GHG emissions.

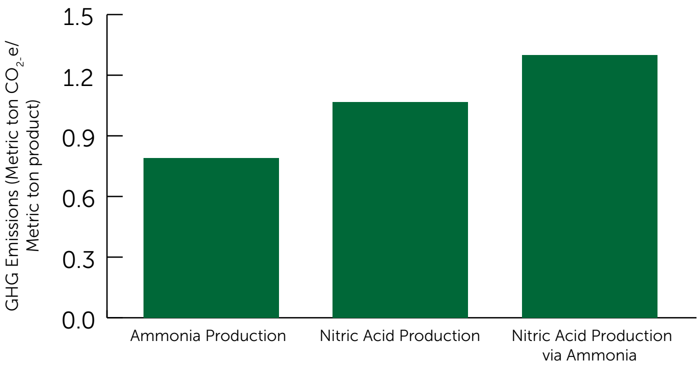

Figure 3. Average US GHG emissions from incumbent ammonia and nitric acid production processes.

CONCLUSION

The production and application of N fertilizers is a significant source of GHG emissions. Nitricity's electrified method to produce nitric acid and nitrate-based fertilizers can substantially reduce emissions. Ultimately, electrifying production and focusing on nitrate-based fertilizers with lower associated field emissions is key to help decarbonize the future.

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