Minnesota Senate Energy Committee

Green Nitrogen Fertilizer: Implications for Minnesota Agriculture

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Saint Paul, MN

Presented by:
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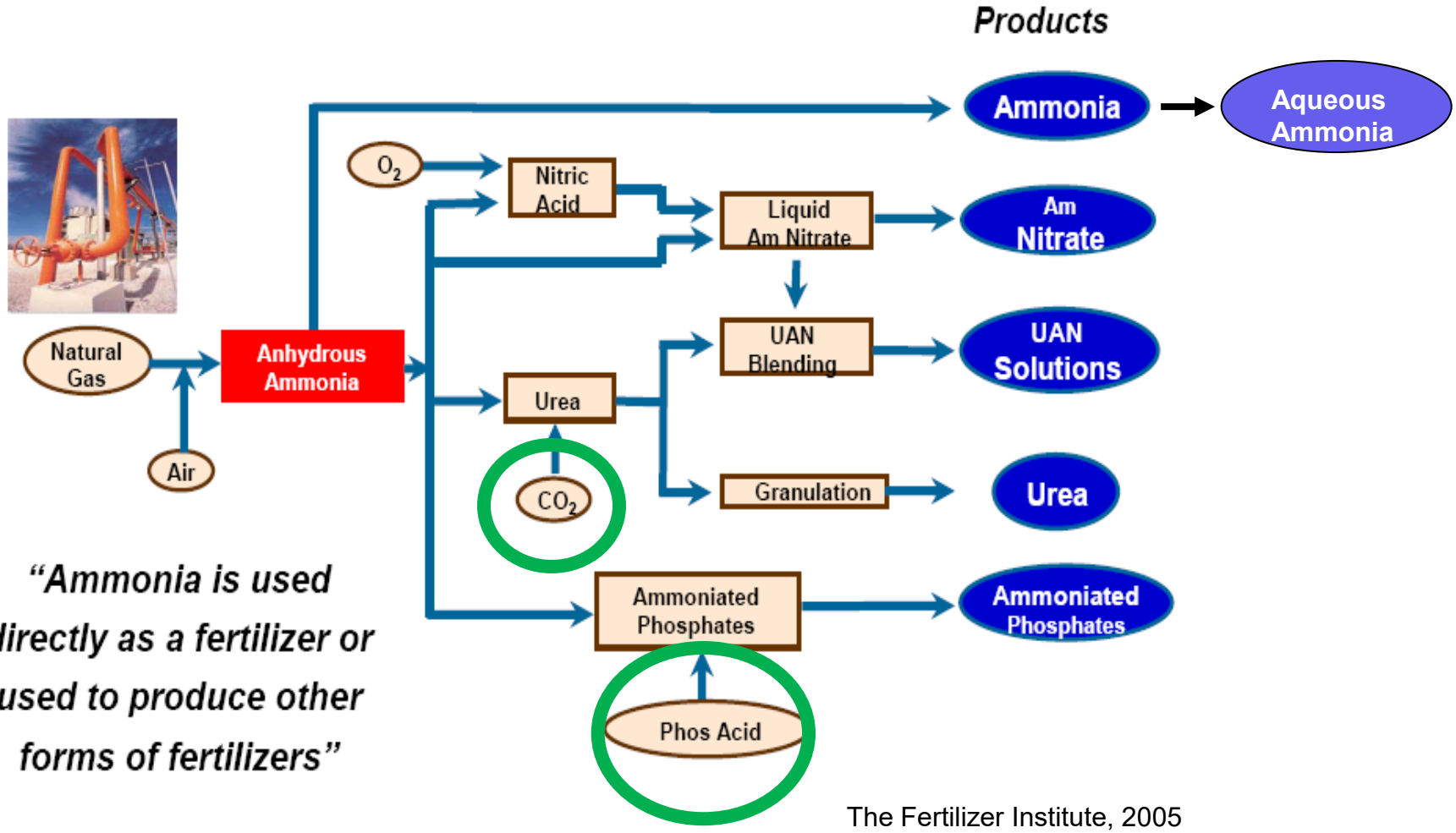
West Central Research & Outreach Center
"Leading innovation in agriculture and beyond"

Nitrogen Fertilizer Production

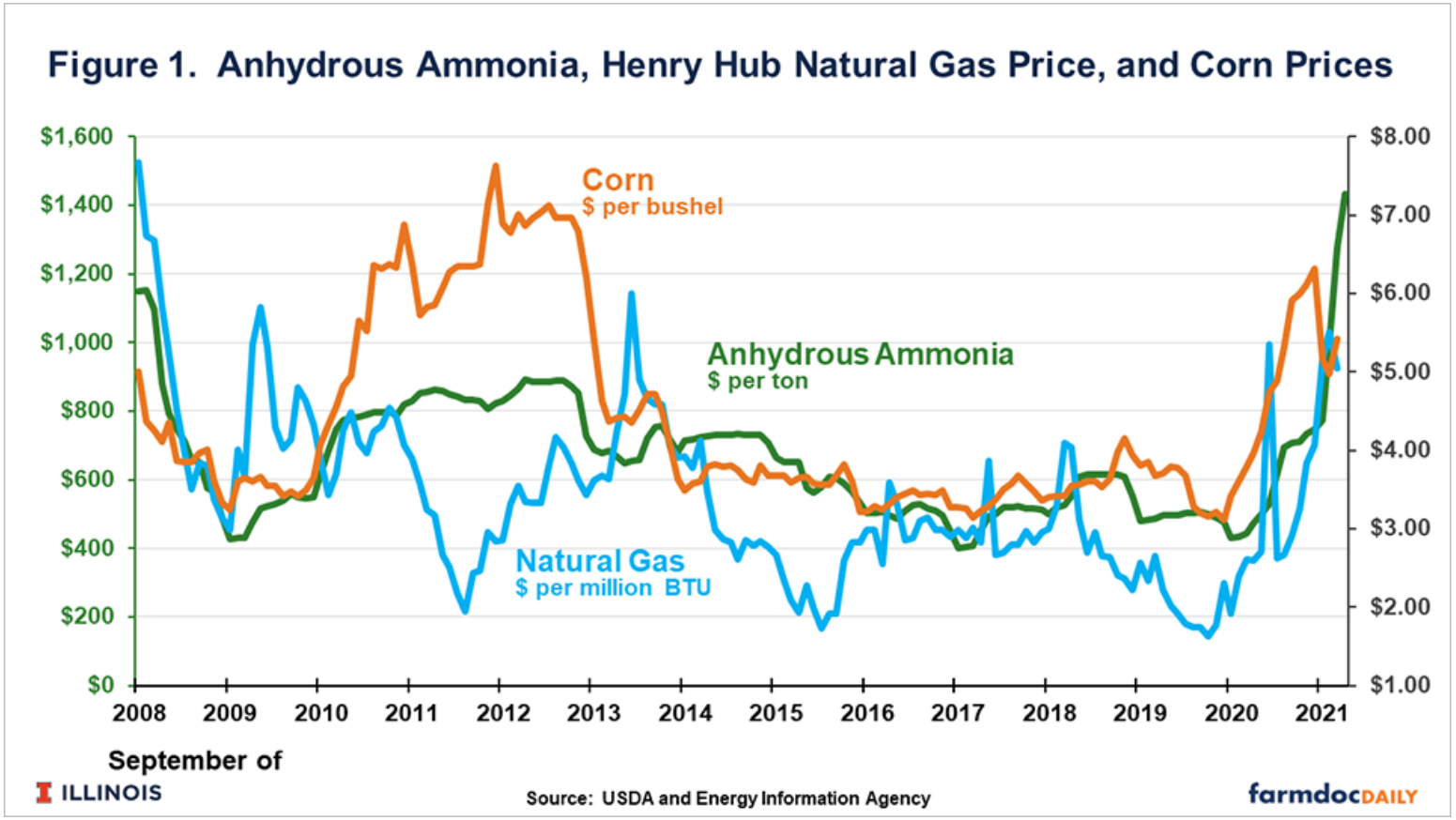


The Fertilizer Institute, 2005

- Proven commercial technology currently available to produce hydrogen, ammonia, urea, and other hydrogen-based fuels in Minnesota.

Why renewable ammonia?

- **Price certainty and stability:** decoupling from global natural gas market
- **Reduce carbon intensity**: >2.6 mt_{CO2}/mt to <0.2 mt_{CO2}/mt
- **United States policy:** Federal clean H_2 production credits up to $3/kg
  - $529/mt ammonia production credit for first 10 years of production!



Palys, et. al. 2022

Green Ammonia: An Elegant Solution

Wind or Solar Energy + Water + Air = Nitrogen Fertilizer

Step 1. Electrolysis of Water

$2H_20 \longrightarrow \mathbf{2H_2} + O_2$

Step 2. Air separation

O_2 and Ar are absorbed in a molecular sieve leaving $\mathbf{N_2}$

Step 3. Haber Bosch Process

$N_{2(g)} + 3H_{2(g)} \rightleftharpoons \mathbf{2NH_{3(g)}}$

$\triangle$ **H = -92.4 kJ**

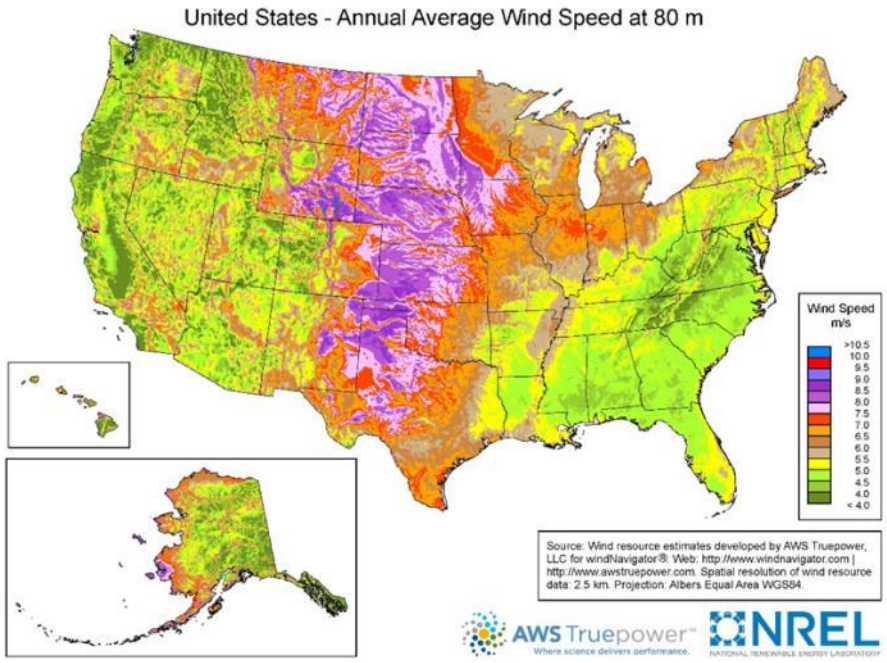
Step 4. Urea Production (Granular N fertilizer)

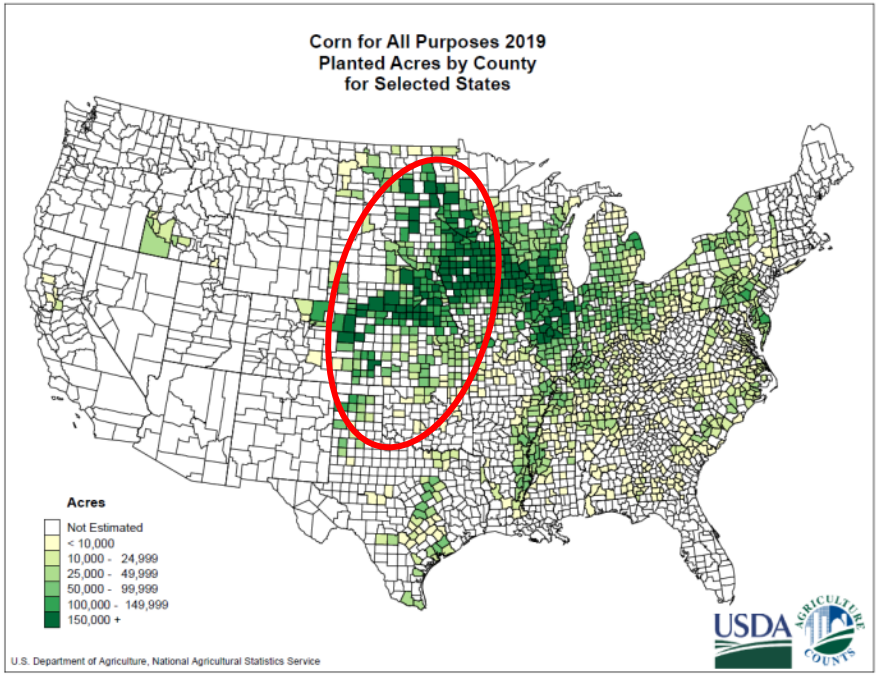
$2NH_3 + CO_2 \rightarrow NH_2COONH_4$ (ammonium carbamate)

$NH_2COONH_4 \rightarrow H_2O + \mathbf{NH_2CONH_2}$ **(dry, granular urea)**

- Carbon capture - Use CO_2 from ethanol production
- circular model

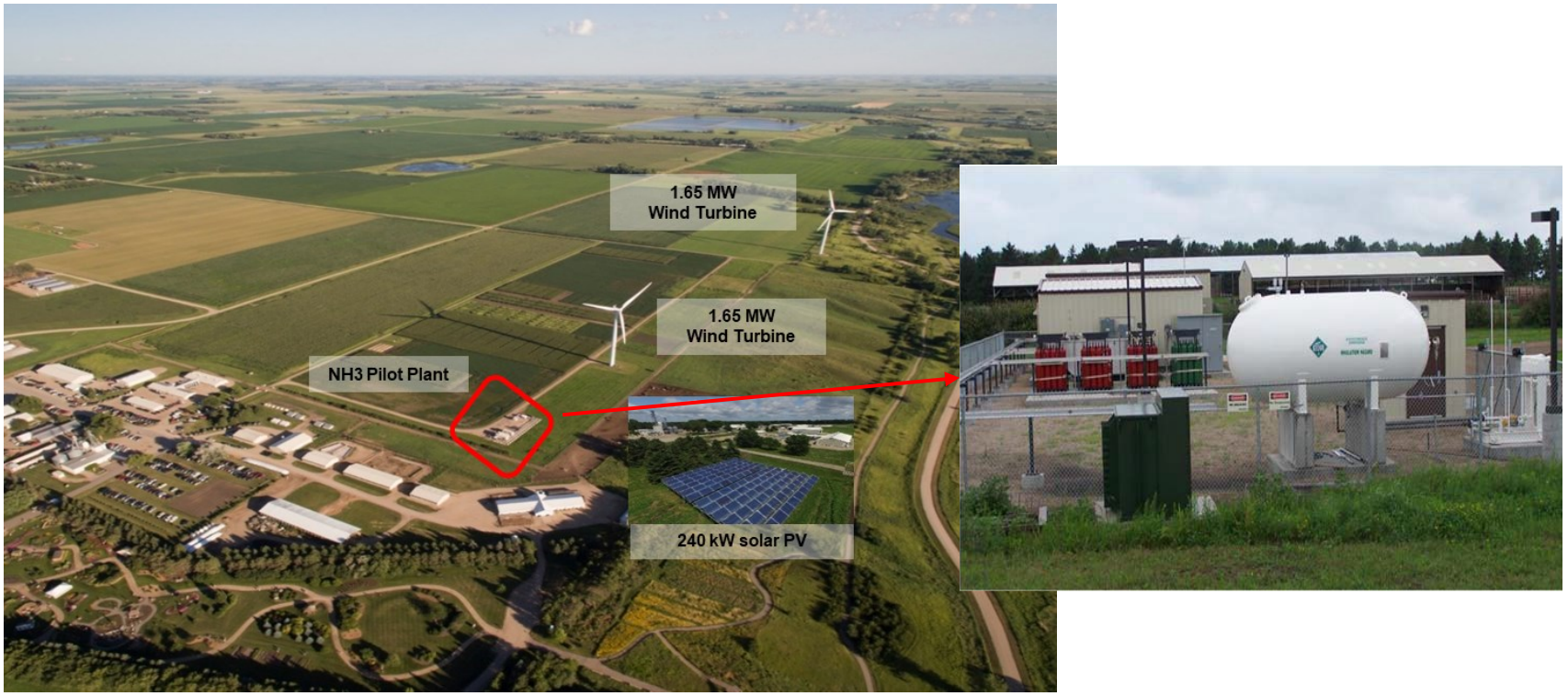
Scale: Green Ammonia





- US wind resource is synergistic with Midwest corn production and nitrogen fertilizer demand – inherently distributed
- US nitrogen fertilizer demand could be met with approximately 50,000 MW of nameplate wind energy capacity – current US wind generation is 105,583 MW of nameplate capacity
- Opportunity to utilize “stranded” wind and solar resources (and excess nuclear)
- Nitrogen fertilizer is a gateway to other green hydrogen uses – export potential

Research to improve efficiency:
US DOE ARPA-E REFUEL Technology Integration Project

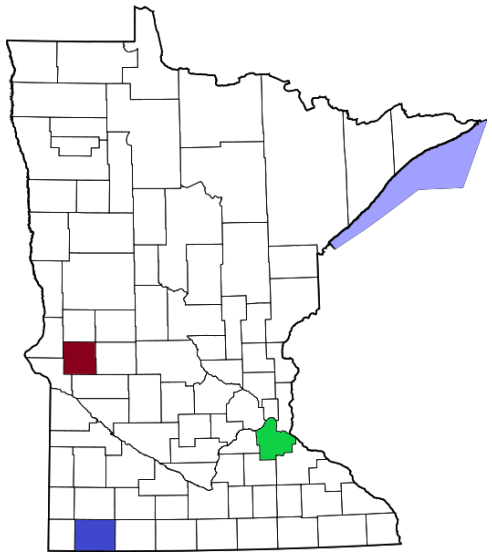


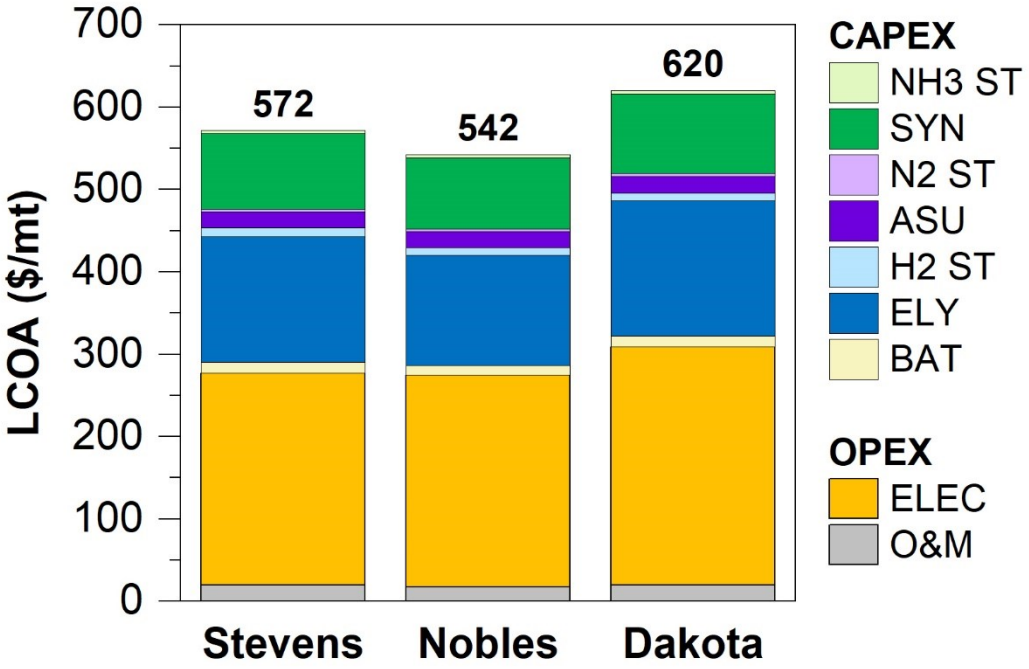
~18x scale-up of existing wind-to-NH_3 pilot plant

Production cost depends on location

- **Stevens county: 44% wind, 15% PV**
- **Nobles county: 52% wind, 16% PV → *-$30/mt* than Stevens**
- **Dakota county: 36% wind, 15% PV → *+$50/mt* than Stevens**

Does not include $529 / metric ton NH_3 value from H_2 incentive!





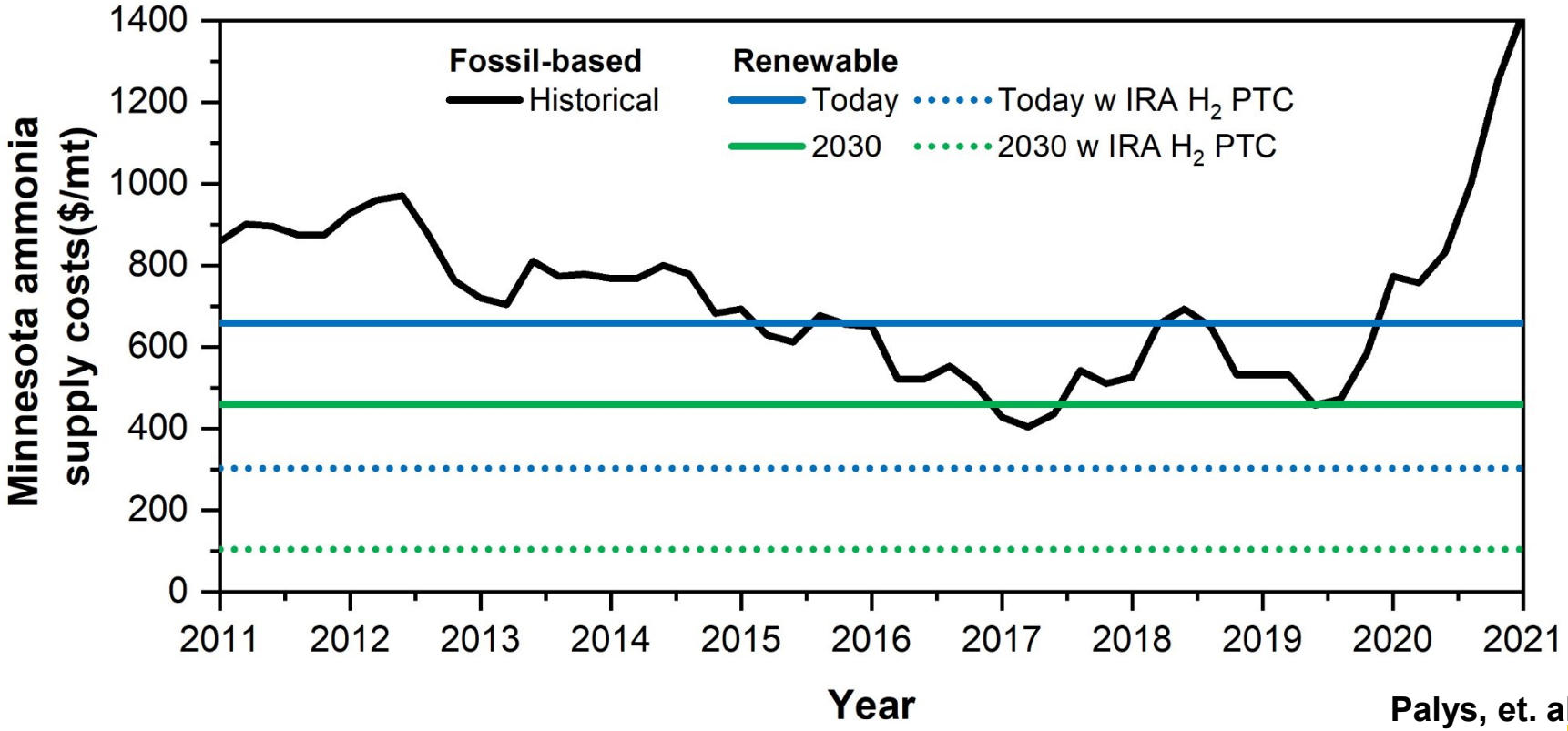
Design for each location to minimize LCOA

Palys, et. al. 2022

IRA H_2 PTC is transformative

IRA: $3/kg H2 credit for CI<0.45 kg_{CO2}/kg_{H2}, labor/wage requirements met

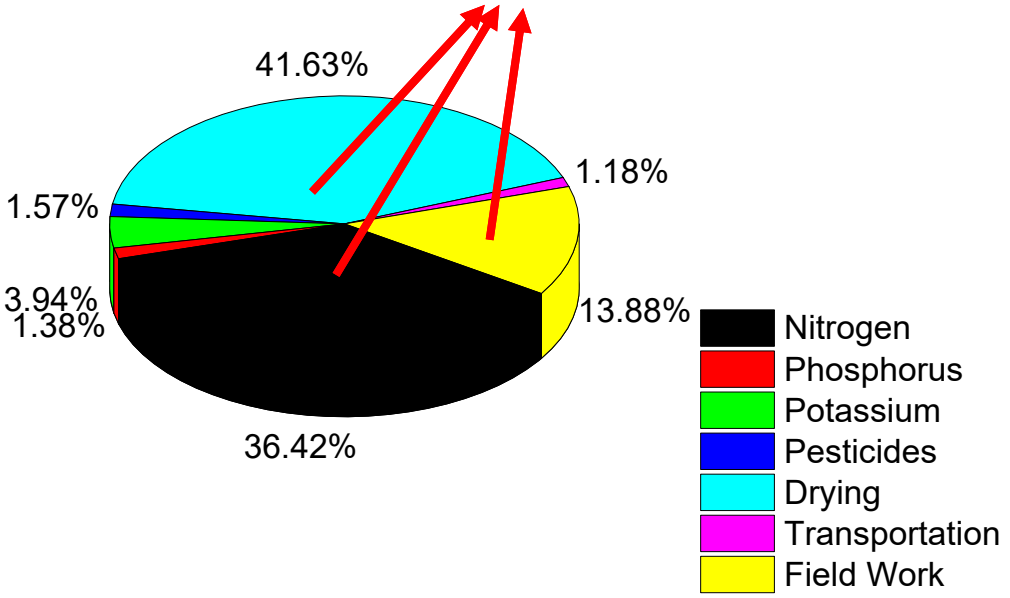
- **$529/mt ammonia for first 10 years of production (ammonia CI<0.08 mt_{CO2}/mt_{NH3})**
- **$356/mt ammonia levelized over 20 year project with 7.5% discount rate**



Palys, et. al. 2022

Transformational: Green ammonia is a drop-in replacement

Potential to reduce fossil energy use in corn production over 90% using ammonia (NH_3) produced using wind energy.



J. Tallaksen, 2016. UMN West Central Research and Outreach Center

- Nitrogen fertilizer production is responsible for 2% of global GHG emissions.

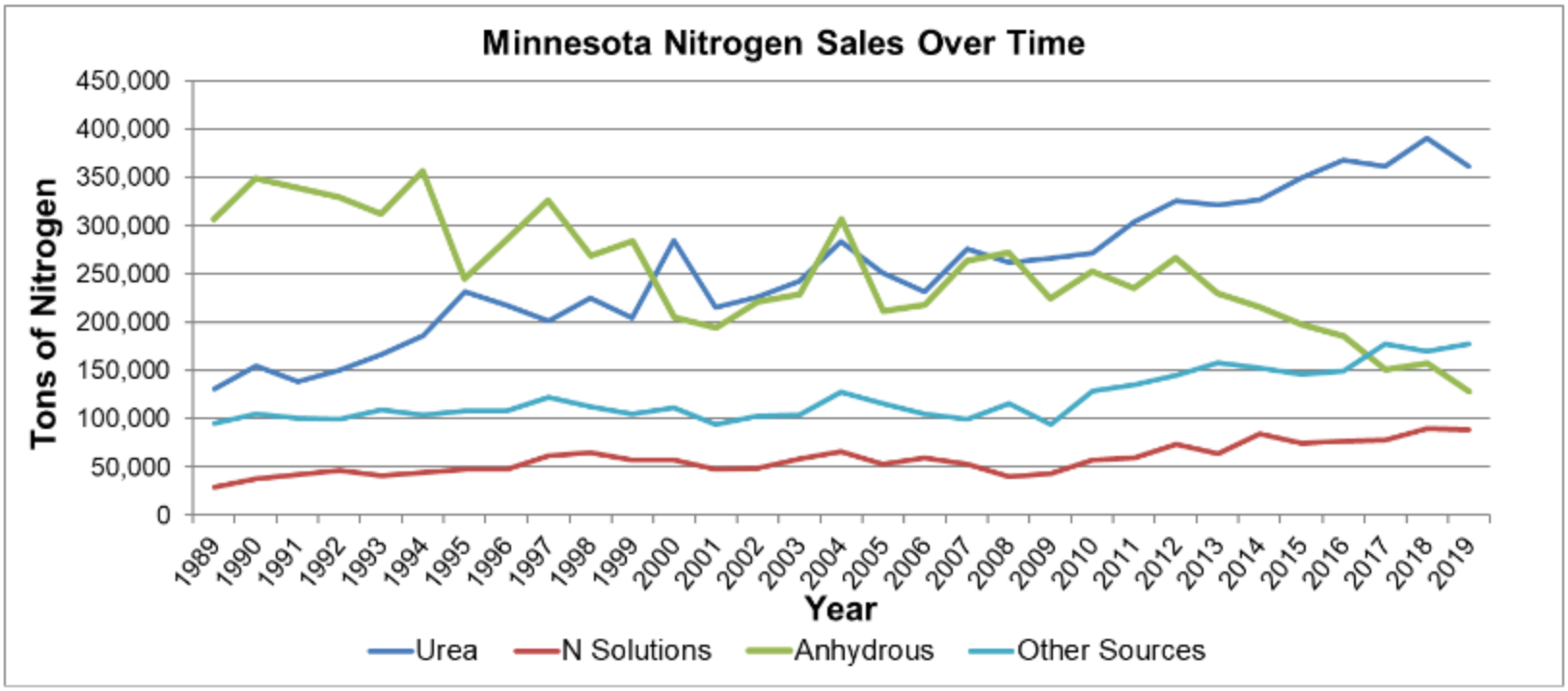
Potential to use green ammonia as a fuel further decarbonizing agriculture and other sectors

Source: Univ. of Minnesota

Source: Amogy

Bottom-line:

- With new federal incentives, we can economically meet all nitrogen fertilizer needs in Minnesota with green nitrogen fertilizer.



Source: MN Dept. of Agriculture

Impact of 100% Green N Fertilizer Production in Minnesota

- Stimulates investment in Minnesota - $2 billion capital investment for five new ammonia production facilities distributed across the State (120,000 to 205,000 t/y range)[1]
- Decarbonizes agriculture production - 95% reduction in carbon intensity of nitrogen fertilizer production (3.2 $tCO_2eq/t.$ vs 0.17 $tCO_2eq/t.$)[1]. Reduces Scope 3 emissions for Minnesota processors, wholesalers, and retailers.
- Greatly increases utilization of renewable energy - 1750 MW of wind and 500 MW solar nameplate capacity across the region.[1] Helps achieve 100% goal.
- Provides competitive and stable nitrogen fertilizer pricing for farmers
- Significant economic driver - Estimated $10B to $25B in total economic benefits through 2035. Estimated $720 MM to $1.73 B in tax revenues.[1]
- Supports Minnesota manufacturing industries and provides potential early adopter benefits and “technology dividends”
- Gateway to other green hydrogen technologies
- If done correctly, allows broad participation and benefits

[1]Palys, et. al., 2022

Acknowledgements

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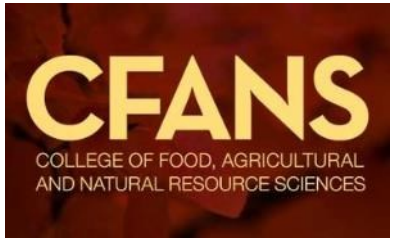
- Clean Energy Resource Teams (CERTS)
- Electric Power Research Institute (EPRI)
- MnDRIVE
- Climate Imperative



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