FARM FOUNDATION®
FORUM
GREENING THE FERTILIZER INDUSTRY
MARCH 21, 2023

Today’s webinar is made possible by a grant from Farm Credit

#FarmFoundationForum
MARTHA KING
Vice President, Programs and Projects
Farm Foundation
MEET FARM FOUNDATION

A 501(C)(3) NON-PROFIT AT THE INTERSECTION OF AGRICULTURE AND SOCIETY
Farm Foundation is an **ACCELERATOR** of practical solutions for agriculture.

We accelerate **PEOPLE AND IDEAS** into **ACTION**.
OUR MISSION AND VISION
GUIDE OUR WORK

MISSION:
To **build** trust and understanding at the intersections of agriculture and society.

VISION:
To **build** a future for farmers, our communities, and our world.
BECOME A FRIEND OF FARM FOUNDATION

See link in chat function

- Donate to Farm Foundation to support our mission
- Receive exclusive benefits and curated content
- Help us continue to provide valuable content like today’s Forum
CONNECTION & COLLABORATE WITH US!

Farm Foundation: Accelerating People & Ideas

Connect with us on social media:

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Farm Foundation  @thefarmfoundation
Submit questions by clicking on the **Q&A Button** at the bottom of your screen.

Please **include your name and company** so questions may be contextually understood.

Due to **time limits**, we may not be able to ask all questions submitted.

This Forum is being recorded and will be posted on our website at [farmfoundation.org](http://farmfoundation.org) as well as the Farm Foundation [YouTube](https://www.youtube.com) channel.

Please take the **short survey** at the conclusion of the Forum.
JAY VROOM
Moderator/Speaker
Chief Innovation Officer,
Vroom Leigh Agriculture
CHERI DE JONG
Principal Owner, Natural Prairie Dairy
Owner and CFO, AgriVision Farm Management
Meet the De Jong's

Donald and Cheri started with 800 cows in the High Plains of Texas, dedicating 15 years to building the organization from the ground up. Now, NPD has over 18,000 certified organic cows and 250 team members in multiple states all dedicated to producing an exceptional product.
Natural Prairie Dairy produces best-in-class, highest quality certified organic milk from family-run, sustainable farms in Texas and Indiana.
Best-in-class cow care

Our cows receive the best care—because happy, healthy cows raised on clean land make great tasting milk. Our cows enjoy...

Organic Pastures
Our land is certified organic by the Texas Department of Agriculture and Oregon Tilth.

Natural Resources
Our land is fertilized by the nutrients our cows produce, replenishing essential nutrients.

Open Grazing
During grazing season, our cows get the nutrients they need by grazing on beautiful pastures.

Organic Feed
We grow our own feed to be used in a unique formula approved by a dairy nutritionist.
We believe organic farming requires the utmost respect for the land. To ensure the quality we're known for, we...

**Work in sustainable harmony**
Because of our scale, we are able to create a farm ecosystem that supports and relies upon the cows, the land and the people who produce it.

**Prove that technology and farming go hand-in-hand**
We run a 21st century farm, with state-of-the-art equipment and technology that makes our farm cleaner and more sustainable.

**VARCOR Waste Management**
We've improved our Indiana farm’s sustainable footprint with the groundbreaking VARCOR system, which processes manure into useful materials.

Give back to the land
What if we could eliminate manure ponds?
VARCOR

The Varcor will *change animal agriculture for the better, transforming dairy farms for the better, forever.*

The VARCOR system can efficiently distill cow manure into:

- **Clean water cows can drink.**
- **Portable dry, odorless NPK**
- **Aqueous ammonia**
VARCOR...a brief history
Earlier this year, Bill Gates posted a video of himself drinking water that was made from human feces. (It went viral, unsurprisingly.)

The water was processed by a machine that collects human waste and converts it into safe, reusable byproducts -- water, electricity and ash. This week, Gates said in a blog post that the "Omniprocessor" machine is getting its first test run in Dakar, Senegal, with the aim of reducing disease and saving lives in the city.

Dakar is a West African city of 3.4 million, about a third of whom have no access to the city's sewer system. Instead, they store their waste in pits or septic tanks.
VARCOR™ Energy Input vs Traditional Methods

Energy Required to Evaporate 370 Litres / Minute of Water

Varcor ~500 kW
Natural Gas Boiler ~15 MW
VARCOR™
Why is Varcor so effective?

1. When you apply heat, evaporation separates the solids from the other components.

- **WATER**
- **VOAs**
- **ODORS**
  - Boiling ≤ 100°C

- **WATER**
- **SOLIDS**
- **DISSOLVED SOLIDS**
- **AMMONIA**
- **ODORS**
- **ETC.**

- **SUSPENDED SOLIDS**
- **DISSOLVED SOLIDS**
  - Boiling > 100°C
VARCOR™
Why is Varcor so effective?

2. As the vapor cools & condenses, it releases each component at a different temperature through distillation.

- WATER
- AMMONIA
- ODORS
- VOAs
- VOCs

Boiling ≤ 100°C
<table>
<thead>
<tr>
<th>Feature</th>
<th>Storage Lagoons</th>
<th>Anaerobic Digestion</th>
<th>VarCor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kills Pathogens</td>
<td>✗</td>
<td>✓ 90%</td>
<td>✓ 100%</td>
</tr>
<tr>
<td>Produces Clean Water</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Eliminates Risk of Nutrient &amp; Bacteria Leaching or Run-Off</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Energy Recovery Potential (Electricity, Heat)</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Revenue Generation &amp; Cost-Savings Potential</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Unsusceptible to Biological Upset Conditions</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Higher Air Quality &amp; Lower Odor</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Creates Dry, Sterile Solids with High Phosphorus Content</td>
<td>✗</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Can Separate Nitrogen into a Concentrated Fertilizer</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
<tr>
<td>Precision Application:</td>
<td>✗</td>
<td>✗</td>
<td>✓</td>
</tr>
</tbody>
</table>
The Varcor also helps to reduce greenhouse gasses by eliminating methane emissions by 33%
This year’s numbers are in...with 15,600,000 gallons of manure processed, we upcycled:

- **12,000,000 gallons of clean water**
- **450,000 pounds of dry, odorless NPK**
- **78,600 pounds of aqueous ammonia, 1200 ppm, with 65% captured**
The future...
Thank You
ALZBETA KLEIN

CEO/Director General
International Fertilizer Association
Global fertilizer market drivers

Prepared by: International Fertilizer Association

For: Farm Foundation, March 2023
Product market structure and price elasticity matters

**Nitrogen**
- China, Russia, U.S.A
- India, Saudi Arabia, Egypt, Trinidad, Canada, Iran

**Phosphate**
- China, Morocco, U.S.A, Russia, Saudi Arabia, India, Brazil, Jordan, Mexico, Israel, Rest of World

**Potash**
- Canada, Russia, Belarus, China, Germany, Israel, Jordan, Chile, Laos, Brazil, Rest of World

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**Energy-intensive**
**Marginal producers in Europe**
**Crop price inelastic**

**Exposed to energy-derived products**
**Use correlated with affordability**

40% of global trade from sanctions countries
**Use correlated with affordability, capped by availability**

Source: IFA
Fertilizer supply was better than expected in 2022

Global urea production (2022 estimate), Mt

- 2017: 160
- 2018: 170
- 2019: 180
- 2020: 185
- 2021: 190
- 2022: 195

Global PA production (2022 estimate), Mt

- 2017: 90
- 2018: 86
- 2019: 82
- 2020: 88
- 2021: 92
- 2022: 97

Global potash production (2022 estimate), Mt

- 2017: 78
- 2018: 78
- 2019: 78
- 2020: 78
- 2021: 78
- 2022: 78

Source: IFA Short-Term Outlook, November 2022
Many factors affect farmer affordability

- Fertilizer price affordability
- Local currency value
- Access to credit
- Ability to hedge against harvested crop
- Ability to switch fertilizer product
- Location - distance from port/plant
- Scale - unit cost of fertilizer

Fertilizer prices, $/tonne

Source: CRU, IFA
Global response to Russia’s invasion of Ukraine

- **Sanctions**
  - Direct
  - Indirect
  - Exemption of fertilizers
  - Shipping / insurance risk

- **Raw materials**
  - Energy
  - Ammonia

- **Fertilizers in national interests**
  - Food security concerns
  - Export restrictions
  - Subsidies / market interventions

Source: IFA, news sources
Reduced fertilizer application has implications for global food production

*Projected production change in calories, by country, 2022*

Global production loss of 216 trillion calories
Equivalent to 2.5% of total global maize, wheat, rice, and soybean production

Assessment based on N application to maize, wheat, rice and soybeans

Source: Gro Intelligence, IFA, Nov 2022
Environmental considerations will continue to drive the sector performance

Scope 2 Emissions

Scope 3 Emissions

Biodiversity

Reducing Emissions From Fertilizer Use Report

Amid an evolving food crisis and in line with environmental goals, the fertilizer industry is helping to reduce agriculture’s carbon footprint while contributing to global food security. From the fertilizer factory to the farm, the industry is committed to playing its part in curbing greenhouse gas (GHG) emissions and making food systems more resilient.

Approximately half the food we eat today has been produced thanks to mineral fertilizers. At the same time, its use is associated with GHG emissions equivalent to an estimated 720 million tonnes of carbon dioxide a year. To help guide a long-term sustainability strategy, IFA is working with its members on decarbonization. In 2021, the International Energy Agency’s Ammonia Technology Roadmap showed pathways to lower emissions in fertilizer production (IFA and the European Bank for Reconstruction and Development provided support). The September 2022, Reducing Emissions from Fertilizer Use report highlights actions to scale up in order to cut scope 3 emissions – the indirect emissions that occur in companies’ value chains. The fertilizer industry recognizes that an
Innovation will drive growth
Thank you
COREY ROSENBUSCH

President and CEO
The Fertilizer Institute
SUSTAINABILITY in the fertilizer industry
Participation in the sustainability report is voluntary for TFI members. In 2021, sixteen manufacturing companies participated, which makes up 92% of the total U.S. production of phosphate, potash, and nitrogen. Eighteen retailers, wholesalers, and distribution companies joined as well, making up 33% of the U.S. fertilizer retail industry.
SAFETY AND SECURITY

2,440
Industry facilities participating in the ResponsibleAg program.

1.6X
Fewer work-related injuries. 2021 was the 2\textsuperscript{nd} safest year on record since the report began.

2.3X
Lower lost time incident rates. This is the number of recordable injuries & illnesses per 100 employees.
ENERGY

39% of reported total energy used in 2021 was generated from waste heat.

GREENHOUSE GASES

31% of GHGs were captured and not emitted in 2021. This is a 368% increase of GHG capture since 2013.

WATER

Participants had a 10% reduction in water use since 2017. We also recycled enough water to fill 1.6M Olympic-sized pools.
From 2019 through 2021, companies in this report invested an average of $1.19 billion annually in capital investments to help the industry meet sustainability goals. These investments increase production efficiencies, reduce energy and water use, reduce greenhouse gas emissions, and strengthen the U.S. economy to meet current and future agricultural needs.
Natural Gas as a Share of Ammonia Production Cost

~33 MMBtu per material ton ammonia
~ 40% for fuel
~ 60% for feedstock

Source: TPI Production Cost Surveys
LOW-CARBON AMMOMIA

Green & Blue

- “GREEN” AMMONIA REFERS TO AMMONIA MADE WITH HYDROGEN PRODUCED WITH WATER, USING RENEWABLE POWER AND ELECTROLYSIS

- “BLUE” AMMONIA IS MADE FROM HYDROGEN PRODUCED USING A STEAM METHANE REFORMING PROCESS, BUT WHERE THE BI-PRODUCT CO2 IS CAPTURED AND SEQUESTERED UNDERGROUND. SOME IN INDUSTRY ARE ALSO REDUCING UPSTREAM METHANE EMISSIONS THROUGH THE PURCHASE OF CERTIFIED LOW-EMISSION NATURAL GAS.
HIGHLIGHTS

- $485 Billion additional spending
- CBO estimates offsets of $790 Billion in savings and revenue
- 15% minimum corporate tax rate
- Increase 45Q tax credit
  - $85/metric ton for carbon capture, sequestration
  - $60/metric ton for reutilization
- $40 Billion to USDA
  - $20 Billion Conservation Funding (RCPP, EQIP, etc.) – 9.5x more than 2018 farm bill
  - $20 Billion other ag related (forestry, drought, etc.)
- Increased resources for permitting reviews (increased staff, review tools, etc.)
The IRA authorizes $270.7 billion towards new energy security deployment over the next 10 years.

**Revenue and Direct spending for energy security in IRA (billion USD)**

- **Clean Vehicles**: $14.2 billion
- **Clean Fuels**: $18.8 billion
- **Investment in Clean Energy Manufacturing and Energy Security**: $36.9 billion
- **Clean Energy and Efficiency Incentives for Individuals**: $36.9 billion
- **Incentives for Clean Electricity and Clean Transportation**: $65.6 billion
- **Clean Electricity and Reducing Carbon Emissions**: $98.3 billion

*Source: CBO*
Monthly Fertilizer Prices: Jan 2007 – Mar 10, 2023

Environmental stewardship is a priority for the fertilizer industry and environmentally focused innovations are driving the industry forward and allowing farmers to do more with less.

There are a number of emerging technologies that are aimed squarely at increasing crop yields while lessening impacts to the environment, including:

- Biostimulants
- Enhanced Efficiency Fertilizers
- Microbials
The U.S. Department of Agriculture is investing up to $2.8 billion in 70 selected projects under the first funding pool of Partnerships for Climate-Smart Commodities.

**Projects by Commodity**
- Plants: 15
- Dairy: 11
- Beef & Cattle: 13
- Crops: 13
- Poultry: 6
- Aquaculture: 1
- Forests: 1
- Energy: 1

**Proposal Investments**
- 70 proposals, on average 50% of the federal investment matched by nonfederal funds.
- 25 proposals: $25M-45M
- 22 proposals: $5M-20M
- 09 proposals: $50M-65M
- 14 proposals: $70M-95M

**Projects by Award Size**
- 50+ universities, including multiple minority-serving institutions, engaged and helping advance projects.
- 50,000+ farms reached, encompassing acres of working land engaged in climate-smart production practices.
- 25M+: More than 50 million metric tons of carbon dioxide equivalent sequestered over the lives of the projects. This is equivalent to removing more than 10 million gasoline-powered passenger vehicles from the road for one year.

Hundreds of expanded markets for producers of and commodities across agriculture ranging from farm retail to wholesale, and beyond.
Immediate Action Items

Urge China to reduce or eliminate their fertilizer export restrictions.

Immediately modernize weight restrictions for 6-axle trucks

Encourage use of fertilizer exemptions by financial institutions

Waive Jones Act restrictions

Eliminate the cross-border vaccine mandate between the U.S. and Canada

Incentivize growers to adopt 4R Nutrient Stewardship practices to maximize efficient fertilizer use

Eliminate hours of service (HOS) restrictions on agricultural commodity shipments

FULL DOCUMENT HERE
Medium to Long-Term Action Items

Make environmental reviews for permitting, including environmental justice screening, fair, equitable, and streamlined

Promote policies that support energy sources, including natural gas

Include potash and phosphate on the Critical Minerals list

Enact climate change policies that protect the global competitiveness of the U.S. fertilizer industry and our farmer customers

The Surface Transportation Board (STB) should pursue regulatory reforms that promote rail competition, fair rail rates and demurrage practices, and reliable service

Modernize our inland waterway infrastructure

Allow for the sustainable reuse of phosphogypsum

FULL DOCUMENT HERE
Nitrogen use efficiency has gone from 1.3 lbs N/bu to 0.9 lbs/bu.

Split nitrogen application yielded 207 bu/ac in corn.

7 bu/ac yield increase from 2019 to 2020 in wheat.


**4R Case Study: New York Dairy Farm**

Sustainability has been the key to making this farmer advocate successful. Their findings show that yield does not have a perfect relationship with N rate, indicating 4Rs can be used to optimize rather than N rate alone. In 2018, the grower had the most advanced 4R practices and the best NUE numbers.

**4R Case Study: Virginia Corn, Soybean, and Wheat Farm**

This family farm began to implement 4R practices 11 years ago and have clearly improved their overall nutrient stewardship. These improvements on the farm can largely be attributed to the time and care put into reviewing soil test results, analyzing the data, and understanding the scenarios that go on in each field. Using the newest technology including variable rate and satellite imagery, the grower was able to fine tune their fertilizer applications further.
Thank You!

Corey Rosenbusch
crosenbusch@tfi.org
@CoreyRosenbusch
LINDA THRASHER
President and Co-Founder
Greenfield Nitrogen

KARL THEIS
Founder
Greenfield Nitrogen
Greening the Fertilizer Industry
March 21, 2023
ABOUT GREENFIELD NITROGEN

Our company was launched with the support of local farmers who wanted to participate in the fertilizer supply chain and have an investment stake in their ammonia crop inputs.

Greenfield Nitrogen is developing a network of green ammonia facilities that maximize the renewable energy from wind and solar and serve the emerging green hydrogen and green ammonia markets.
SHOVEL READY SITE

- 96,000 short tons / year of zero carbon, green ammonia (275 tons per day) and 44,000 tons storage.

- Plant will use ~145 MW of renewable electricity from local wind farms via a smart grid system.

- Key permits are secured, including water and air quality / permit to construct. Site assessments are also complete.

- Local farmers and businesses invested $7.7M seed capital. Strong support from State of Iowa and local officials.
GREEN AMMONIA: IS IT ALCHEMY?

NO -- IT’S A REALITY – THANKS TO THE IRA

The hydrogen production tax credit (“45V”) in the Inflation Reduction Act provides up to a $3 / kg for clean hydrogen production.
**Green Hydrogen**

**Electrolysis Process**

Green "H2" - $3.00/kg tax credit

**Biogenic CO2**

**Renewable Methanol**

**Renewable UAN** (urea ammonium nitrate)

**Renewable Urea or Diesel Exhaust Fluid**

**Sustainable Aviation Fuel (SAF)**

**Ethanol Production**

**Ammonia Synthesis (Haber-Bosch process)**

**Low Carbon "Distillers Grain"**

**Low Carbon Protein - Livestock**

**Power Generation**

**Industrial – Amino Acids**

**Fertilizer (Low Carbon Corn)**

**Biogenic CO2**

**Renewable UAN (urea ammonium nitrate)**

**FUTURE OPPORTUNITIES**

**Renewable Electricity**

**Water**

**Air**

**Ammonia Synthesis (Haber-Bosch process)**

**NH₃** Green Ammonia – NH₃

**Fuel**

**Marine Fuel**

**Farm Tractors**

**Power Generation**

**Industrial – Amino Acids**

**Green Ammonia – NH₃**
WHAT DOES THIS MEAN TO THE FARMER?
THE CHALLENGE: OFFSETS, REDUCTIONS, AND CALCULATIONS

Carbon Offsets:
• Cover crops
• Reduced tillage (no till and/or strip till)
• Plant trees
• Perineal buffer strips around borders and streams.

Carbon Reducions:
• Rotate crops
• Use biodiesel
• Apply green ammonia
• Plant shorter season corn.

Carbon Intensity (CI) Documentation:
• Yearly recording of farming practices
• Soil testing
• Third party audit
• Verification for carbon credit payment

Optimum CI Index:
Highest Carbon Reduction
Highest Carbon Credit Revenue
Best Environmental Message
CARBON INTENSITY: CORN PRODUCTION

U.S. Department of Energy GREET Model Corn Production Carbon Intensity
(Lancaster Co. with Optimized Low Carbon Corn Production Practices)

-6.6 g/mj for N Fertilizer (“green ammonia”)
1.8 g/mj if “green ammonia” is used for Nitrogen Fertilizer
Greenfield Nitrogen: Zero Carbon Ammonia Facility
Made with water, wind and sun energy

- **Electrical Usage**
  - 860 kWh per ton – Loop & Air Separation Unit
  - 9000 kWh per ton - Electrolyzer
  - 100% renewable energy

- **Water Usage**
  - 800 gallons per NH3 ton
  - 60% less water usage

**Traditional Nitrogen Facility: Multiple Products Made with Fossil Fuels**

40% of CO2 is used as feedstock; later released through use of nitrogen products at farm field for urea & UAN
- CO2 is used for Urea & UAN Production
- CO2 captured through energy intense Amine wash process

**Energy Usage**
- 29 - 45 MM BTU fossil fuel/electrical per NH3 ton
- Requires energy intense boilers

<table>
<thead>
<tr>
<th>CO2 lb. release per 1 lb. N</th>
<th>CO2 lb. release per 1 acre</th>
<th>Reduced CO2 lb. release per 1 acre</th>
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</thead>
<tbody>
<tr>
<td>3.19 lb.</td>
<td>639 lb.</td>
<td>639 lb.</td>
</tr>
<tr>
<td>2.43 lb.</td>
<td>485 lb.</td>
<td>485 lb.</td>
</tr>
<tr>
<td>5.20 lb.</td>
<td>1040 lb.</td>
<td>1040 lb.</td>
</tr>
</tbody>
</table>

**Average CO2 equivalent reduction per acre:** 721 lb.
THANK YOU!
90th Anniversary Gala

Celebrating 90 years of accelerating practical solutions for agriculture.

Save the Date
Thursday, June 15, 2023
5:30 PM

The Drake
Chicago, Illinois

farmfoundation.org/90thgala
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We hope to see you at a future event!

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