JISEA Joint Institute for Strategic Energy Analysis

JISEA-CSU Sustainable Agriculture Workshop

Oct. 21, 2024

Sponsored by

NSF CO-WY ENGINE

NREL Transforming ENERGY | Colorado School of Mines | Colorado State University | Howard University Office of Research | Massachusetts Institute of Technology | Stanford University | University of Colorado Boulder

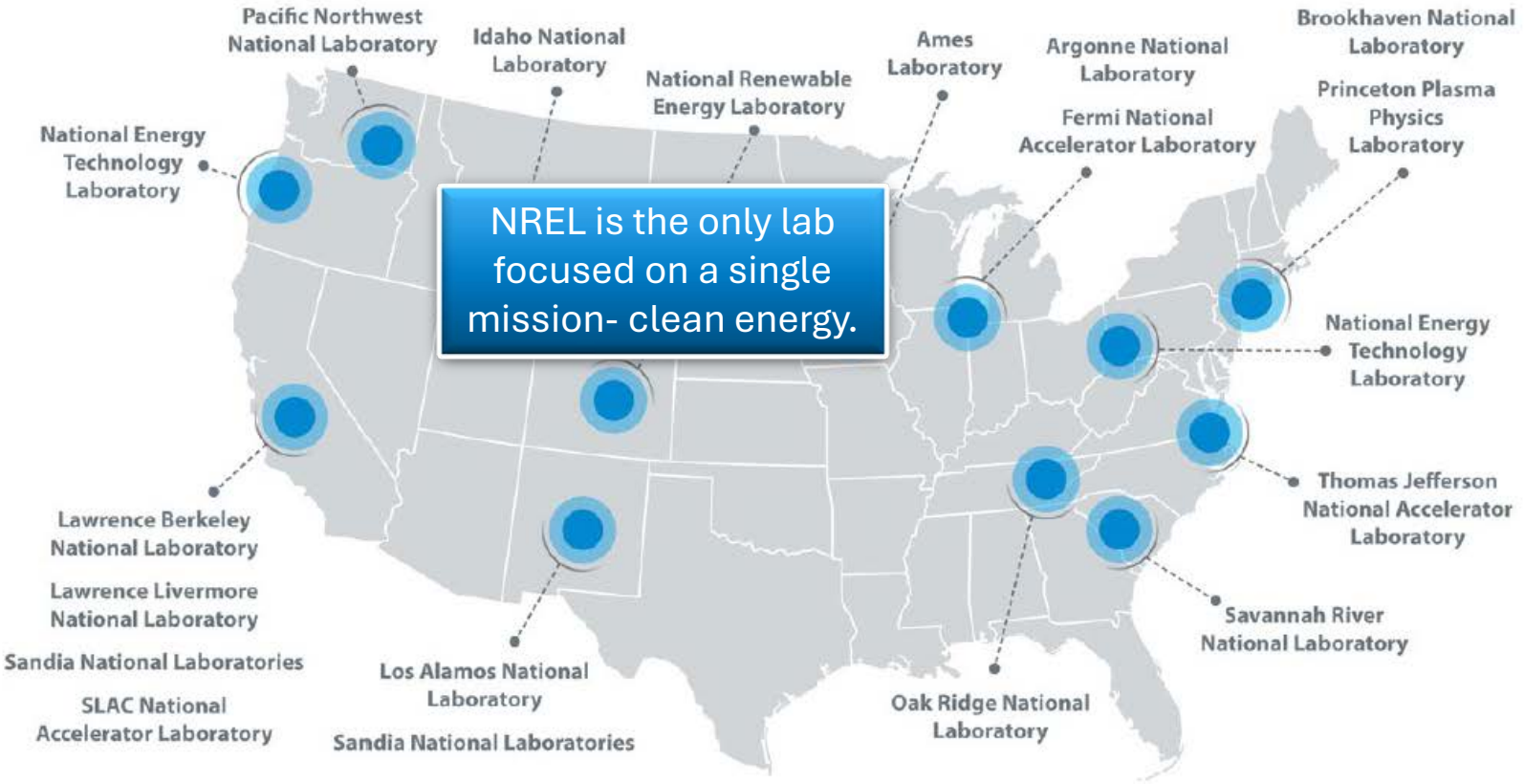
Welcome

Elizabeth Doris, JISEA Director

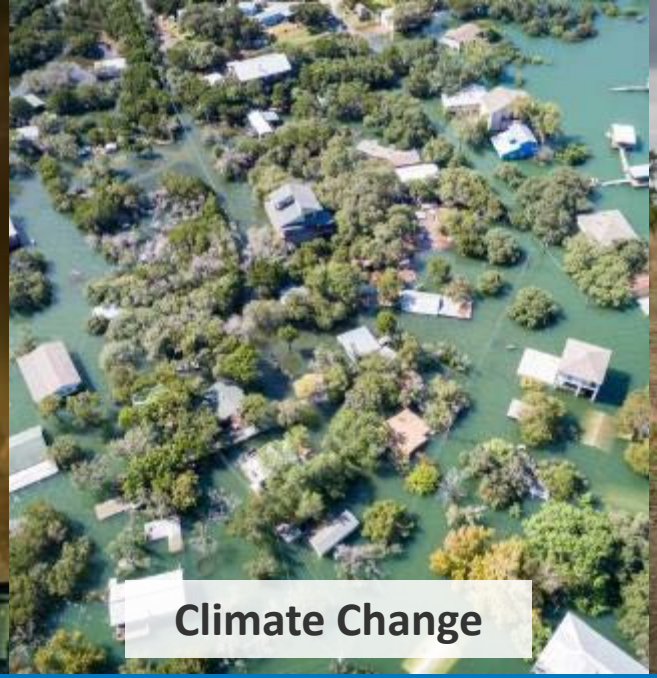
JISEA-CSU Sustainable Agriculture Workshop

Oct. 21, 2024

Photo by Werner Slocum, NREL 69160



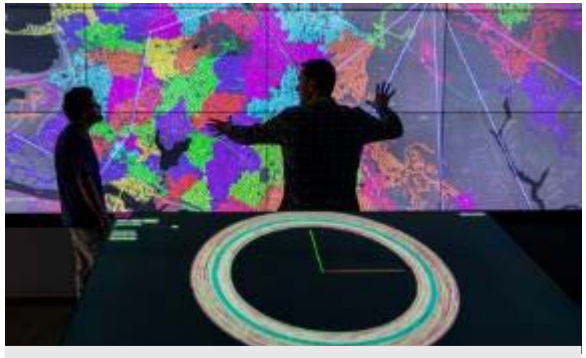
The 17 DOE National Laboratories have led scientific innovation in the United States for more than 80 years.



The Triple Planetary Crisis

The **triple planetary crisis** refers to the three main issues that humanity currently faces, reinforcing one another and driving further damage. Each must be resolved for us to have a viable future on this planet.

Integrated Energy Pathways

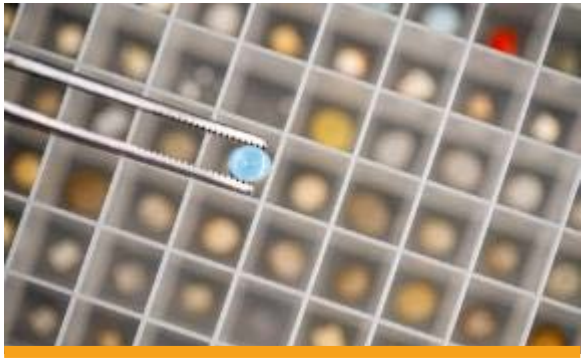


Developing the foundational knowledge and technologies to **optimize the integration of renewables, buildings, industry, energy storage, and transportation**—modernizing our energy systems and ensuring a secure and resilient grid.

Electrons to Molecules

Accelerating the **conversion of electricity and small waste gases** (e.g., CO_2, H_2O, N_2) into chemical bonds for the purposes of chemical, material, or fuel synthesis and/or energy storage.

Circular Economy for Energy Materials

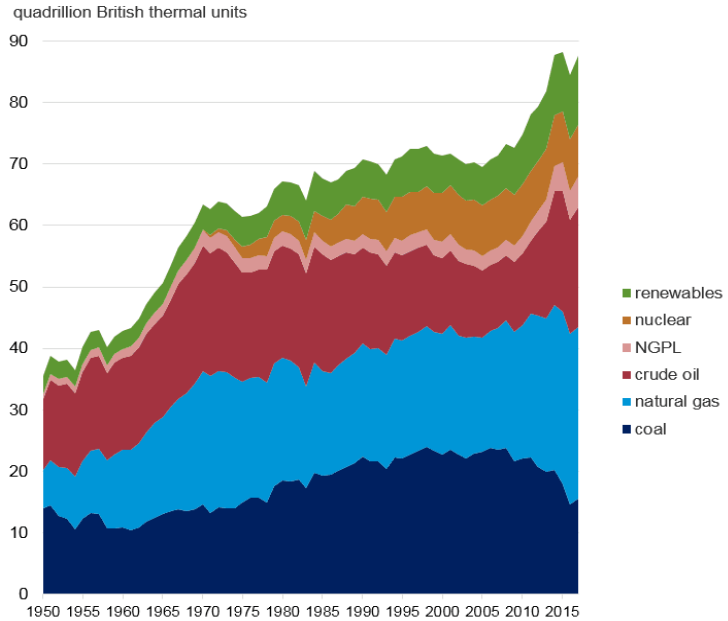


Establishing the **foundational knowledge/technology** for design, recycle, reuse, remanufacture, and reliability for **energy-relevant** materials and processes.

NREL's Three Critical Objectives

Clean energy is growing

U.S. primary energy production by major sources, 1950-2017



Note: NGPL is natural gas plant liquids.
Source: U.S. Energy Information Administration, *Monthly Energy Review*, Table 1.2, April 2018

eia


THE WHITE HOUSE

Administration Priorities COVID-19 Briefing Room Español

BRIEFING ROOM

FACT SHEET: President Biden Takes Executive Actions to Tackle the Climate Crisis at Home and Abroad, Create Jobs, and Restore Scientific Integrity Across Federal Government

JANUARY 27, 2021 • STATEMENTS AND RELEASES

President Biden set ambitious goals that will ensure America and the wor can meet the urgent demands of the climate crisis, while empowering American workers and businesses to lead a clean energy revolution that achieves a carbon pollution-free power sector by 2035 and puts the Unite States on an irreversible path to a net-zero economy by 2050. Today's acti advance those goals and ensure that we are tapping into the talent, grit, and innovation of American workers, revitalizing the U.S. energy sector, conserving our natural resources and leveraging them to help drive our nati toward a clean energy future, creating well-paying jobs with the opportunity to join a union, and delivering justice for communities who have been subjected to environmental harm.

INTERIM NATIONAL SECURITY STRATEGIC GUIDANCE

MARCH 2021

OUR STRENGTH ABROAD REQUIRES US TO BUILD BACK BETTER AT HOME.

…but not for everyone

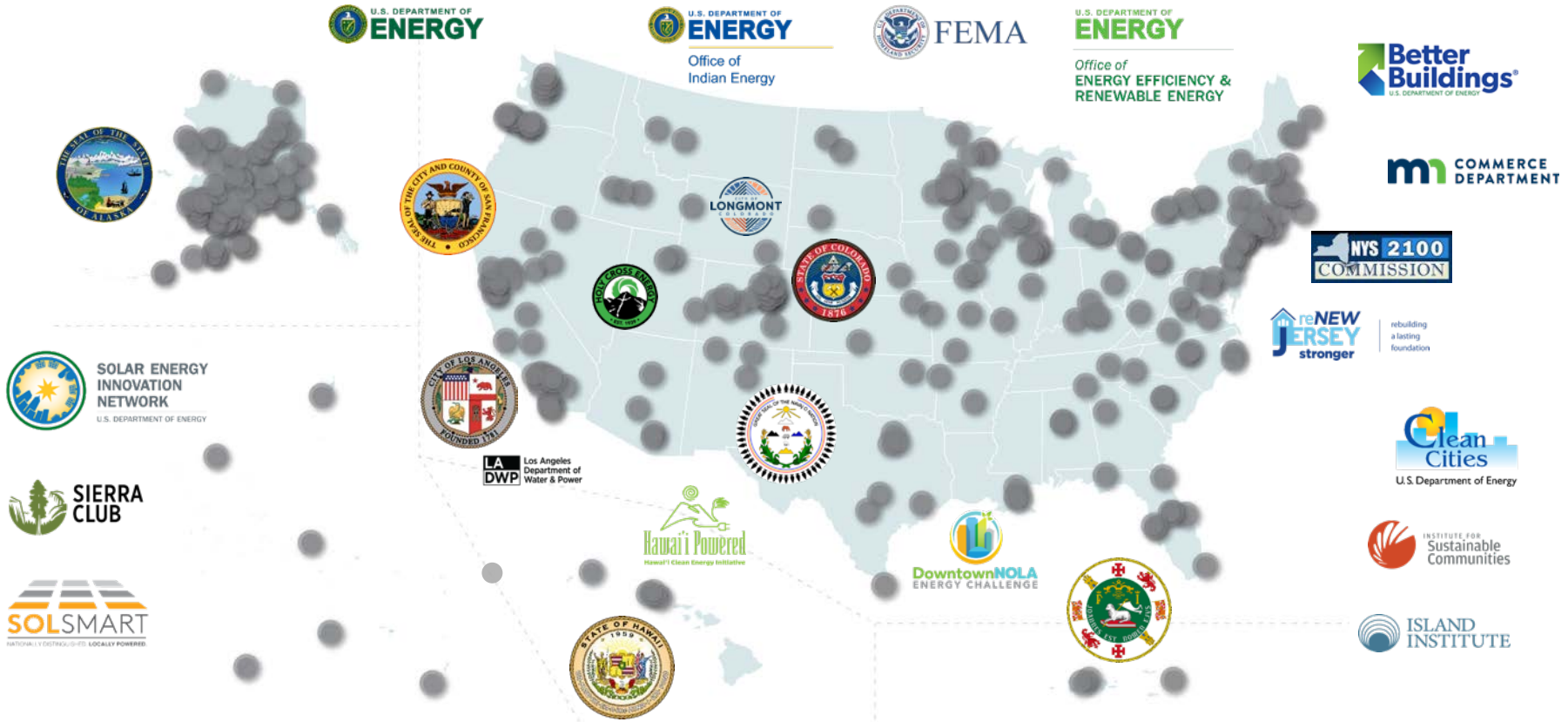
- **Black-majority census tracts installed 69% less rooftop PV** than no-majority tracts of same household income
- **Less than half of U.S. community solar projects include low-income households**
- Nearly 60% of all new solar capacity in 2018 was utility-scale PV, expanding access. However, **benefits such as lower costs are rarely transferred directly to customers**

- Since 2006, **90% of electric vehicle income credits were received by the top income** quintile
- **Renters and those living in multi-family housing often lack access to home charging locations**, where 80% of electric vehicle charging occurs
- **37% of rental housing units have a garage or carport** compared to 78% of owner-occupied housing

- The **least affluent 20% of households spend a 3x greater share of income on transportation** than the most affluent 20%
- **30%-45% of urban populations** exposed to **poor air quality near busy roads**
- **≈10% of people with multiple disabilities have no access to paratransit** because they live in paratransit deserts

- **70% of American households** live in neighborhoods where **combined housing and transportation costs are not affordable**
- 14.5% of U.S. households reported receiving a **disconnect or delivery stop** notice
- More than 20% of U.S. households reported reducing or **foregoing food or medicine** to pay energy bills

The success of a traditional technology-centric approach is limited by socioeconomic factors.



NREL has partnered with and supported **more than 3,000** communities, tribes, jurisdictions, utilities, and businesses for **energy transitions** planning, technical assistance, capacity building, workforce development, and more.

NREL at a Glance

3,915 Workforce, including:

- 2,913 regular/limited term
- 531 contingent workers
- 223 postdoctoral researchers
- 155 graduate student interns
- 93 undergraduate student interns

—as of 5/15/2024

World-class research expertise in:

- Renewable Energy
- Sustainable Transportation & Fuels
- Buildings and Industry
- Energy Systems Integration

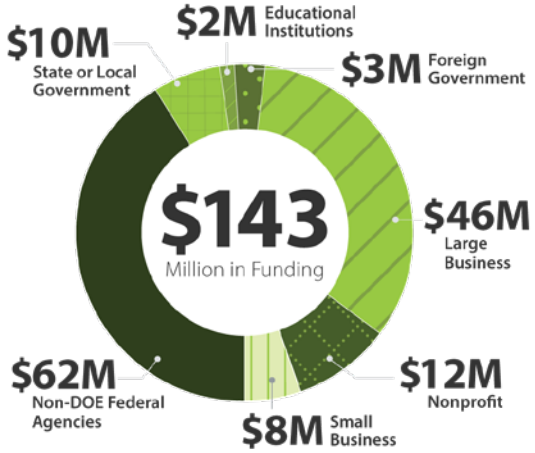
Partnerships with:

- Industry
- Academia
- Government

4 Campuses operate as living laboratories

More Than 1,100 Active Partnerships in FY 2023

Agreements by Business Type



Funding by Business Type

Staying Ahead of Future Energy Challenges

Through innovative, collaborative methodologies, the **Joint Institute for Strategic Energy Analysis (JISEA)** integrates diverse voices from research, universities, nonprofits, and industry to identify, frame, and build expertise around emerging, complex energy system challenges.

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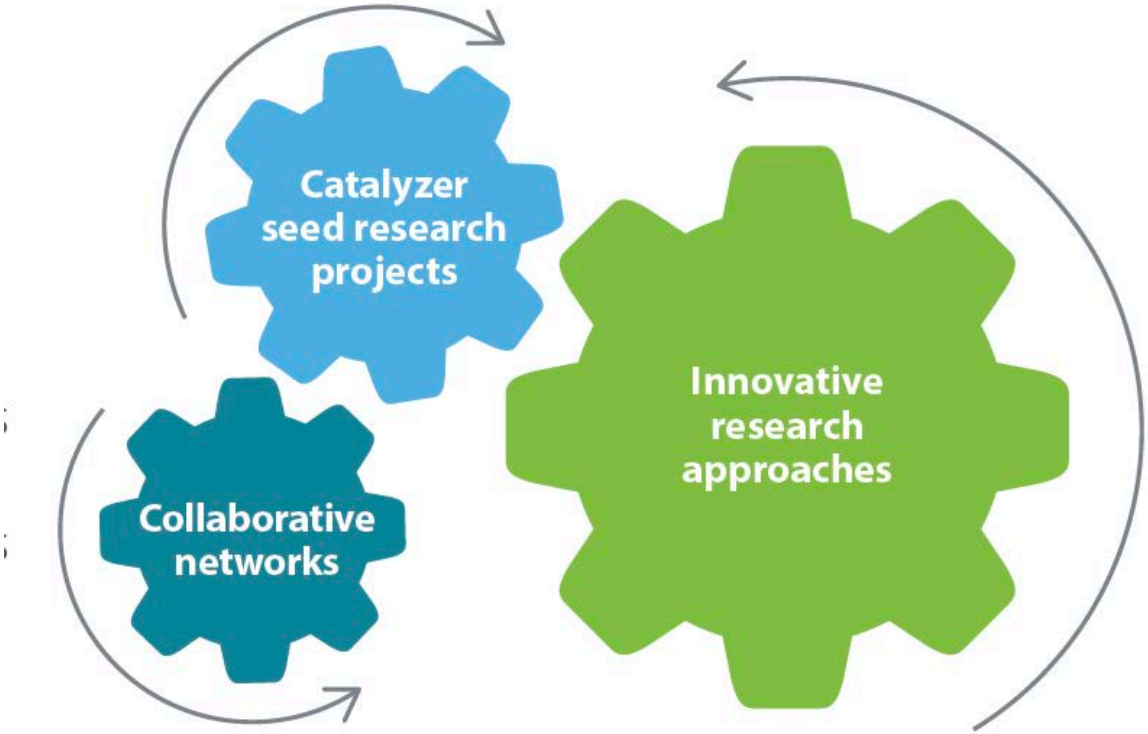
Social Science Integration for Improved R&D Outcomes



AMERICAN MADE
U.S. DEPARTMENT OF ENERGY

LASSO Prize

Large Animal and Solar System Operations

Follow the prize on HeroX!
HeroX.com/LASSO

Offering $8+ million in cash prizes to bring cattle agrivoltaics to life!

Around one-third of U.S. land is used for grazing cattle. Co-locating photovoltaic arrays with cattle grazing could help:

- Preserve agricultural land
- Improve cattle health
- Provide revenue for ranchers, farmers, and rural economies
- Accelerate solar energy deployment
- Meet national decarbonization goals

The American-Made LASSO Prize brings together muti-stakeholder teams to:

- Build pilot sites
- Generate best practices, use cases, business models, and data on costs and energy and agricultural outcomes.

LASSO Prize Tracks:

- **Operating Projects Track:** Open to cattle agrivoltaics projects that are fully operational by the Phase 1 deadline
- **Standard Track:** Open to teams developing new cattle agrivoltaics projects

Bonus Prizes Offered!

Largest PV System Bonus Prize

Awarded to the team with the highest-capacity cattle agrivoltaics system over 5MW-dc in the Standard Track

Data Bounty Bonus Prize

Awarded to the team that submits the most valuable data from cattle agrivoltaics projects, above and beyond minimum requirements

Institute Catalyzers

Launch new, crosscutting capabilities to achieve clean energy goals at speed and scale. Analytical insights help design large-scale concepts for future research.

Climate Adaptation and Clean Energy

Energy and Atmos Systems (2020-23) Explores relationships across climate, air quality, and energy systems.

Climate Adaptation (2023-25) The right, secure, energy tech in the right places where people are.

Industrial Decarb

Green Computing (2022-24) Analyzes pathways to reduce the energetic cost of computing, advancing green computing as a salient research domain at NREL.

Technology/Society Interface

Justice Underpinning R&D (2023-25) Developing an online tool to integrate energy justice considerations into energy technology research and development.

Sustainable Communities (2019-22) Mapped pathways for sustainable transitions at the community level, focusing on rural and disadvantaged communities.

jisea.org/our-work/catalyzer

+2

JAM25: February 25-27, 2025 @NREL

	Monday	Tuesday	Wednesday	Thursday	Friday
Activity	Travel/ side meetings/ opening reception NREL Tours	**NREL Learning Day** Up to 6 tracks • Workforce • Adaptation x clean Energy (Migration) • Commercialization in research • Community Engaged Research • Rural//Agriculture	**JAM25 Interactive Working Sessions** AM: Adaptation PM: Workforce	**JAM25 Sessions** AM: Emerging Topics PM**: American Made Event**	Travel/ side meetings NREL Tours
Goal		Education/info sharing FROM NREL (“what’s NREL doing”)	Interactivity to push forward and develop research teams on emerging areas	Identify new areas with a really diverse set of interested parties	

Get an invitation for you or staff: Sarah.Truitt@nrel.gov

Get more engaged in planning, speaking, or suggest a sponsor: Elizabeth.Doris@nrel.gov

Thank you for your time and dedication in this space

CSU Spur
CO-WY Engine powered by Innosphere Ventures
Technical and Operation Staff at NREL, in JISEA, and at CSU Spur

Reach out to me: Elizabeth.Doris@nrel.gov

JISEA Joint Institute for Strategic Energy Analysis

JISEA-CSU Sustainable Agriculture Workshop

Brittany Staie, National Renewable Energy Laboratory

Oct. 21, 2024

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Today's Questions and Agenda

PAST

What technologies and strategies have been successful in ag decarb in the US?

→ Presentations and Case Studies: Crop, Livestock, Energy Decarb Opportunities

PRESENT

What implementation barriers are preventing full agricultural decarbonization and how can we work to overcome them?

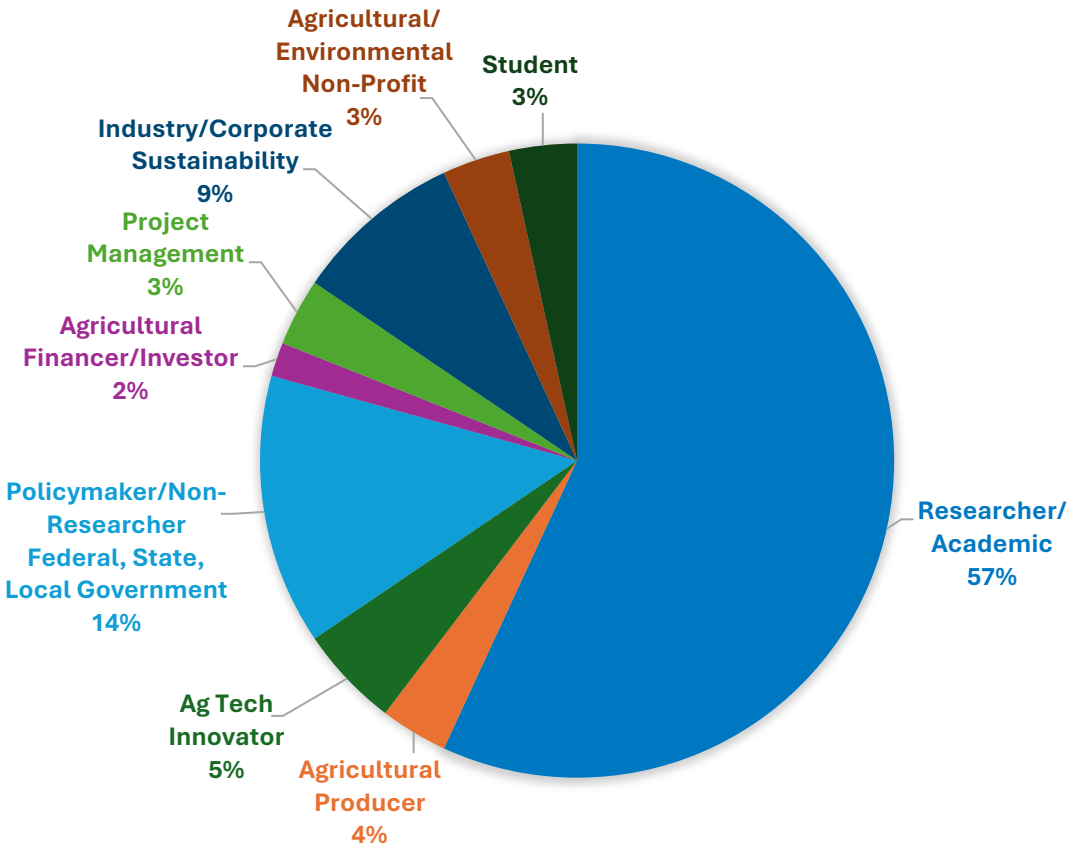
→ Panels: Barriers to Implementation and Economics and Policy

FUTURE

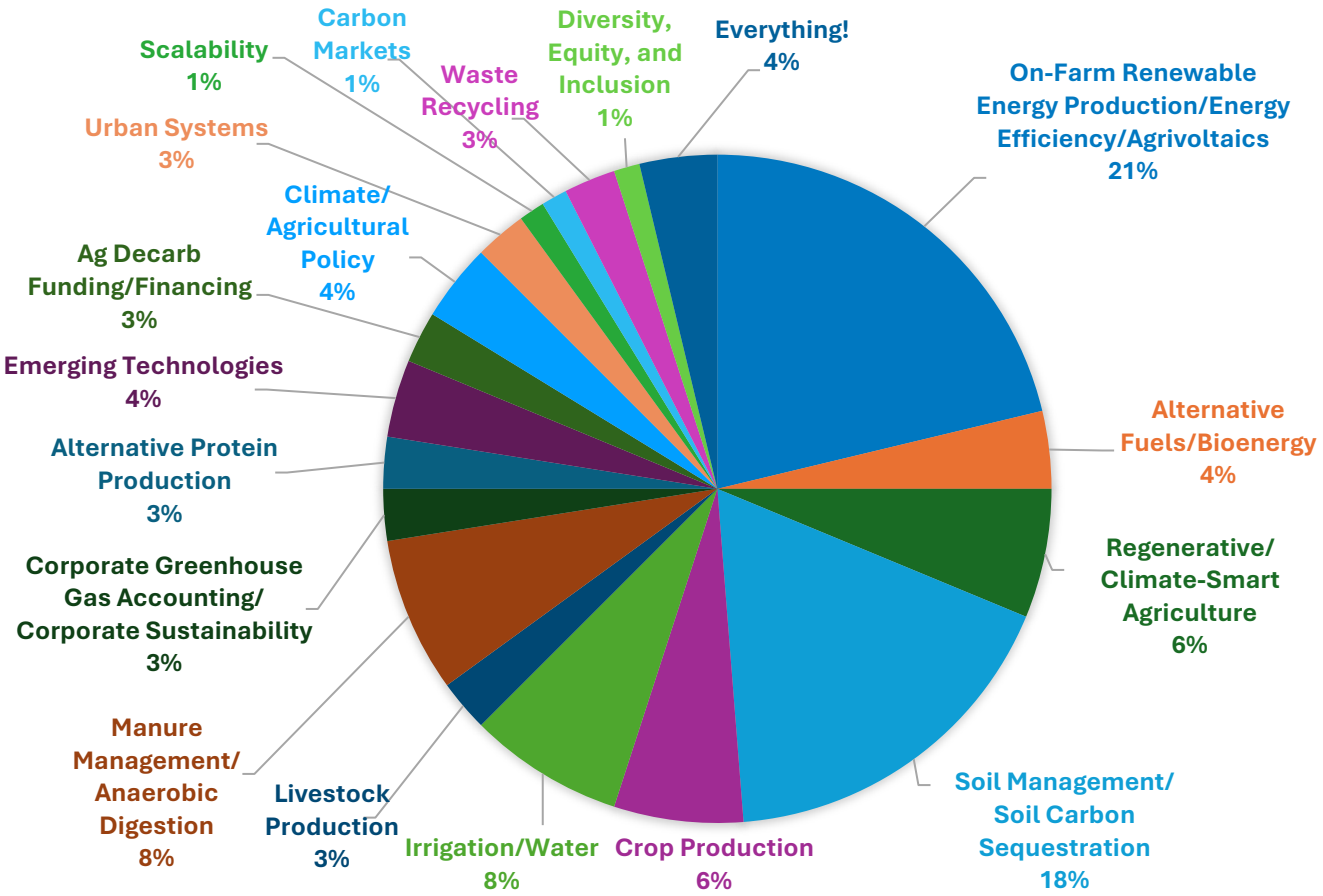
Where should future agricultural decarbonization research focus?

→ Interactive Brainstorming Activity: 1-2-4 All

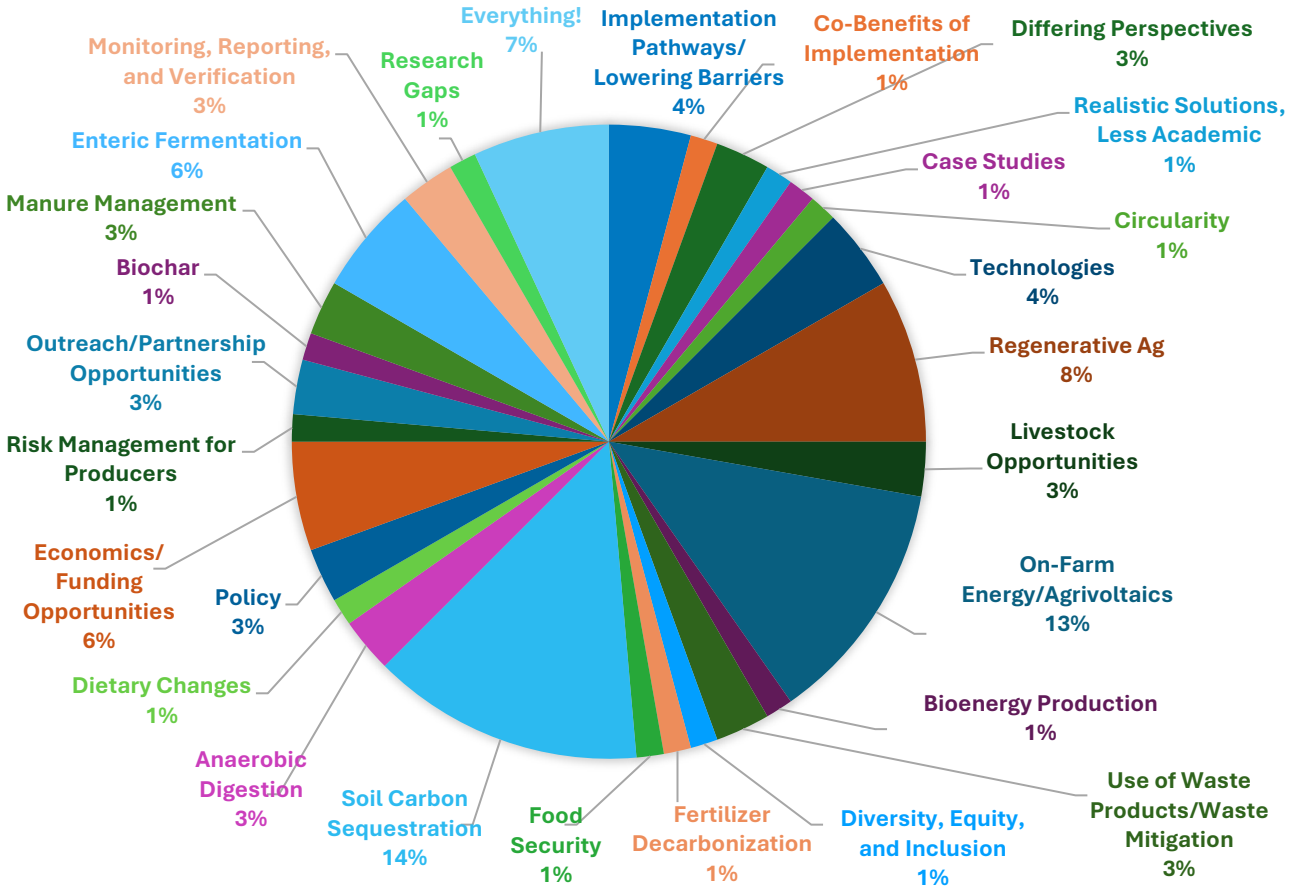
In the Room: Who is Here Today?



In the Room: Agricultural Decarbonization Expertise



In the Room: Agricultural Decarbonization Interests



NREL's Work in Agricultural Decarbonization

Report Summary

- Literature review of over 300 publications
- Analysis of the current state of U.S. agricultural GHG emissions and mitigation solutions
- Outlines research gaps, barriers to adoption, co-benefits, and tradeoffs of agricultural decarbonization solutions

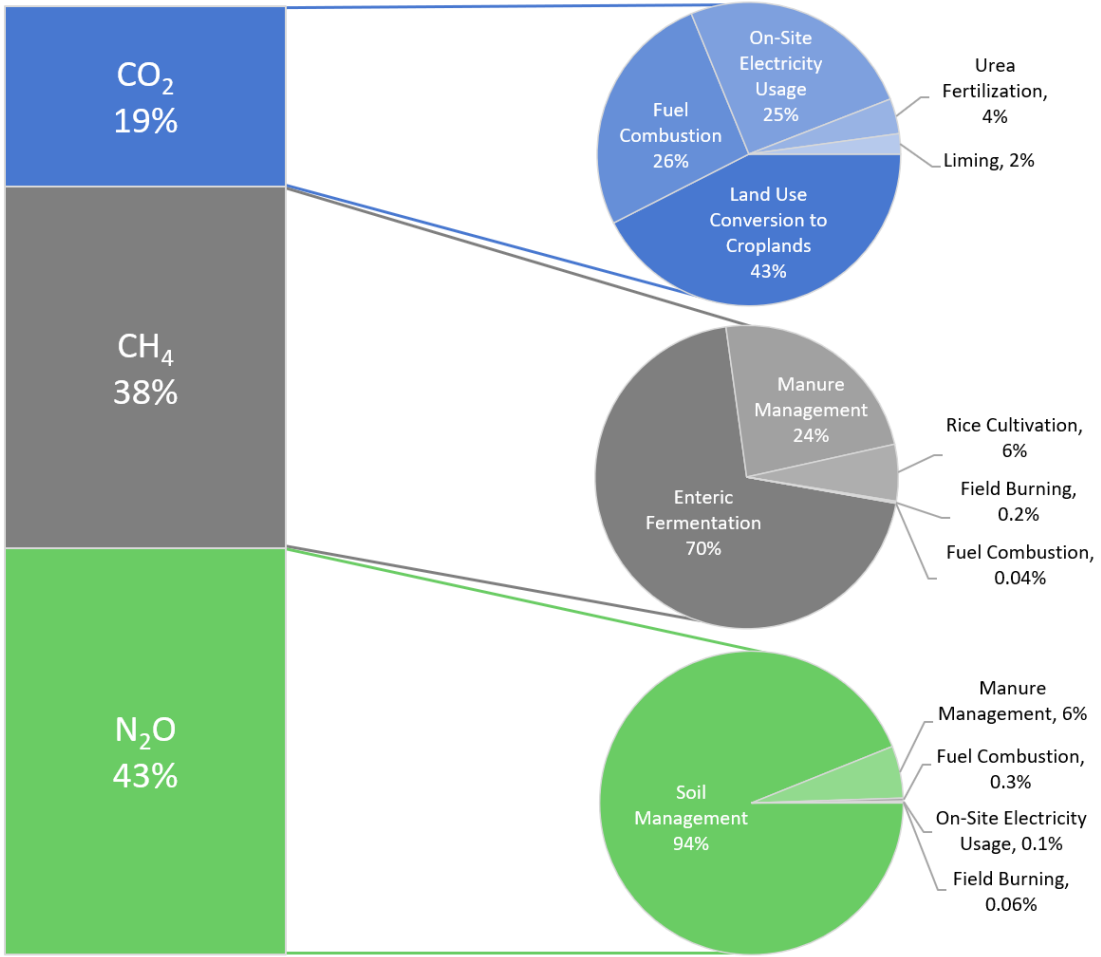
Pathways for Agricultural Decarbonization in the United States

Brittany Staie,[1] Austin Kinzer,[2] Jordan Macknick,[1] Yong Wang,[1] Randy Cortright,[1] Thomas Foust,[1] Sami Ghantous,[1] Patrick Lamers,[1] and Darlene Steward[1]

Staie, Brittany, Austin Kinzer, Jordan Macknick, Yong Wang, Randy Cortright, Thomas Foust, Sami Ghantous, Patrick Lamers, and Darlene Steward. 2024. Pathways for Agricultural Decarbonization in the United States. Golden, CO: National Renewable Energy Laboratory. NREL/TP-5100-86071. https://www.nrel.gov/docs/fy24osti/86071.pdf

Agricultural GHG Emissions in the US

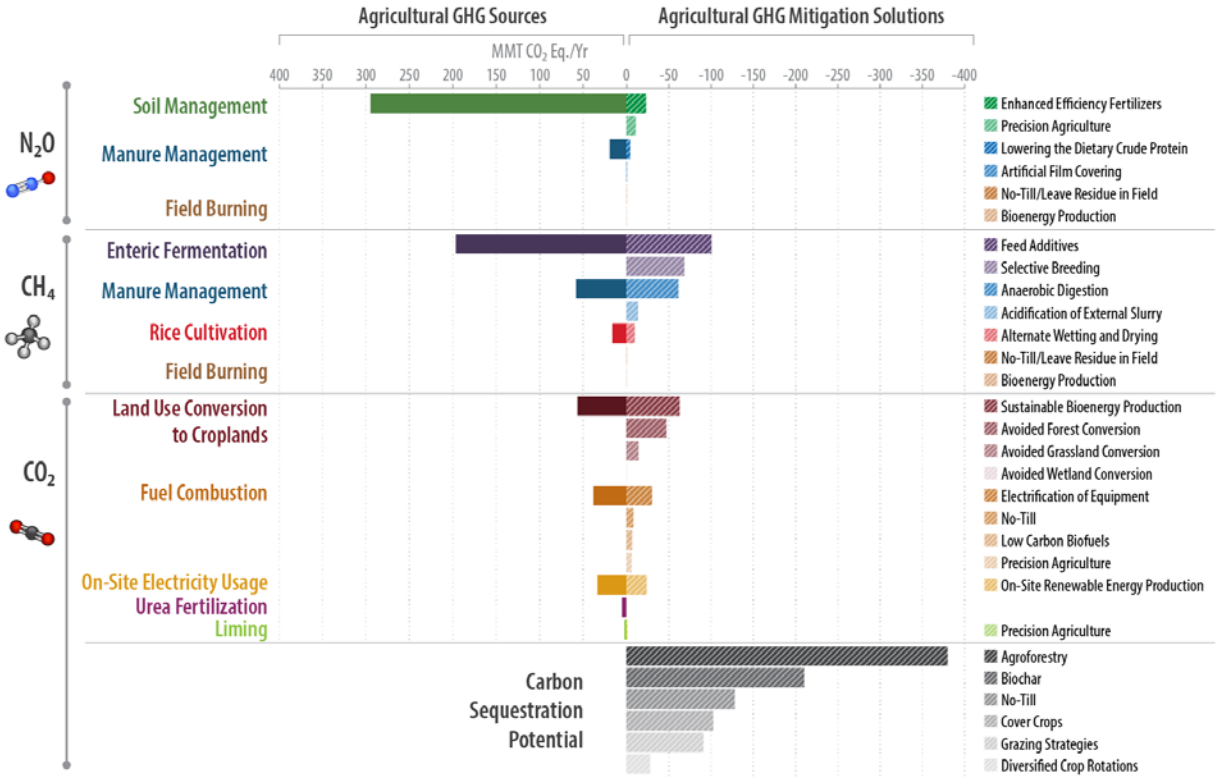
- Nitrous oxide and methane emissions make up 81% of agricultural GHG emissions in the US
- Heavy emitters:
  - Soil management (40%)
  - Enteric fermentation (27%)
  - Manure management (11%)



(Staie et al., 2024). Data from EPA (2023)

Agricultural GHG Mitigation Solutions

- Soil Management and Enteric Fermentation are the largest GHG emissions sources
  - Hard to fully abate with currently available technologies and many processes based on natural activities
- Large opportunity for carbon sequestration in US croplands but significant barriers exist to implementation and accurate GHG mitigation estimation



(Staie et al., 2024)

Potential Barriers to and Co-benefits of Strategy Implementation

Barriers

- Yield impacts
- High initial costs/farmer profit impacts
- Increased time/labor requirements for farmers
- Learning curves for new technologies
- Untested technologies

Co-Benefits

- Ecological
- Socio-economic
- Energy equity/security
- Food security/sovereignty
- Health benefits
- Sustainable workforce development
- Educational/community opportunities
- Cultural benefits

JISEA Sustainable Agriculture Catalyzer

JISEA
Joint Institute for Strategic Energy Analysis

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Sustainable Agriculture Catalyzer

The Sustainable Agriculture Catalyzer is investigating the potential opportunities, research gaps, and barriers to implementation related to cobenefits of various agricultural decarbonization strategies.

Agricultural decarbonization strategies present an opportunity to bring a wide range of benefits beyond emissions reductions to stakeholders in the agricultural supply chain. However, various factors, including costs, accessibility of technologies, and timescale of implementation can lead to trade-offs associated with these strategies. There are potential benefits and trade-offs in a variety of areas:

Thank you!

Brittany Staie

Brittany.Staie@nrel.gov

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Keynote Presentation

Catherine Stewart
Agricultural Research Service
U.S. Department of Agriculture

USDA Agricultural Research Service
U.S. DEPARTMENT OF AGRICULTURE

ARS Contributions to the Inflation Reduction Act

Catherine Stewart

Steve Del Grosso

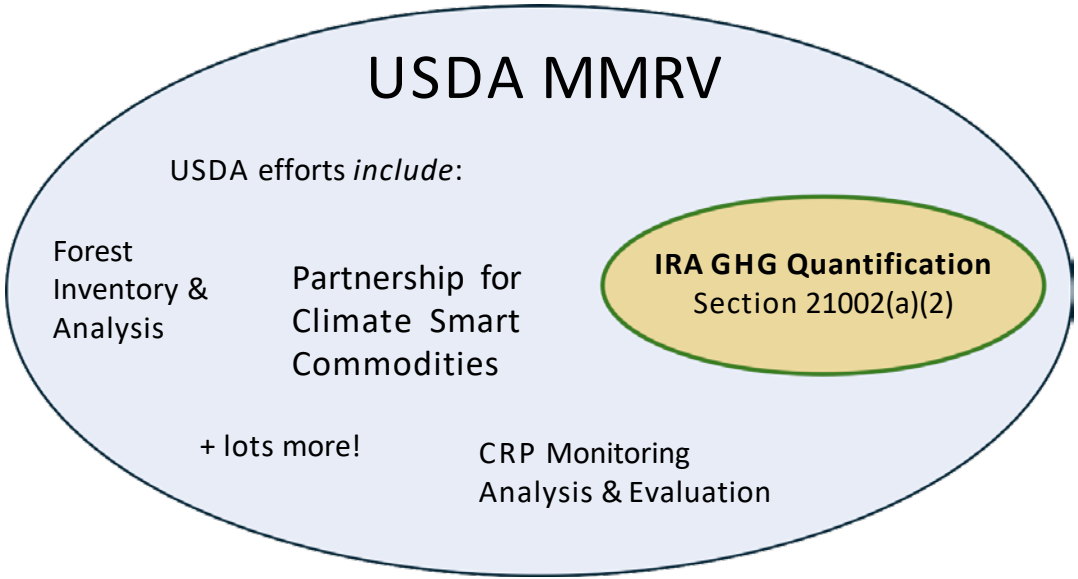
USDA-ARS Fort Collins, CO

Inflation Reduction Act Section 21002(a)(2)

- $300,000,000 to carry out a program to quantify carbon sequestration and carbon dioxide, methane, and nitrous oxide emissions, through which the Natural Resources Conservation Service shall collect field-based data to assess the carbon sequestration and reduction in carbon dioxide, methane, and nitrous oxide emissions *outcomes* associated with activities carried out pursuant to this section and use the data to monitor and track those carbon sequestration and emissions *trends* through the Greenhouse Gas Inventory and Assessment Program of the Department of Agriculture.

There's a lot going on in Measurement, Monitoring, Reporting, and Verification!

National Strategy to Advance an Integrated U.S. Greenhouse Gas Measurement, Monitoring, and Information System



https://www.whitehouse.gov/wp-content/uploads/2023/11/NationalGHGMMISStrategy-2023.pdf

Inflation Reduction GHG Quantification Act Action Areas

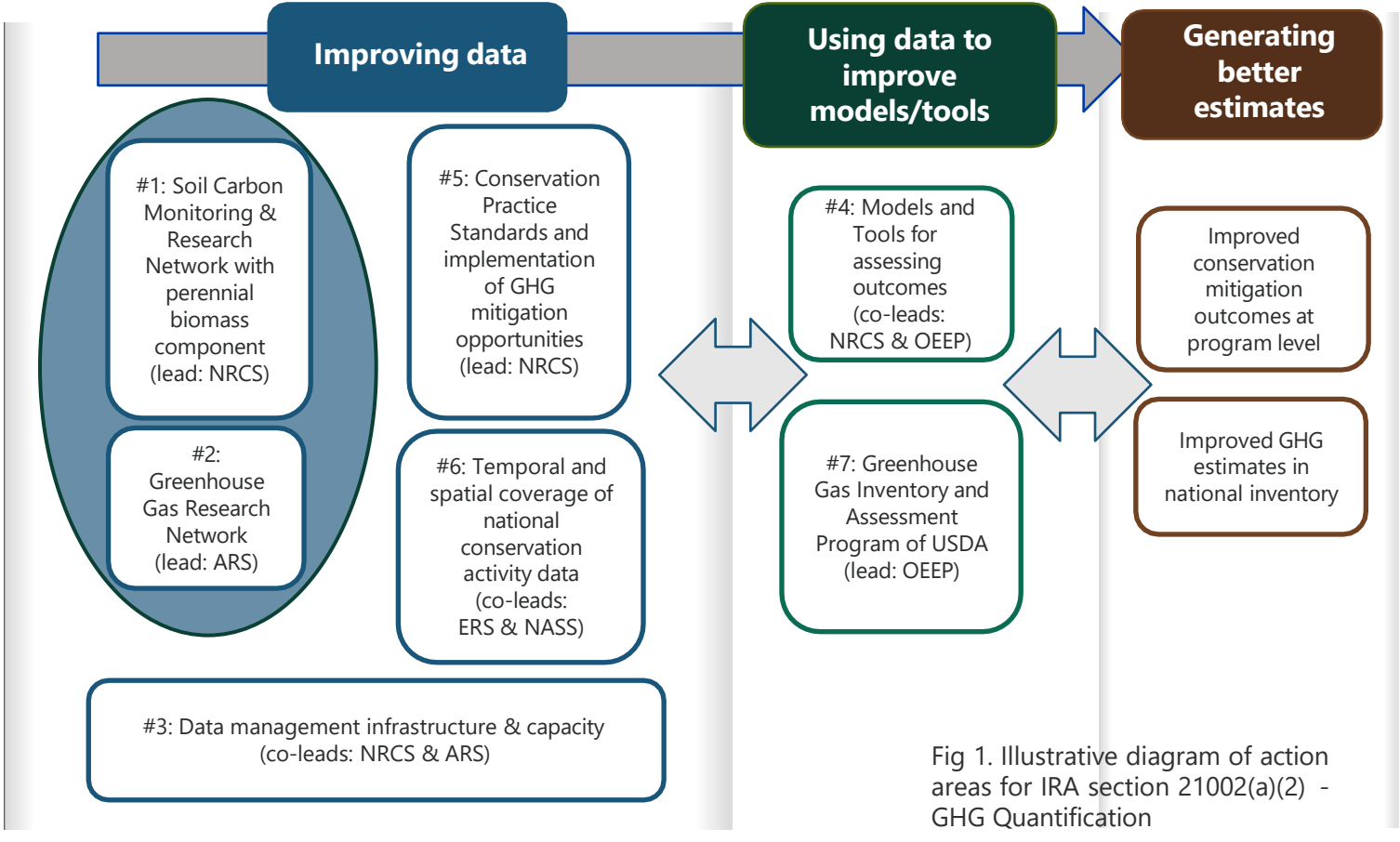


Fig 1. Illustrative diagram of action areas for IRA section 21002(a)(2) - GHG Quantification

USDA

Inflation Reduction Act GHG Quantification Investment*

Goal

Quantify carbon sequestration and GHG emissions to improve conservation outcome estimates

Approach

Collect field-based data

Use data to improve models to:

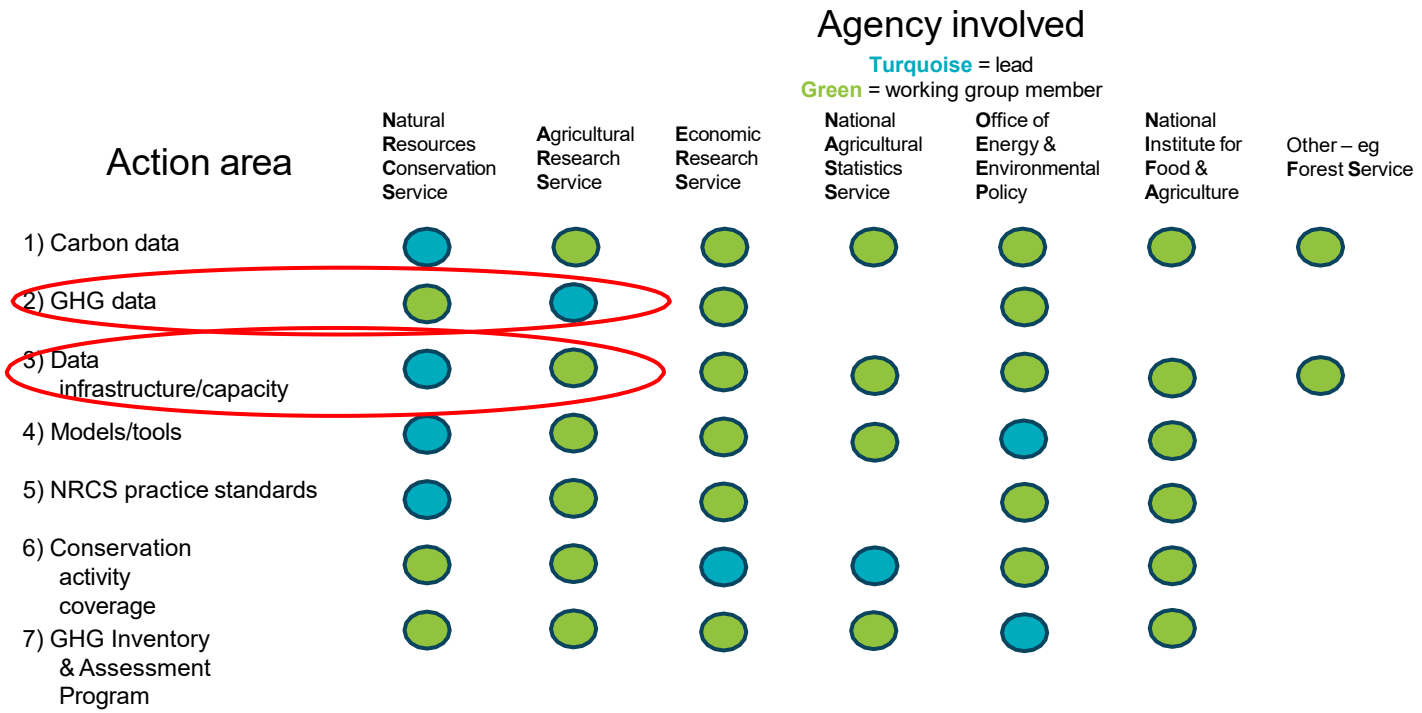
- assess the mitigation outcomes of conservation programs
- improve national inventories.

*IRA Section 21002(a)(2)

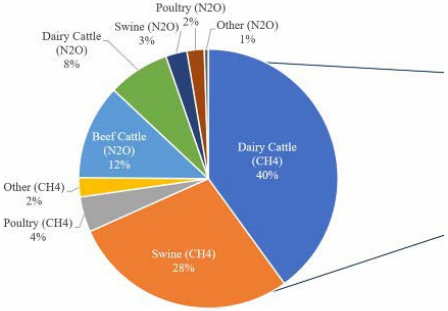
USDA

Collaboration among USDA agencies

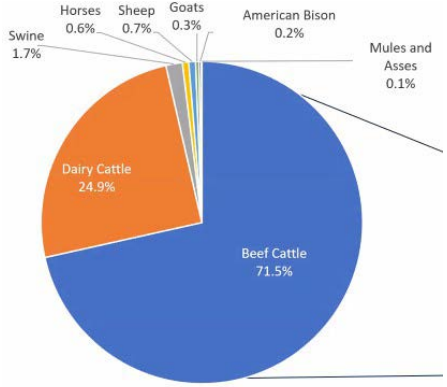
- All action areas have working group members from other agencies
- Working group members support coordination and work plan development



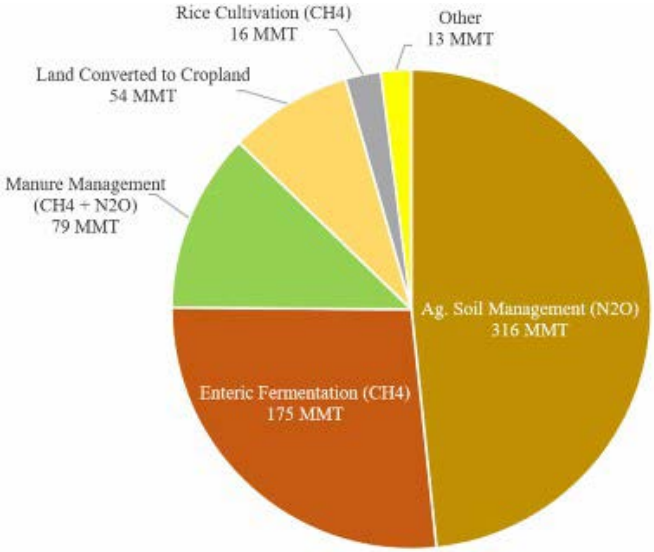
Ag sector emissions



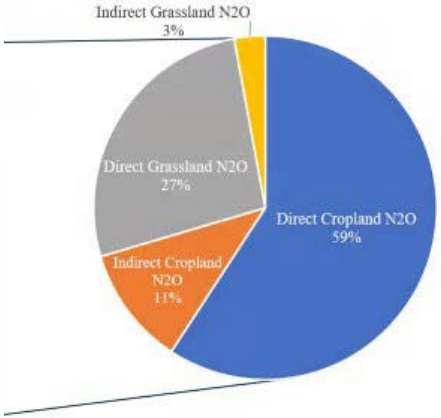
Manure Management N2O and CH4 Emissions: 79.2 MMT



Enteric CH4 Emissions: 175.2 MMT



Agricultural Sector GHG Emissions: 635.1 MMT CO2e



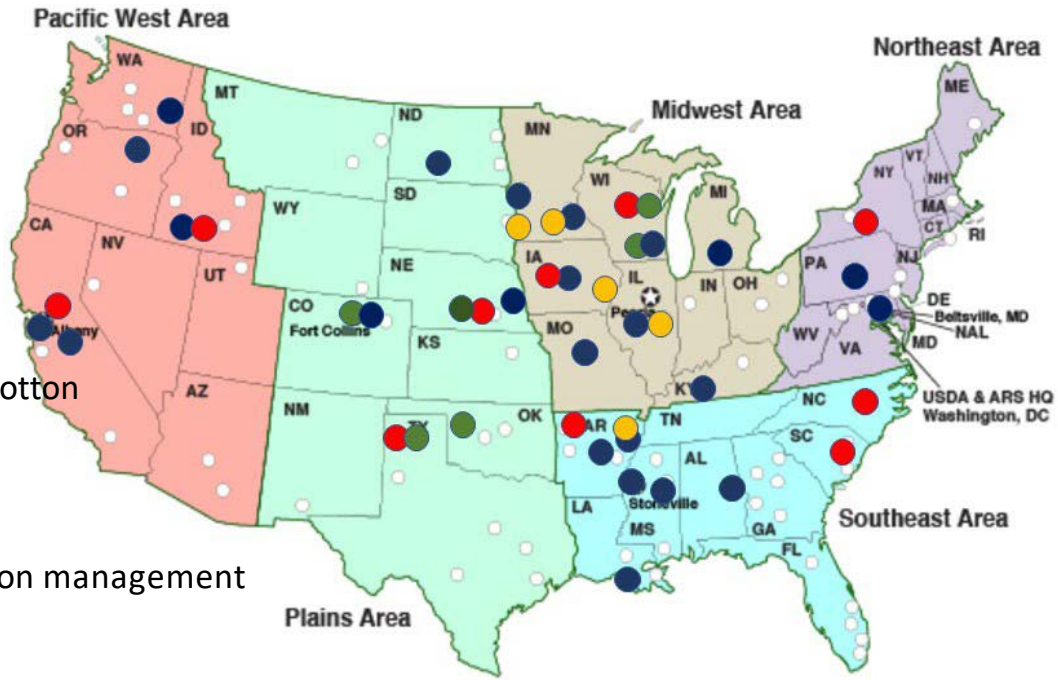
N2O Emissions from Ag Soils: 316.2 MMT CO2e

[Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2022 | US EPA]

AA#2 ARS GHG Quantification

Measure data gaps

- Land Emissions, n = 24 sites
- Enteric Methane, n = 5 sites
- Animal Housing, n = 10 sites
- Tall Towers, n = 5 sites

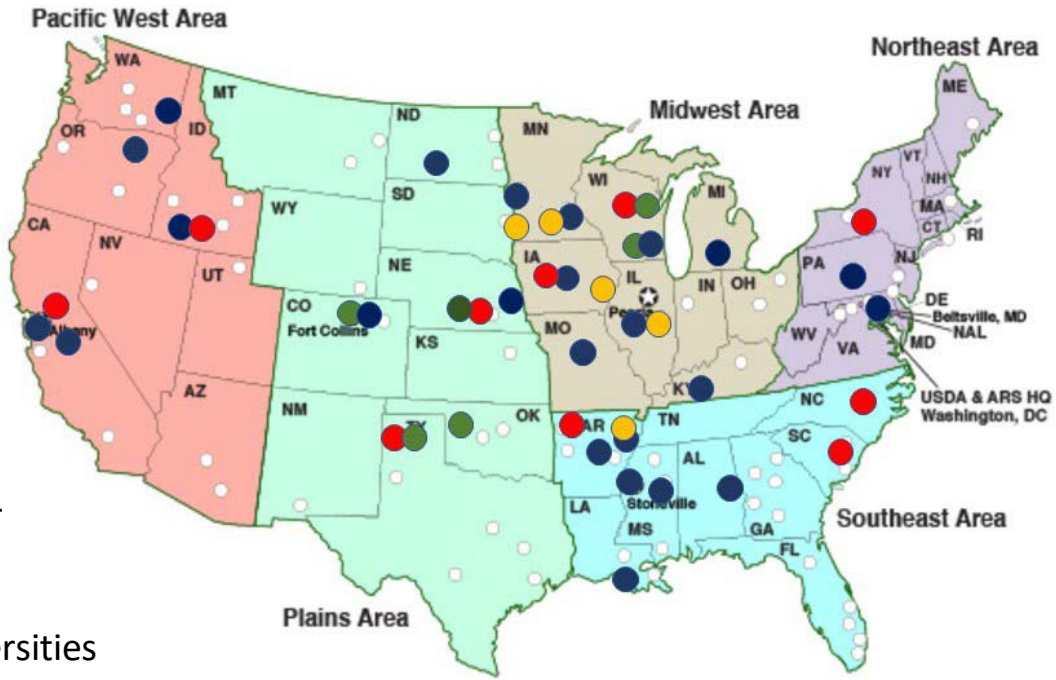


- **Production systems:**
  - Corn, soybean, wheat, rice, orchard, rice, cotton
  - Cattle, swine, chicken
- **Management:**
  - N management, Tillage, Cover crop, irrigation management
  - Manure management, perennial crops
  - Feed management & barn management

AA#3 ARS Data Solution Team

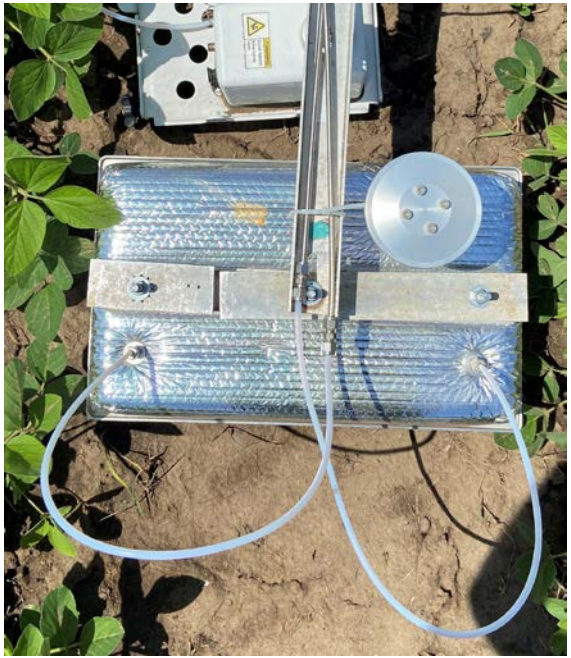
Diverse Data Streams and Scales

- Land Emissions, n = 24 sites
- Enteric Methane, n = 5 sites
- Animal Housing, n = 10 sites
- Tall Towers, n = 5 sites



- **Data Streams:** Periodic vs real-time/continuous, point data vs imagery data
- **Scales:** Individual animal vs herd, plot or barn (ft^2), field (ac), regional (mi^2), national
- **Data Contributors:** ARS, partner universities

Cropland Measurement Approaches



Plot-scale process research

Field-scale system research

Tall Tower measurement and modeling

Practices, approaches, data uses and outcomes intensively coordinated with NRCS, others

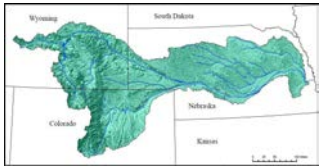
Identifying GHG Data Gaps

Plot-level NOx

Plot-level NH_3

Plot-level chamber N_2O

Regional-level tall tower CO_2



Watershed-level H_2O/NO_3

Regional-level tall tower N_2O

Farm-level N_2O

Use of available data (modeling, inventory)

Data availability

EPA GHG Inventory process

Tier 3 DayCent Ecosystem Modeling Platform

Model Development/ Calibration

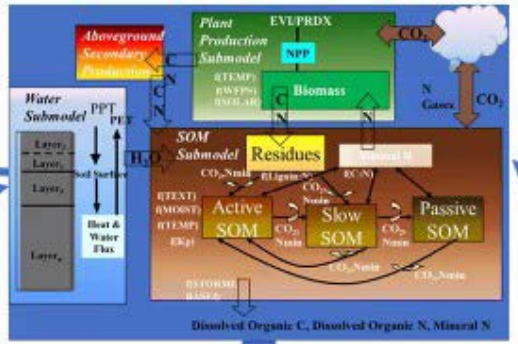
Parameter Sensitivity Analysis

Posterior Parameter Distributions

Sampling Importance Resampling

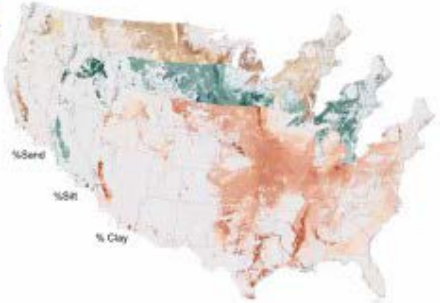
Observations

DayCent Ecosystem Model



Output Data: SOC Stock Changes, N_2O emissions, CH_4 emissions

Input Data: Geospatial Datasets/Surveys (e.g., soil texture)



Ogle et al. 2024

EEFs and irrigation management

Table 12.1: Average effects of nitrification inhibitor (NI) or polymer-coated urea (PCU) on N_2O emission expressed as % reduction compared to control mean (standard deviation) calculated among cited studies

Crop[a]	System[b]	Tillage[c]	N_2O Reduced by NI		% N_2O Reduced by PCU		Country (State, Region, or Province)	References[d]
			#[e]	%	#	%		
M	Rf	CT	8	27.9 (35.3)	7	16.2 (41.0)	Germany; Indonesia; USA (Iowa, Indiana, Minnesota)	1
		ST	3	7.5 (9.8)	1	0 (–)	USA (Iowa)	2
		NT	9	0.2 (39.4)	8	–37.1 (39.0)	USA (Indiana, Kentucky, Minnesota)	3
		N/A	1	43.3 (–)	1	9.1 (–)	Indonesia	4
	I	CT	8	49.9 (10)	2	–21.7 (30.2)	USA (Colorado); China (Hebei, Shanxi, North China Plain)	5
		ST	4	48.2 (22.8)	1	45.9 (–)	USA (Colorado)	6
		NT	5	44.1 (12.4)	2	44.7 (5.6)	USA (Colorado); China (Henan)	7
		N/A	3	44.7 (21.1)	–	–	Australia; Spain	8
W	Rf	RT	–	–	1	22.1 (–)	Canada (Manitoba)	9
	I	CT	7	24.1 (14.5)	1	33.0 (–)	China (Hebei, Shanxi, North China Plain); India	10
		NT	3	17.0 (2.0)	–	–	India	11
		N/A	13	20.4 (9.5)	–	–	Australia; India	12
Ra/W	N	CT	1	–4 (–)	1	48.4 (–)	Canada (Manitoba)	13
R	F	N/A	22	23.8 (14.9)	–	–	China; India	14

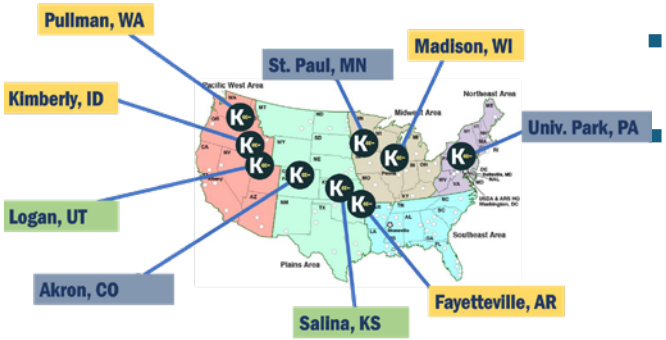
[a]M, maize; W, wheat; Ra, rapeseed; R, rice.
[b]I, irrigated; Rf, rainfed; N, not reported; F, flooded or paddy.
[c]CT, conventional tillage; N, not reported; NT, no tillage; ST, strip tillage.

Johnson et al. 2017

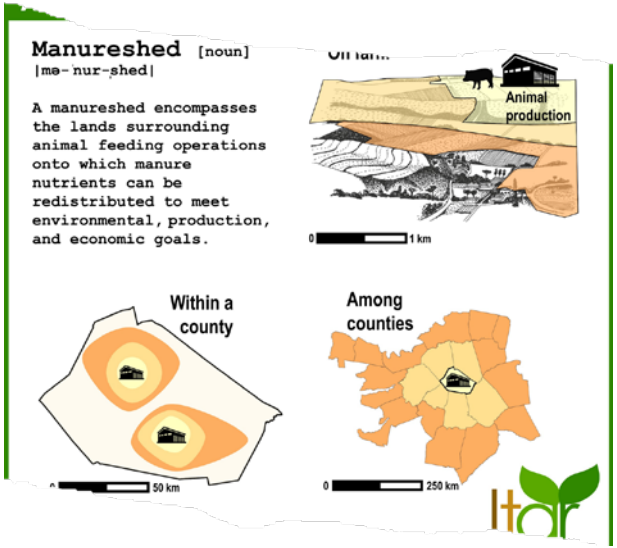
USDA

Benefits Beyond Carbon

Kernza® /Intermediate wheatgrass



- **Inclusion of perennial crops:**
- Deep, persistent root systems,
- continual soil cover,
- increased water and nutrient recovery,
- reduced nitrate leaching, improved carbon balance
- decreased soil erosion, &
- reductions in fossil fuel-derived inputs.



- **Manure management:** connect crop and livestock resource cycles, increased water and nutrient recovery, reduced nitrate leaching, improved carbon balance,& reductions in fossil fuel-derived inputs.

Take home

- Integrated, collaborative efforts are necessary to address data gaps an improve our predictive models.
- Solutions are implemented at the entity level, but up and downstream impacts should also be considered.
- Existing technologies can have a substantial impact in reducing emissions.
- Next generation technologies from both measurement & mitigation can contribute toward decarbonization efforts.
- Co-benefits move beyond just carbon and can emphasize nutrient recycling and conservation.

Resources

- Greenhouse Gas Inventory and Assessment Program |USDA
- Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990- 2022 |US EPA

Agricultural Decarbonization in the US – Successes and Opportunities: **Crops**

Jordan Macknick
National Renewable Energy Laboratory

Agricultural decarbonization opportunities in crop production

Jordan Macknick

JISEA-CSU Sustainable Agriculture Workshop

October 21, 2024

Agricultural Decarbonization Scope

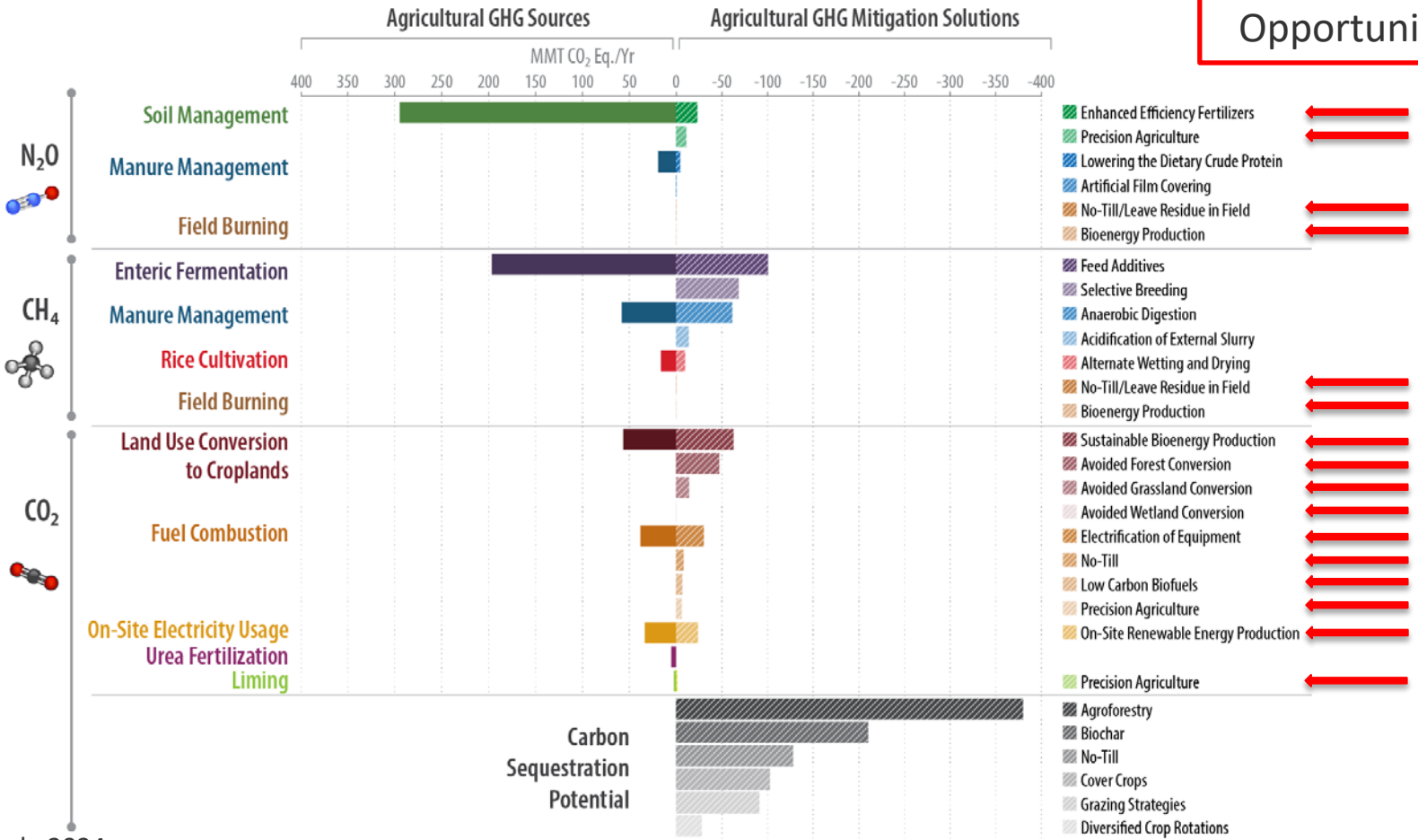
GHG Emission Sources

Pre-Production	Production	Post-Production
▪ Fertilizer Production and Distribution ▪ Pesticide Production and Distribution ▪ Lime Production and Distribution ▪ Agricultural Equipment Manufacture and Distribution	▪ Land-Use Conversion to Croplands ▪ Soil Management ▪ Urea Fertilization ▪ Liming ▪ Field Burning ▪ Rice Cultivation ▪ Enteric Fermentation ▪ Manure Management ▪ Fuel Combustion ▪ On-Site Electricity Usage	▪ Pre-Retail Transportation ▪ Processing ▪ Packaging ▪ Storage ▪ Retail ▪ Post-Retail Transportation ▪ Food Service ▪ Household Consumption/Cooking ▪ Food Waste

Staie et al., 2024

Agricultural GHG Mitigation Solutions

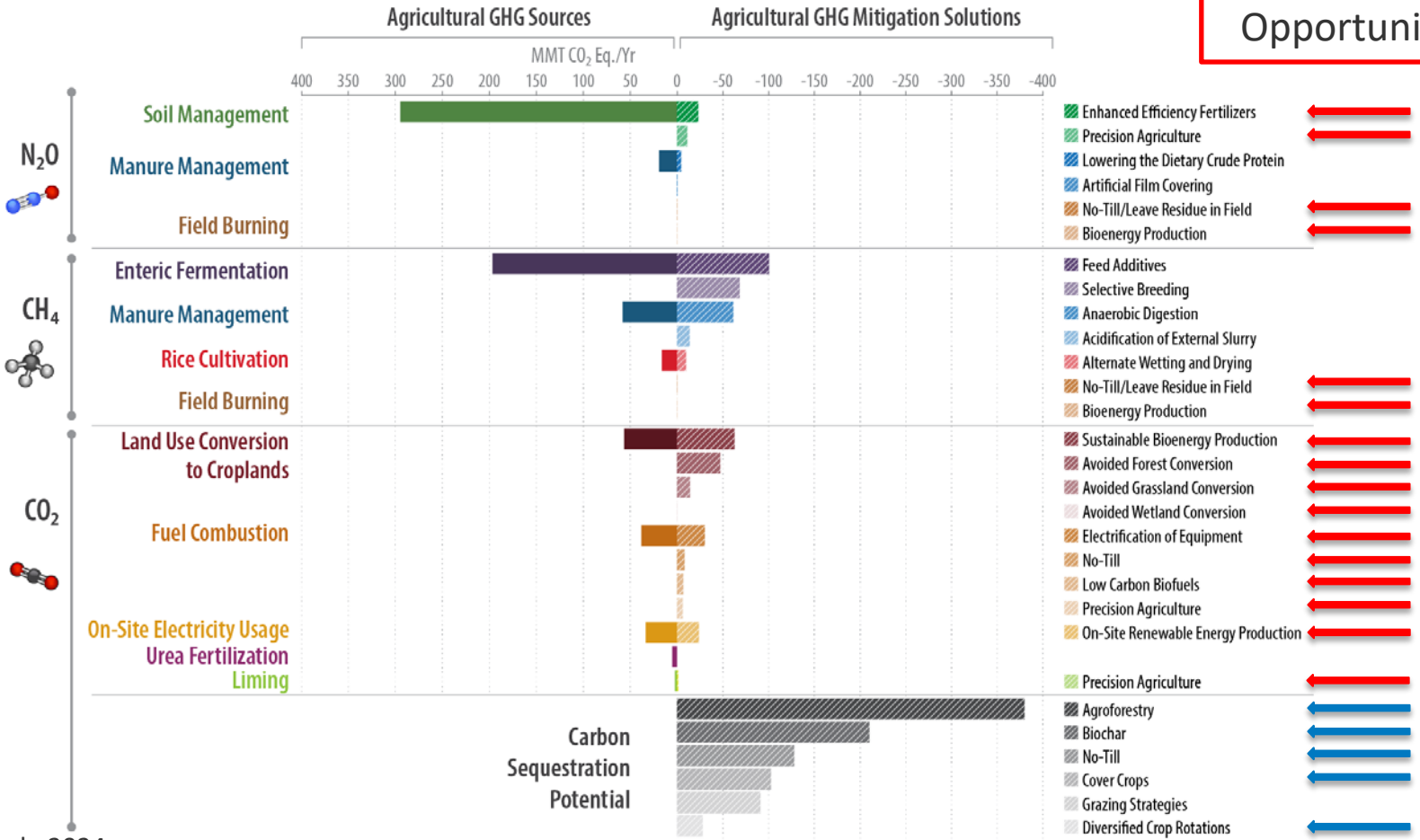
Crop Production Opportunities



Staie et al., 2024

Agricultural GHG Mitigation Solutions

Crop Production Opportunities



Staie et al., 2024

Crosscutting Solutions

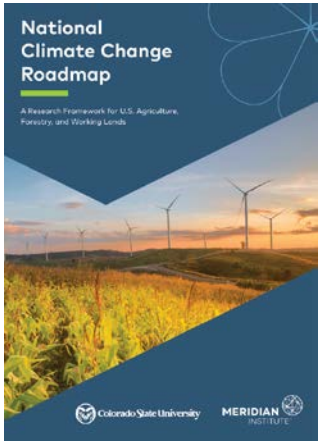
- Five solutions offer GHG mitigation potential for multiple sources and/or offer a carbon sequestration mechanism

	Energy Efficiency and Renewable Energy Production	Precision Agriculture	No-Till	Integrated Nutrient Management	Biochar
Fuel Combustion	X	X	X		
On-Site Electricity Use	X				
Manure Management	X				
Soil Management		X	X	X	X
Urea Fertilization		X		X	
Liming		X			X
Rice Cultivation			X		
Field Burning			X		
Soil Carbon Sequestration Potential			X	X	X

Staie et al., 2024

National Climate Change Roadmap for U.S. Agriculture

- USDA NIFA funded
- CSU-led (Gene Kelly, Jan Leach, Courtney Schultz, Erin Jackson)
- 61 Scientists across 51 institutions
- Diversity in disciplines and sectors



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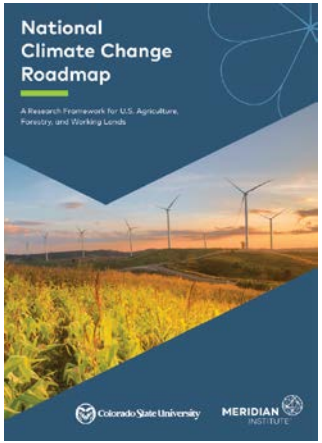
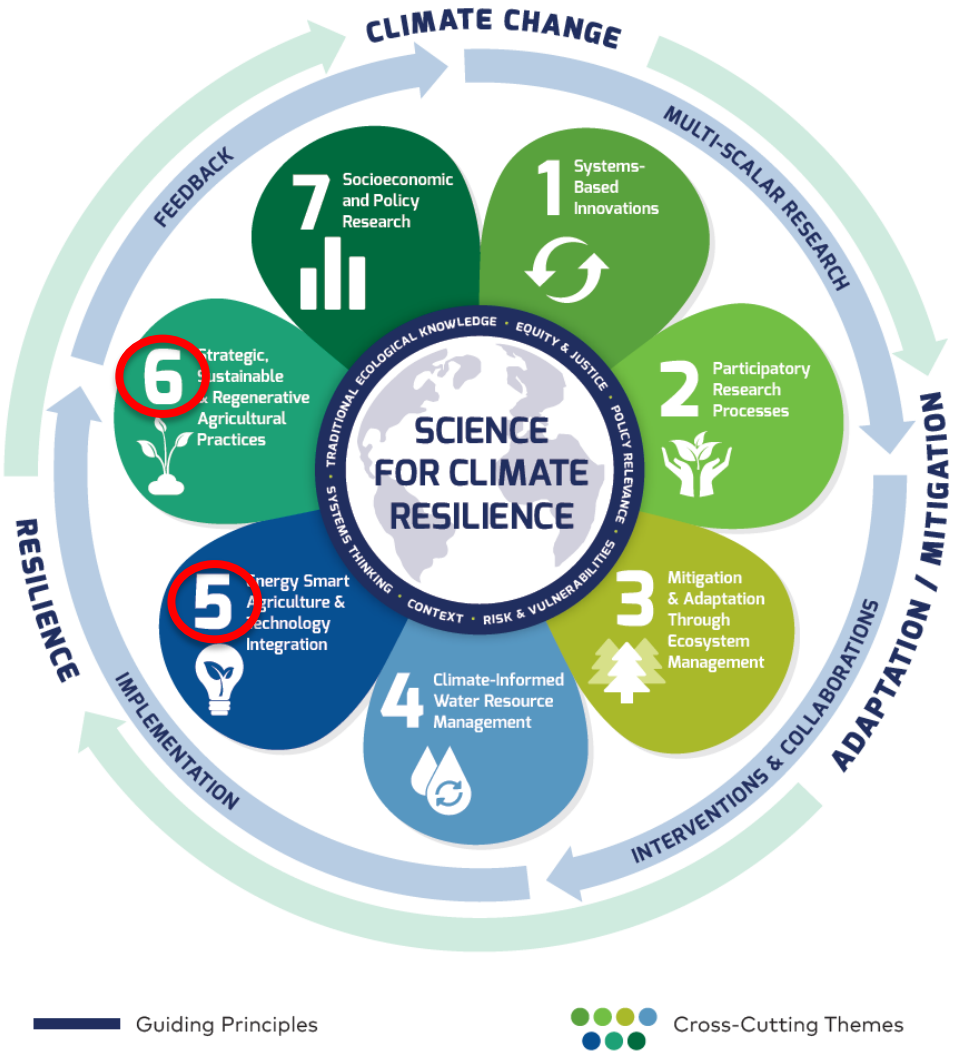




Thank you!

Jordan.Macknick@nrel.gov
303-275-3828

www.nrel.gov

Agricultural Decarbonization in the US – Successes and Opportunities: **Livestock**

Jordan Lambert
Colorado State University

Championing Producer-Centric Innovation

THE AG INNOVATION CENTER

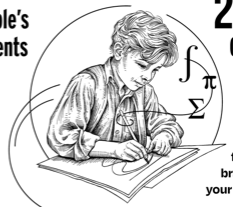
COLORADO STATE UNIVERSITY | CSU SPUR

Why should we care about AG DECARBONIZATION?

In 2020, American Dairy Cows Supplied Enough Nutrition To Meet:

169 million people's Protein requirements

Protein from dairy products is complete - meaning it contains all 9 essential amino acids that keep your body strong.

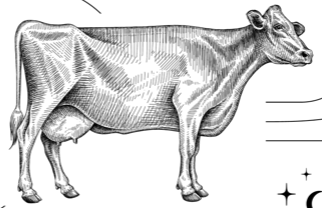


29% of American Choline requirements

Cholines supports your memory, mood, and muscle control, as well as forms the membranes that surround your body's cells.

57% of American vitamin B12 requirements

Vitamin B12 is essential for making the neurotransmitters that help you feel happy and sleep well - serotonin and dopamine.



54% of American vitamin D requirements

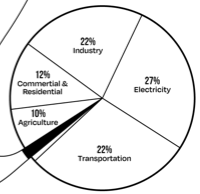
Vitamin D makes your muscles move, makes your nerves carry messages between your brain and body, and builds strong bones.

71 million people's Energy requirements

Your brain uses energy to think and your body uses energy to move.

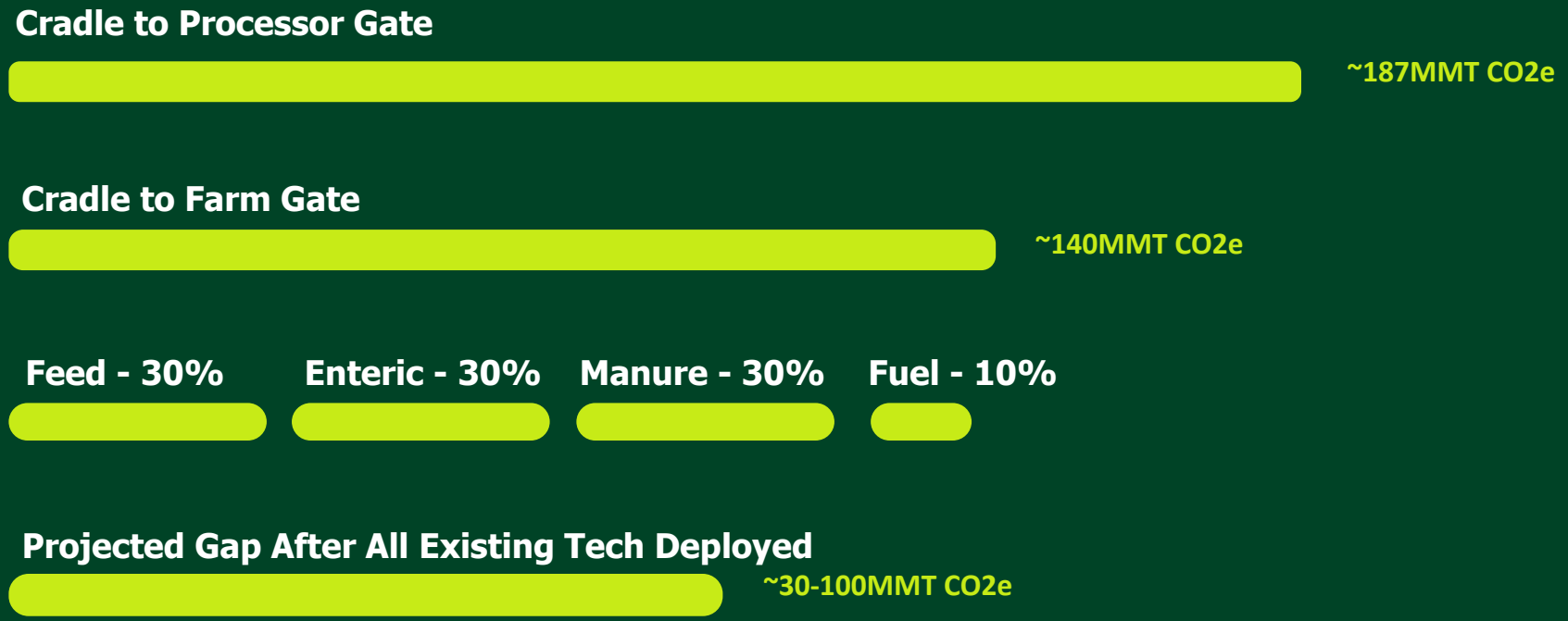
39% of American vitamin A requirements

Vitamin A helps you defend against infection and keeps your eyes, heart, lungs, and reproductive organs healthy.



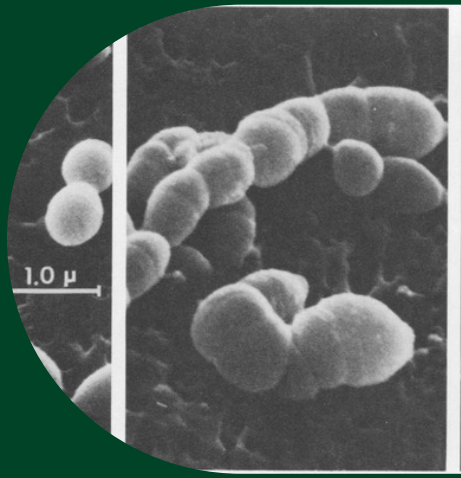
All for less than 2%
of all US Greenhouse Gas Emissions

US DAIRY GHG FOOTPRINT



Why is it hard to abate

ENTERIC EMISSIONS?



Methane production by microbes are integral to the rumen ecosystem, converting feed into energy, which complicates efforts to reduce methane without affecting animal productivity (Tseten et al., 2022).

Genetic variability among animals influences methane production, necessitating tailored approaches for different breeds (Place, 2024).

The **type and quality of feed** significantly impact methane emissions; high-fiber diets tend to produce more methane (Galati et al., 2023).

Economic and safety concerns regarding feed additives hinder their widespread adoption (Tseten et al., 2022).

Why is it hard to abate

MANURE EMISSIONS?

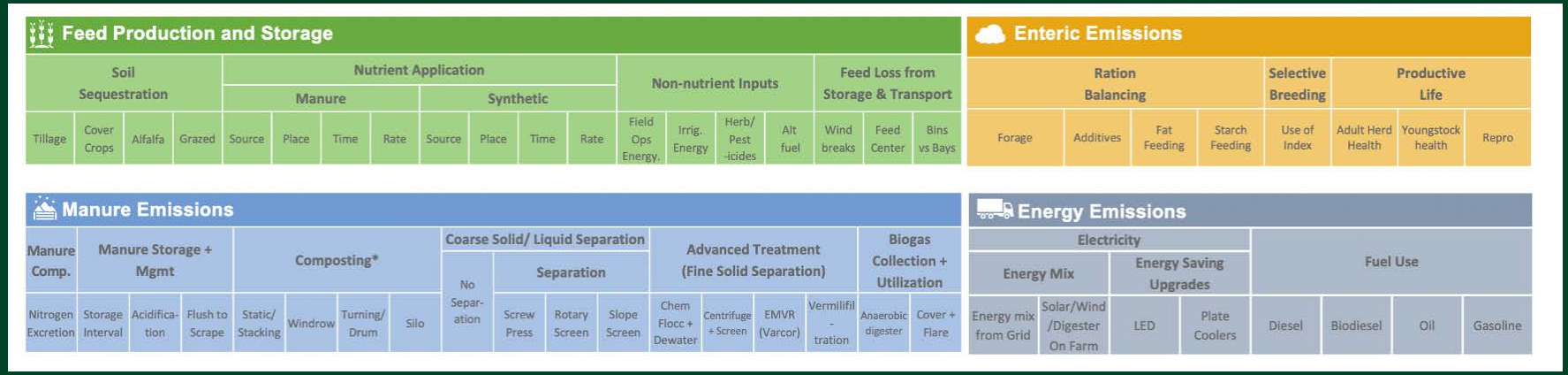
Manure management is complicated - emissions are influenced by factors such as manure type, storage conditions, and environmental factors, complicating mitigation efforts (Meiirkhanuly et al., 2020).

Mitigating some negative externalities can cause others - Manure causes several types of emissions that have tradeoffs with each other (Sajeev et al., 2017) and preventing water runoff has created conditions for more emissions

Existing Interventions are incomplete and too operationally complex to be deployed economically on a diversity of farming operations

Manure is a heterogenous product, making it challenging to develop markets willing to pay for manure benefits

WAYS OF REDUCING EMISSIONS



Feed Production and Storage

Soil Sequestration				Nutrient Application								Non-nutrient Inputs				Feed Loss from Storage & Transport		
				Manure				Synthetic										
Tillage	Cover Crops	Alfalfa	Grazed	Source	Place	Time	Rate	Source	Place	Time	Rate	Field Ops Energy.	Irrig. Energy	Herb/ Pest -icides	Alt fuel	Wind breaks	Feed Center	Bins vs Bays

Enteric Emissions

Ration Balancing				Selective Breeding	Productive Life		
Forage	Additives	Fat Feeding	Starch Feeding	Use of Index	Adult Herd Health	Youngstock health	Repro

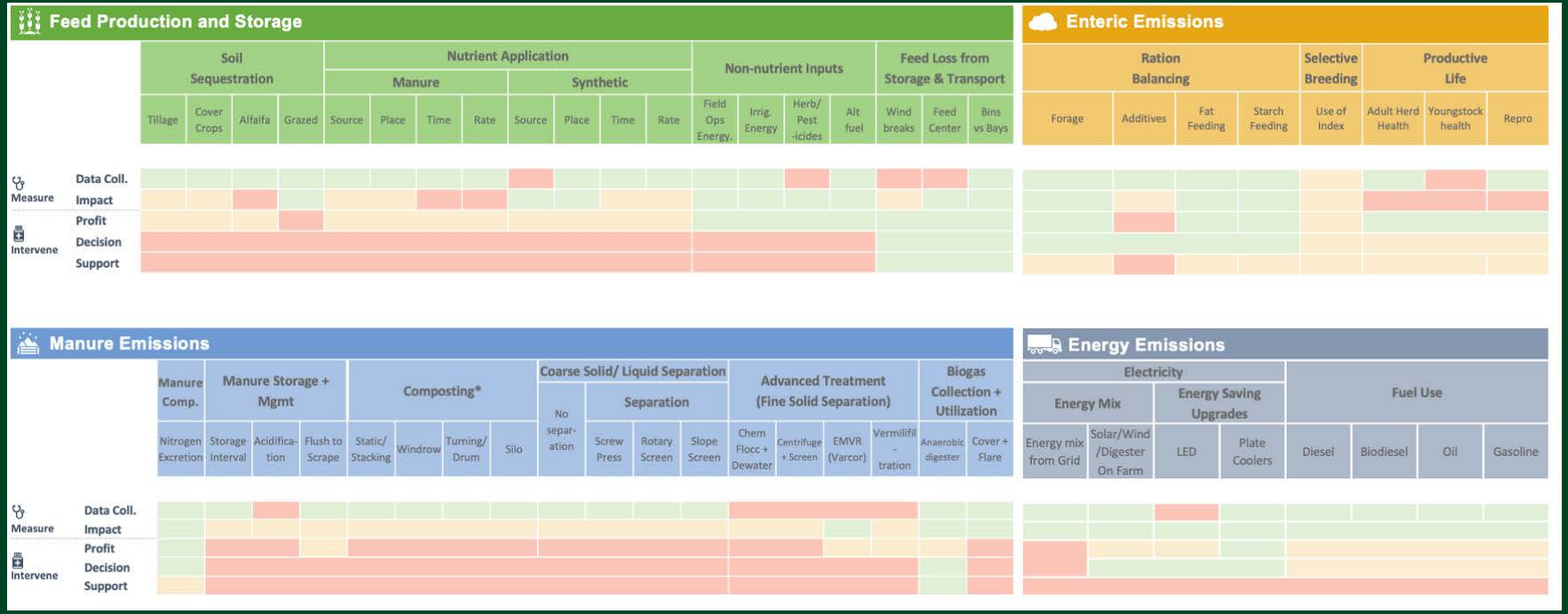
Manure Emissions

Manure Comp.	Manure Storage + Mgmt			Composting*				Coarse Solid/ Liquid Separation				Advanced Treatment (Fine Solid Separation)				Biogas Collection + Utilization	
								No Separ-ation	Separation								
Nitrogen Excretion	Storage Interval	Acidifica-tion	Flush to Scrape	Static/ Stacking	Windrow	Turning/ Drum	Silo		Screw Press	Rotary Screen	Slope Screen	Chem Flocc + Dewater	Centrifuge + Screen	EMVR (Varcor)	Vermilifil - tration	Anaerobic digester	Cover + Flare

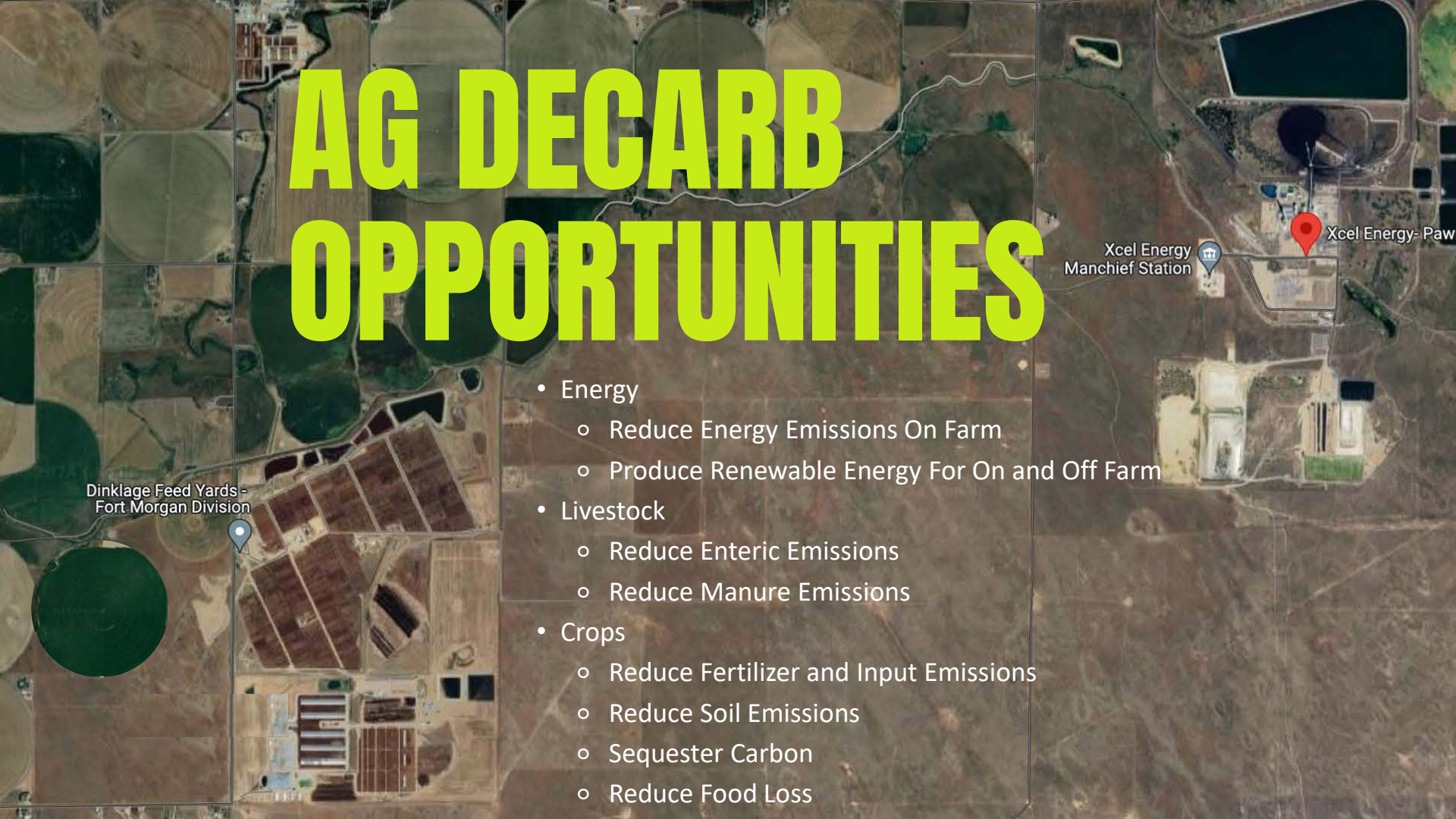
Energy Emissions

Electricity				Fuel Use			
Energy Mix		Energy Saving Upgrades					
Energy mix from Grid	Solar/Wind /Digester On Farm	LED	Plate Coolers	Diesel	Biodiesel	Oil	Gasoline

READINESS TO DEPLOY



AG DECARB OPPORTUNITIES

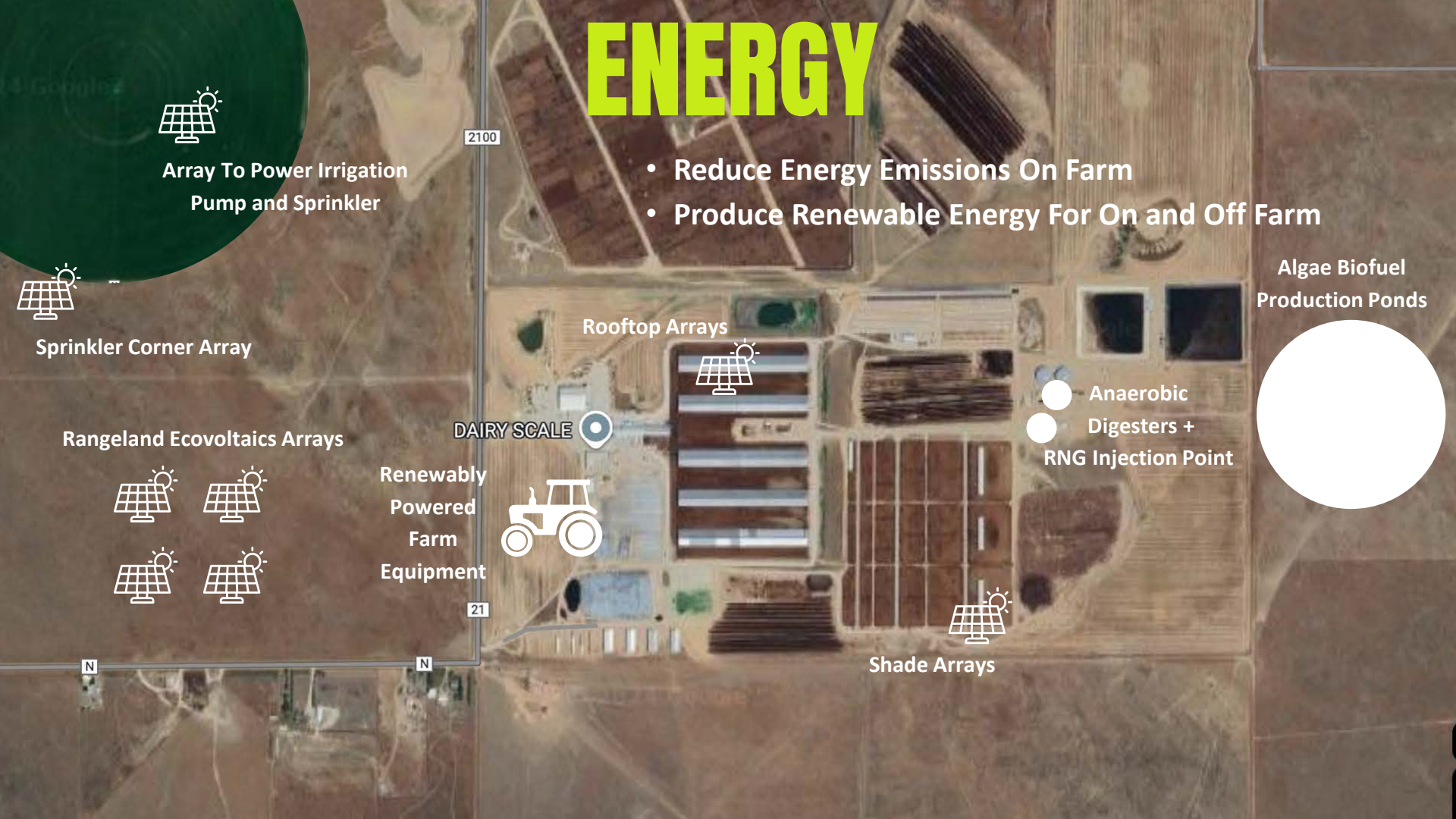


- Energy
  - Reduce Energy Emissions On Farm
  - Produce Renewable Energy For On and Off Farm
- Livestock
  - Reduce Enteric Emissions
  - Reduce Manure Emissions
- Crops
  - Reduce Fertilizer and Input Emissions
  - Reduce Soil Emissions
  - Sequester Carbon
  - Reduce Food Loss


2100
21
DAIRY SCALE
2100
21

ENERGY

- Reduce Energy Emissions On Farm
- Produce Renewable Energy For On and Off Farm



CROPS

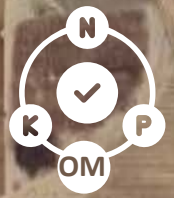
- Reduce Fertilizer and Input Emissions
- Reduce Soil Emissions
- Sequester Carbon
- Reduce Food Loss

Renewable Fertilizer Application

Cover Crop Application

DAIRY SCALE

Upcycle Food Loss



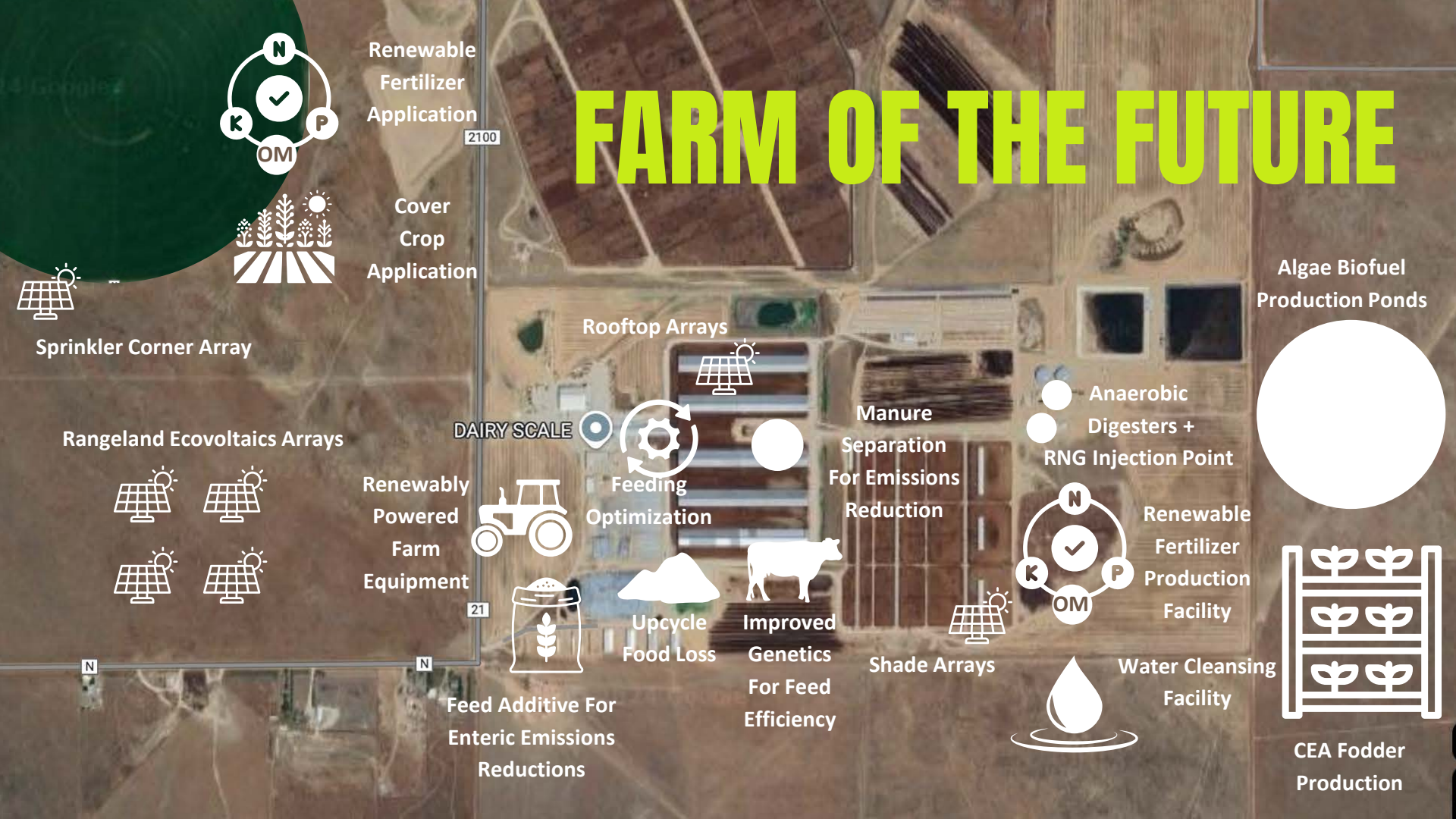
Renewable Fertilizer Production Facility

Water Cleansing Facility

CEA Fodder Production

LIVESTOCK

- Reduce Enteric Emissions
- Reduce Manure Emissions


FARM OF THE FUTURE
Renewable Fertilizer Application
Cover Crop Application
Sprinkler Corner Array
Rooftop Arrays
Algae Biofuel Production Ponds
Anaerobic Digesters + RNG Injection Point
DAIRY SCALE
Rangeland Ecovoltaics Arrays
Renewably Powered Farm Equipment
Feeding Optimization
Manure Separation For Emissions Reduction
Renewable Fertilizer Production Facility
Upcycle Food Loss
Improved Genetics For Feed Efficiency
Shade Arrays
Water Cleansing Facility
Feed Additive For Enteric Emissions Reductions
CEA Fodder Production
N
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21

THANK YOU!

Contact me at
jordan.lambert@colostate.edu

Agricultural Decarbonization in the US – Successes and Opportunities: **Energy**

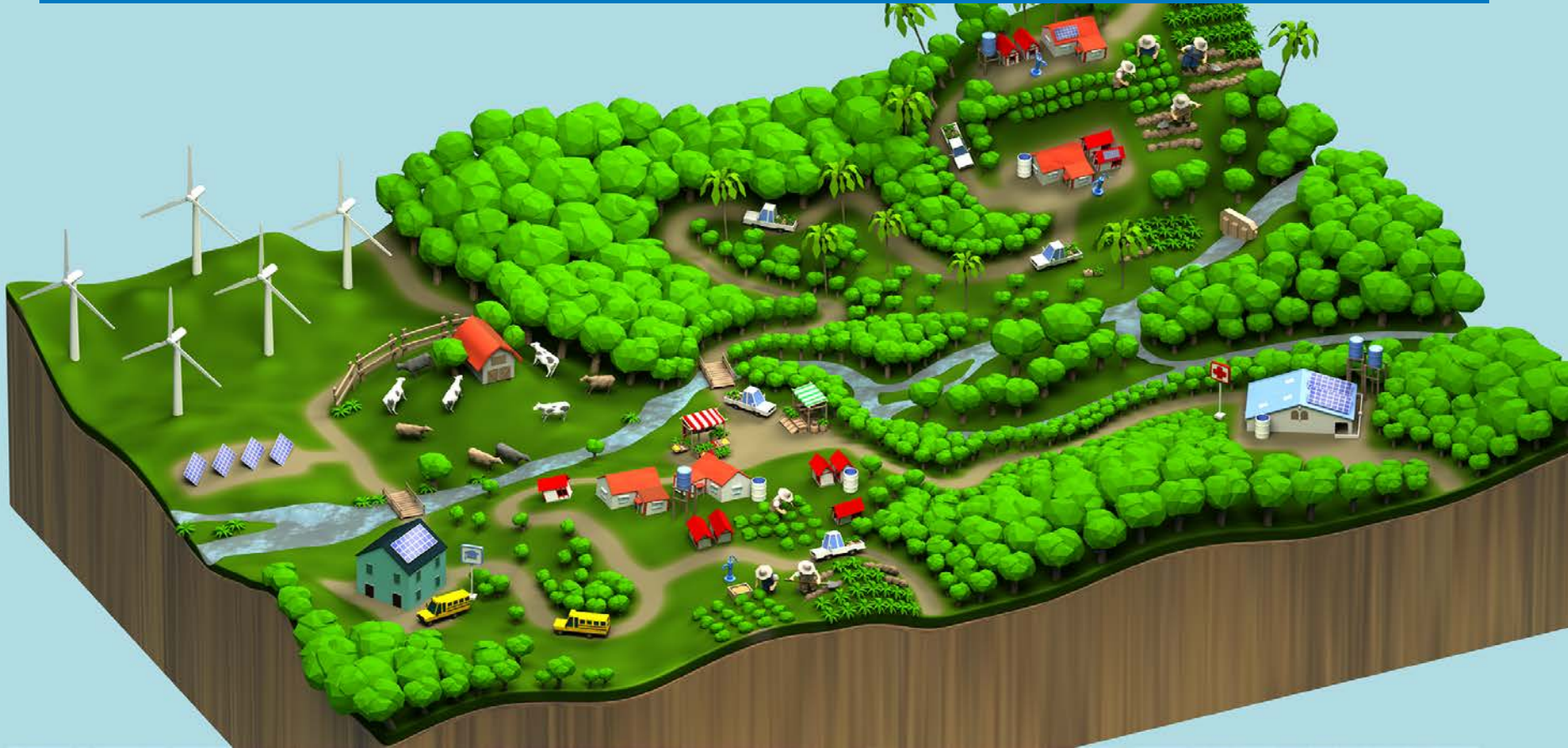
Sherry Stout
National Renewable Energy Laboratory

Opportunities for On-Farm Clean Energy

Sherry Stout
State, Local, and Tribal Lab Program Manager

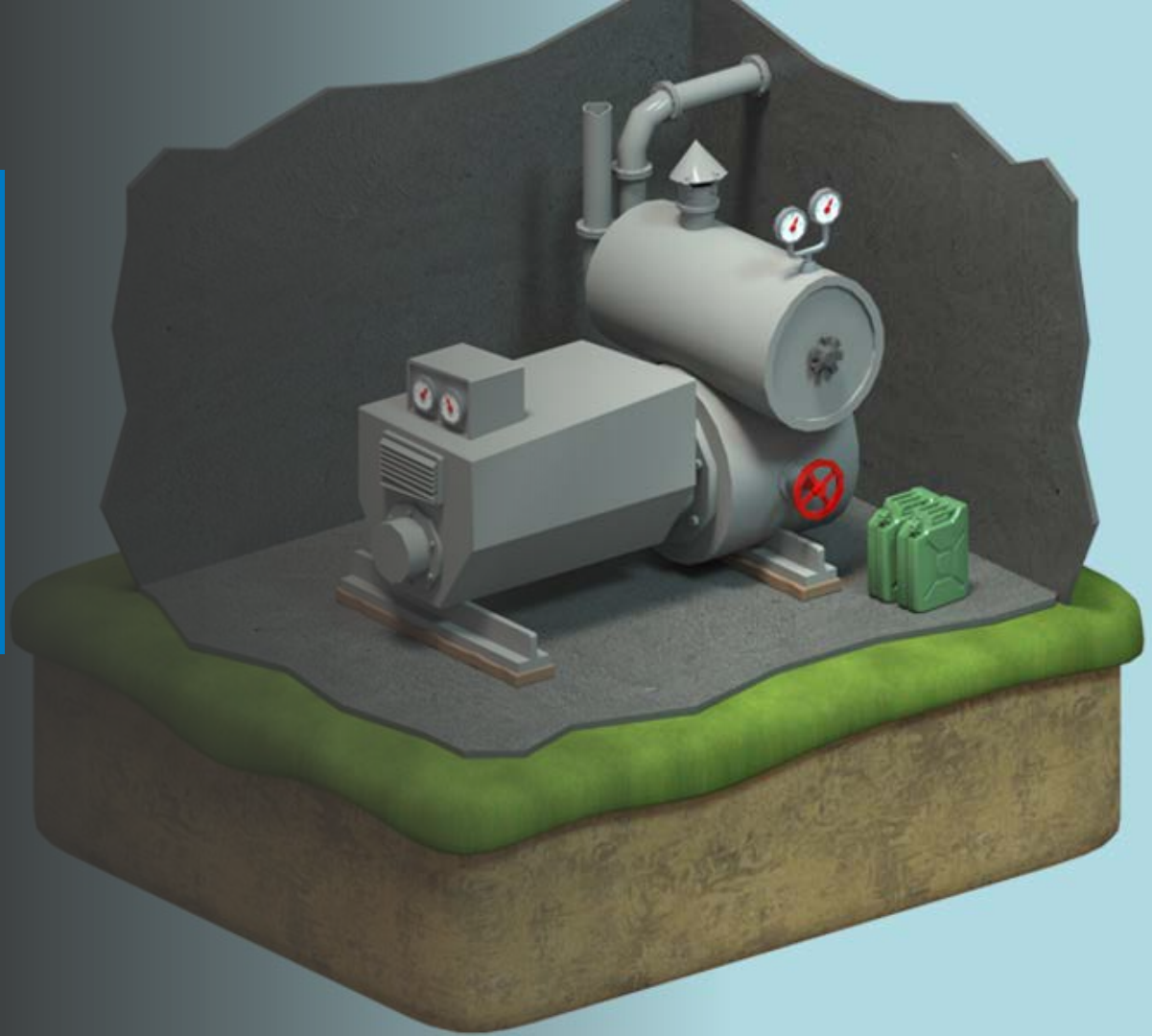
Farmers face a myriad concerns and opportunities

Opportunities for On-Farm Clean Energy Use



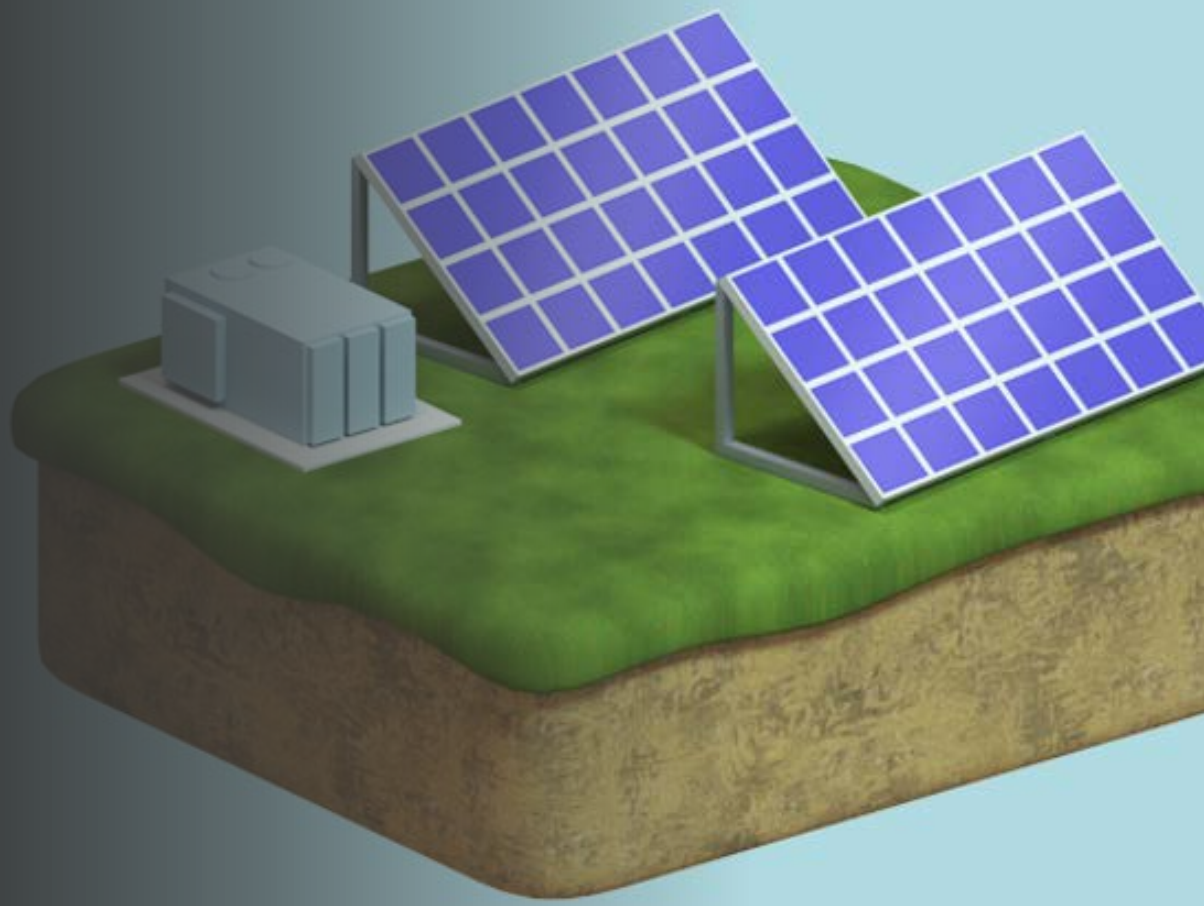
Off setting diesel

Most of us use it!
Goals:
Reduce price volatility
Increase clean energy use



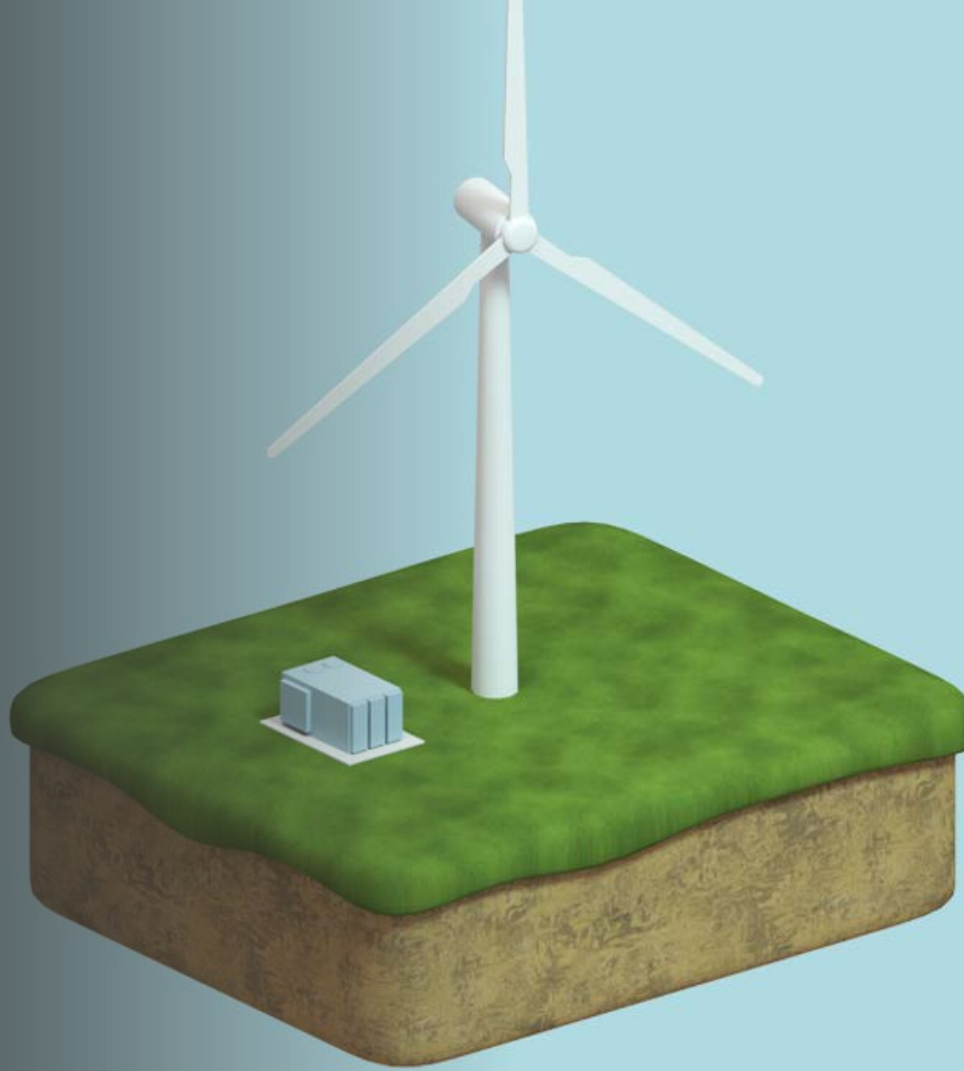
Distributed Scale Solar PV

Grid connected… or not!
Goals:
Reduction of input costs
Generation of revenue



Distributed Wind

Small… or large!
Goals:
Generation of revenue
Reduction of input costs – depends on scale!



Thank You

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NREL
Transforming ENERGY

Successful Implementation of Agricultural Decarbonization Solutions

Josie Hart
Denver Botanic Gardens


Decarbonizing
Small-Scale
Vegetable
Farming

Denver Botanic Gardens

Chatfield Farms

Josie Hart

Associate Director of Farm Programs

Chatfield Farms

Denver Botanic Gardens

josie.hart@botanicgardens.org

DENVER BOTANIC GARDENS

Motivation for Regenerative Mindset

World population is projected to increase from 7 billion in 2013 to more than 9 billion in 2050. To sustain this level of growth, food production will need to rise by 70 percent.

Between 1982–2007, 14 million acres of prime farmland in the U.S. were lost to development.

Improving soil health is key to long-term, sustainable agricultural production

Chatfield CSA: 400 vegetable shares weekly

300 Paid Shares

100 Donated

.25 acre cut flowers

Medicinal and Herb Gardens

Onsite Farming Education

Onsite Compost Program

Prairie and Riparian Restoration

What are "intensive" growing techniques?

practices that increase the productivity of a growing space allow us to get higher yields out of smaller spaces, reduce labor spent growing vegetable crops and otherwise maximize efficiency and value.

How it works:

- Densely planted or seeded beds with narrow pathways ensure that the space is used efficiently for growing crops
- Succession planting, interplanting, and cover cropping (or tarping) are used to ensure that the soil is always covered with plants
- Beds are well composted to ensure nutrients are available and the soil is only lightly loosened to minimize disturbance
- Drip irrigation ensures that we are only watering the crop – not the pathways – and gives us more control over the amount of water used.

Agroforestry

Partnership with Colorado State Forest Department, 28 species of Oak (Burr) and plantings of Scott's Pine to demonstrate beneficial native plantings

Wind breaks, alley planting, carbon storage, fungi

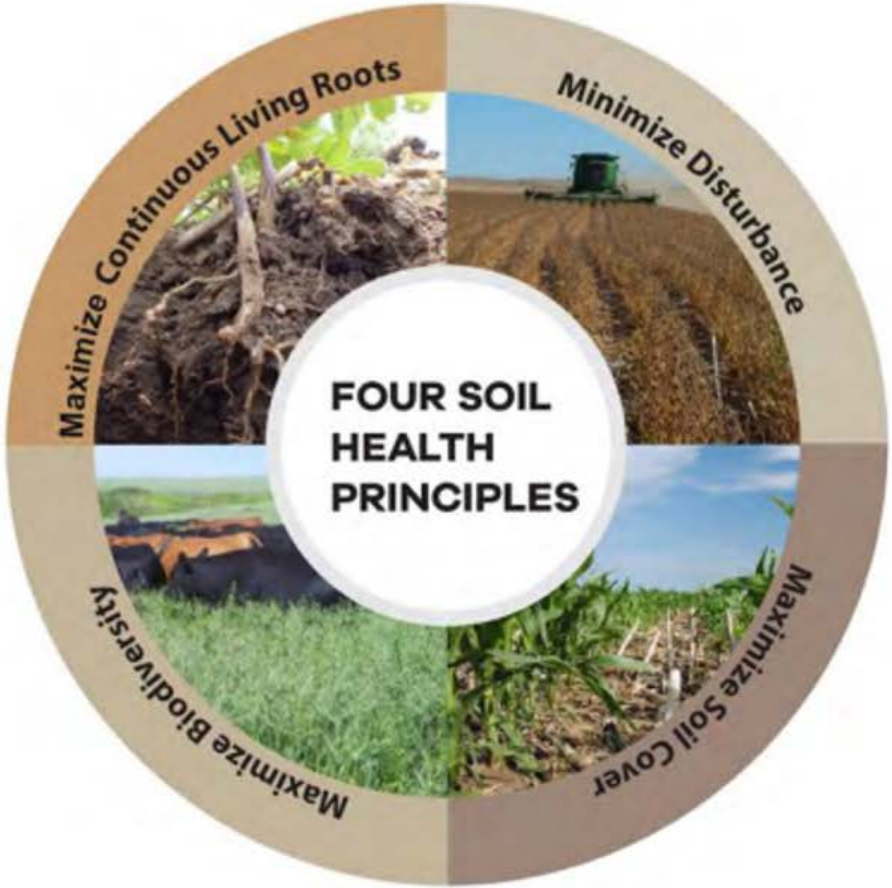
Colorado State Forestry Department and Chris Hartung

This year three new windbreaks (500 trees) were installed as part of a 20-year, multi-agency, North America-wide provenance study of bur oak (*Quercus macrocarpa*). Working with Colorado State Forest Service, we are providing a site for 28 different seed sources of the oak, which will tell researchers which seed sources, geographically, are best suited for Colorado. Other source studies are being conducted on Scots pine (*Pinus sylvestris*) and western soapberry.

Most trees were watered 0-3 years to establish

Soil Health

- Carbon sequestration
- Living roots in the soil
- Conservation tillage
- Keep the soil covered
- Retain rainwater through organic matter
- Above and underground biodiversity



Compost Program at Chatfield

Organic Matter – Carbon!

SOM is highest at the soil surface and is critical for stabilizing soil aggregates.

Maintaining SOM helps support additior soil functions including water infiltration drainage and storage, nutrient-holding capacity and release, and habitat for soil biota.


Power of Cover
Crops

Chatfield Techniques – Soil Coverage

- Cover Cropping
- Deep Mulching
- Silage Tarping
- Native Insectary Strips
- New Windbreaks! Elderberry, Willow, Native Shrubs and Edibles like Currant


The Chatfield
Community
Solar Garden

Agrivoltaics

- Agriculture and Solar Energy Production
- Enhances land-use for farmers
- Protection from the sun/severe weather, shade for humans
- Farmers receive credits from Xcel
- Potential revenue for community solar grid
- 12 finished community solar projects completed, 6 more coming in Denver
- Farmers can own their own grid, or can contribute to community grids

Food and Energy Security

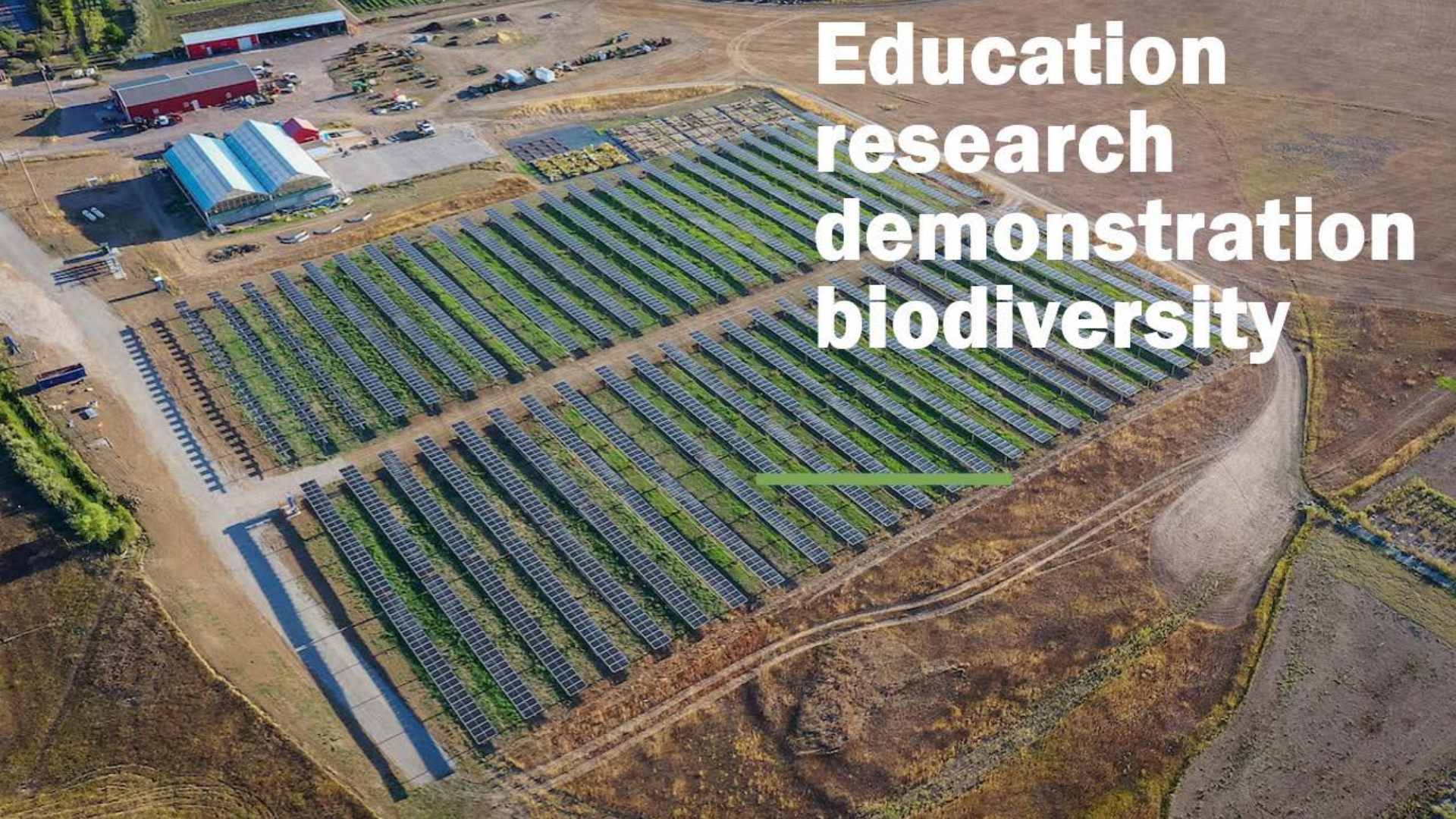
- All produce will be donated through established partnerships
- 1.2 MW solar capacity
- 150 families receive discounted power – Energy Outreach Colorado
- 20% of power donated to Chatfield Farms, York St. location

Five C's –
SUCCESS

1. climate
2.configuration
3.crops
4.compatibility
5.collaborations

Collaborations -

NREL
Transforming ENERGY


Education
research
demonstration
biodiversity

The Climate Protection Fund is the backbone of this effort. This fund dedicates more than $40 million to climate action every year. Come with us on our journey to make Denver a safe, healthy, resilient, and sustainable city.

Environmental Justice

The Climate Protection Fund specifies that the fund "should, over the long term, **endeavor to invest fifty percent (50%) of the dedicated funds directly in the community with a strong lens toward equity, race, and social justice**." We are aiming for that 50% requirement to be a floor, not a ceiling.

Creating Jobs – Creating Food Security

Thank you

Panel: Barriers to Implementing Agricultural Decarbonization Solutions

Melissa Brandao
Rogue Cattle Co

Steve Decker
NREL

Mark Guttridge
Ollin Farms

Eric Gibson
Rabobank

Moderated By:
Austin Kinzer
American Farmland Trust

Barriers to Implementing Agricultural Decarbonization Solutions Panel

Steve Decker
NREL

Barriers to Adopting On-Farm Anaerobic Digestion

Steve Decker, Anelia Milbrandt

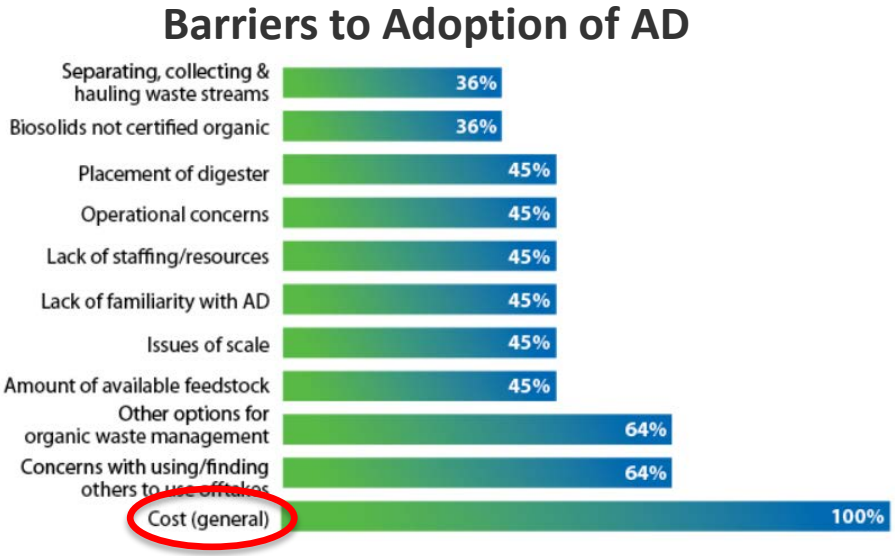
JISEA-CSU Sustainable Agriculture Workshop

Oct. 21, 2024

Photo from iStock-627281636

Key Barriers

- High AD cost (it could be prohibitive for small operations)
  - RNG usually generates more revenue than electricity, but it also requires a significantly higher capital investment
- Meeting regulatory or permitting requirements
- Low electricity rates
- Social/environmental concerns (NIMBY due to increased traffic, odor, noise)
- Limited by-/co-products (biosolids, compost/bedding)



Source: BioCycle, Opportunities To Scale AD Of Food Waste In Washington State, 2024
https://www.biocycle.net/opportunities-to-scale-ad-of-food-waste-in-washington-state/

Examples and Lessons Learned from the Waste-to-Energy Technical Assistance for State, Local, and Tribal Governments

Policy Gaps in the Southwest:

- A community struggles with the absence of supportive policies that incentivize WTE projects
  - Regulatory complexities and lack of financial incentives have delayed the adoption of AD systems

Community Opposition in the Northeast:

- In a community, local residents have voiced opposition to the installation of an AD facility (NIMBY)
  - Concerns about odor, traffic, and environmental impact are the key reasons behind resistance, despite the environmental benefits of AD

Source: iStock

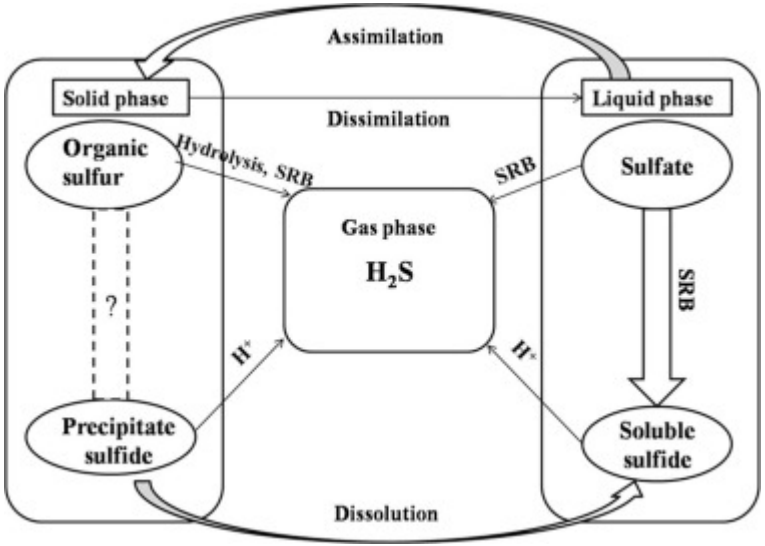
Examples and Lessons Learned from the Waste-to-Energy Technical Assistance for State, Local, and Tribal Governments

Technical Barriers in the Midwest:

- A community has successfully produced RNG, but the high levels of hydrogen sulfide (H_2S) make it difficult to meet pipeline quality standards
  - This highlights the need for better gas upgrading technologies or pretreatment options to ensure RNG is pipeline-ready

Budget Constraints in the Southeast:

- A community is evaluating whether AD is the most viable WTE solution given their limited budget
  - The cost-effectiveness of AD needs to be evaluated against other technologies, factoring in long-term economic and environmental benefits



Barriers to Implementing Agricultural Decarbonization Solutions Panel

Mark Guttridge
Ollin Farms

OLLIN FARMS

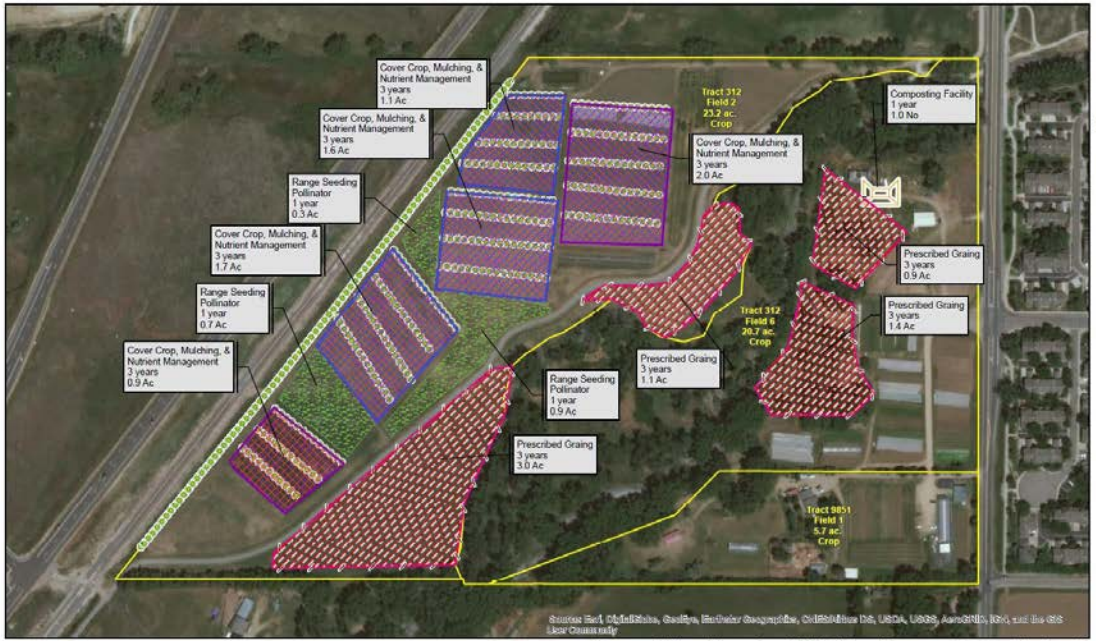

Access to Healthy
Local Produce

Conservation Plan Map

Date: 2/5/2019

Customer(s): OLLIN FARMS LLC
District: LONGMONT
Approximate Acres: 49.6
Legal Description: SE4 SE4 Sec. 17-T2N-R69W

Field Office: LONGMONT
Agency: USDA - NRCS
Assisted By: SYLVIA HICKENLOOPER
State and County: CO, BOULDER

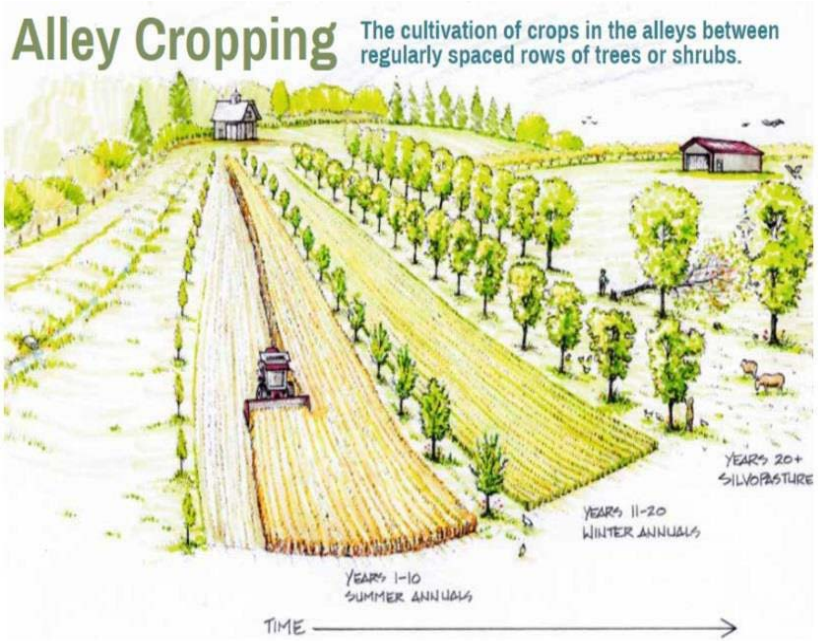


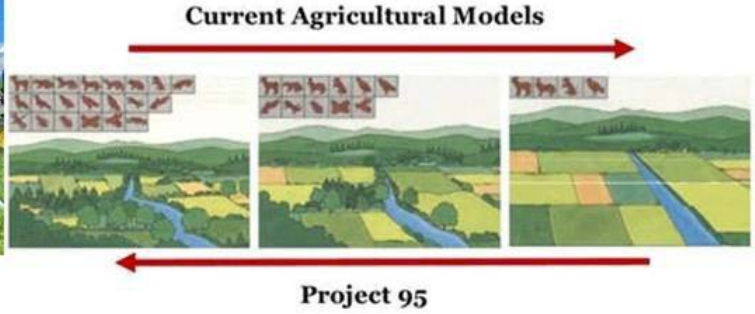
Prepared with assistance from USDA-Natural Resources Conservation Service

USDA

160 0 160 320 480 640
Feet

N


Alley Cropping
The cultivation of crops in the alleys between regularly spaced rows of trees or shrubs.
YEARS 20+
SILVOPASTURE
YEARS 11-20
WINTER ANNUALS
YEARS 1-10
SUMMER ANNUALS
TIME


Current Agricultural Models
Project 95


Demonstration and Hands-On Education of Regenerative Practices
On-farm Composting
Perennial Plantings
Cover Crops
Mycelium/Woodchip Mulching
Pollinator Plantings
Biochar Applications
Soil Mineral Balancing
Winter Bale Grazing
Compost Tea Production
OLLIN FARMS
project 95

Youth Classes and Leadership

“Yes, we need to leave a better planet for our children, but as important is to leave better children for our planet” -Kena

Barriers to Implementing Agricultural Decarbonization Solutions Panel

Melissa Brandao
Rogue Cattle Co

Barriers to Implementing Agricultural Decarbonization Solutions Panel

Eric Gibson
Rabobank

Sponsorship Presentation: CO-WY Engine

Alan Rudolph
CO-WY Engine

The Colorado-Wyoming Climate Resilience Engine

The new frontier in reliable climate technologies

Developing **Innovative** solutions to climate change by leveraging environmental monitoring and data science for **resilient communities**

Alan Rudolph
Engine CTO

Innosphere
Vine St
Fort Collins, CO
alan@CO-WYengine.org

NSF ENGINES: COLORADO-WYOMING CLIMATE RESILIENCE ENGINE

Expected outcomes in 3 Pillars of Activity Over Ten Years and $160M

- Use Inspired R&D
- Translation and Acceleration to Commercialization
- Workforce Development

22K New Jobs

$1.5B GDP Boost

$1B Capital Raised

210 R&D and Translational Grants

1,300 Internships/ Apprenticeships

3,100 Certificates Earned

136 Post-Docs Placed

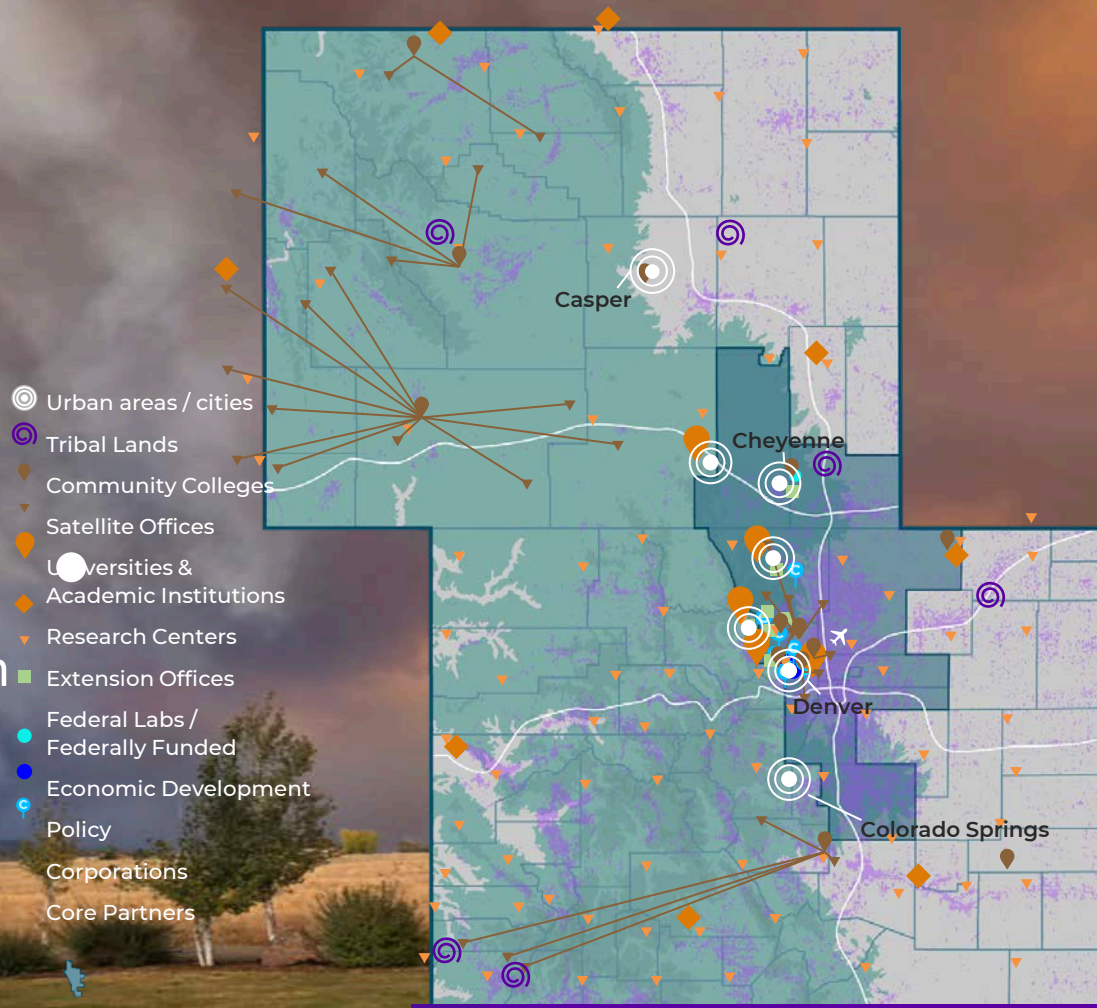
400 Student Trained Systems Engineering

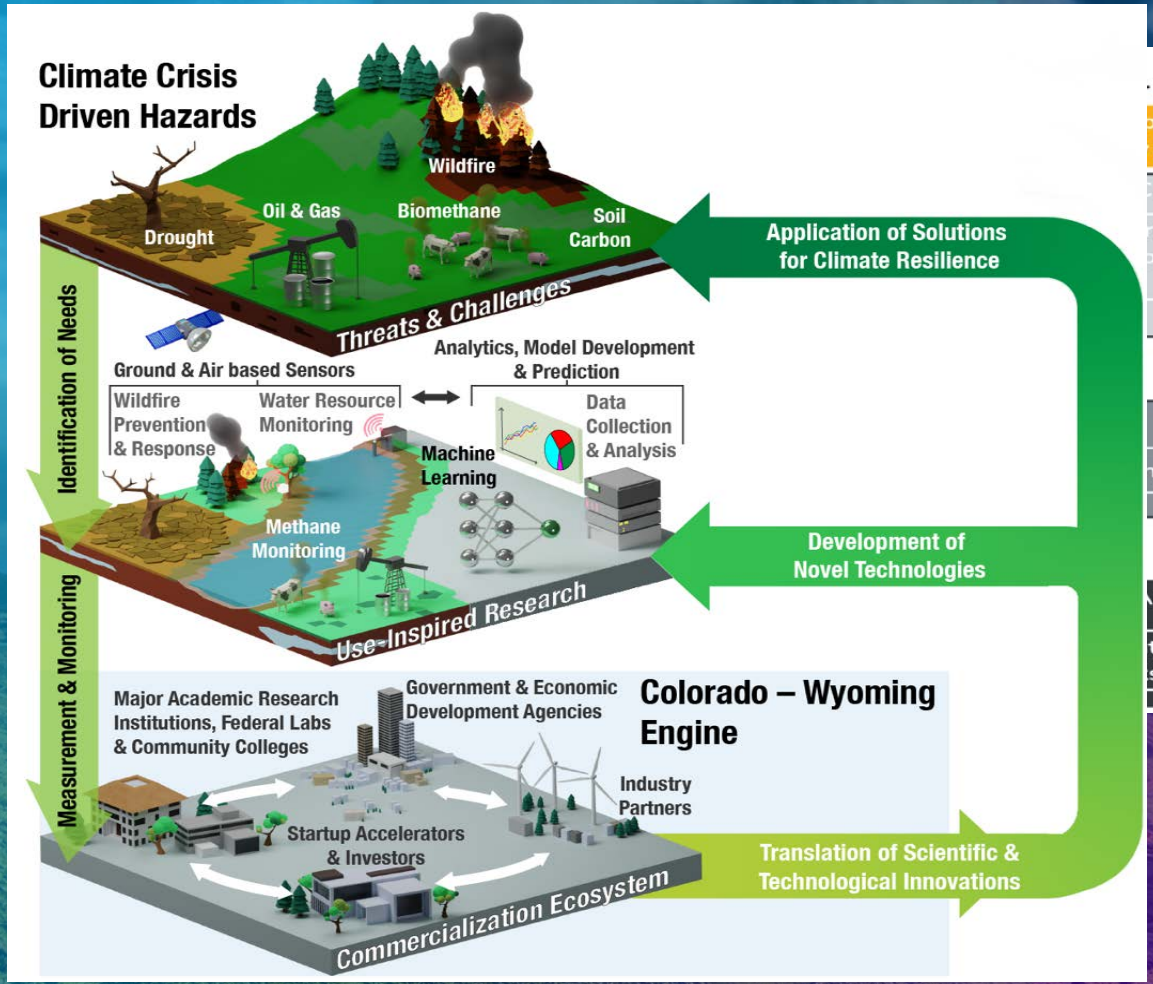
CO-WY ENGINE

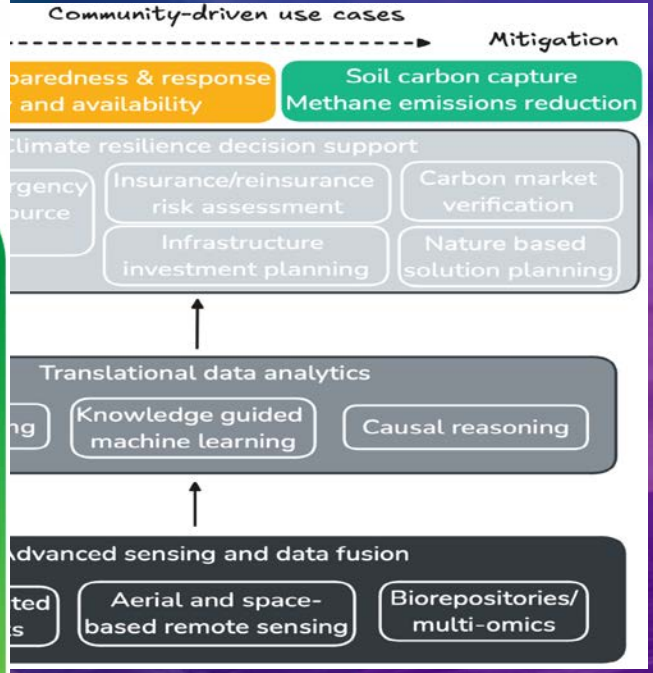

PHASE 2:
Nascent
PHASE 3:
Emergent
PHASE 4:
Growth
PHASE 5:
Mature
Years 1-2
NSF $7.5M/Year
Cost Share $7.5M/Year
Years 3-5
NSF $15M/Year
Cost Share $15M/Year
Years 6-10
NSF $20M/Year
Cost Share $20M/Year
Nascent Phase
Organization and partnerships are solidified and innovation activities ramp up
Emergent Phase
Tech products & services, scaled workforce capabilities, & innovation ecosystem attracts sizeable external funding
Growth Phase
Innovation ecosystem grows as a national leader
Mature Phase
Innovation ecosystem is well established and can sustain itself

CO-WY **Region of Service**

- Forefront of climate changes
- Culture of collaboration
- Unparalleled expertise and dynamic partnerships
- Led by an established ecosystem builder **INNOSPHERE**




Climate Crisis
Driven Hazards
Wildfire
Drought
Oil & Gas
Biomethane
Soil
Carbon
Threats & Challenges
Application of Solutions
for Climate Resilience
Identification of Needs
Ground & Air based Sensors
Analytics, Model Development
& Prediction
Wildfire
Prevention
& Response
Water Resource
Monitoring
Data
Collection
& Analysis
Machine
Learning
Methane
Monitoring
Development of
Novel Technologies
Use-Inspired Research
Measurement & Monitoring
Major Academic Research
Institutions, Federal Labs
& Community Colleges
Government & Economic
Development Agencies
Colorado – Wyoming
Engine
Industry
Partners
Startup Accelerators
& Investors
Translation of Scientific &
Technological Innovations
Commercialization Ecosystem


Community-driven use cases
Mitigation
paredness & response
and availability
Soil carbon capture
Methane emissions reduction
Climate resilience decision support
rgency
ource
Insurance/reinsurance
risk assessment
Carbon market
verification
Infrastructure
investment planning
Nature based
solution planning
Translational data analytics
ng
Knowledge guided
machine learning
Causal reasoning
dvanced sensing and data fusion
ted
s
Aerial and space-
based remote sensing
Biorepositories/
multi-omics

CO-WY ENGINE

Collaborators and Partners

Universities & Academic Institutions:	**Research Universities**: Colorado School of Mines, Colorado State University, University of Colorado Boulder, University of Colorado Denver; **EPSCoR:** University of Wyoming (UW), UW's High Plains American Indian Research Institute; **University:** University of Northern Colorado; **Workforce Drivers and Minority Serving Institutions**: Metropolitan State University of Denver, Colorado Community College System, Wyoming Community College Commission.
Corporates:	Lockheed, NVIDIA, Palantir Technologies, Mars, Shell, Denver Water, Chevron, Trimble
Federal Labs/ Federally Funded:	National Oceanic and Atmospheric Administration (NOAA), National Center for Atmospheric Research (NCAR), National Renewable Energy Laboratory (NREL), US Dept. of Agriculture's Agricultural Research Service (ARS), National Institute of Standards and Technology (NIST), NSF's National Ecological Observatory Network (NEON), CO-LABS, Inc.
Translation:	Innosphere Ventures, Rockies Venture Club, Activate, CSU STRATA, Third Derivative
Economic Development:	Metro Denver Economic Development Corporation, Colorado Office of Economic Development and International Trade, Wyoming Business Council, City of Boulder, City of Fort Collins, City of Greeley, City of Denver, City of Cheyenne
Policy:	Local Governments for Sustainability (ICLEI), Colorado Cleantech Industries Association (CCIA), Denver Chamber of Commerce, Clean Air Task Force

CO-WY Regional Innovation Engine

- **Catalyze partnerships** to expedite innovative climate-resilient technologies.
- **Accelerate** market-ready, globally-scalable scientific and technological innovations.
- **Build** new businesses that monetize the new technologies being developed.
- Achieve **economic growth and job creation** through integrated programs in use-inspired research, workforce development, translation and partnerships.
- **Grow the labor force** in climate-resilient technologies by championing experiential learning, re-skilling and uptraining, certificates and new educational programming.
- **Develop technologies and expertise necessary** for establishing evidence-based standards and scientific-targets for responding to climate changes.
- **Improve climate resilience** by decreasing the impacts of aridification through successfully deploying new technologies and practices.

CO-WY ENGINE

Use-inspired R&D programmatic focus areas

Technology Roadmap

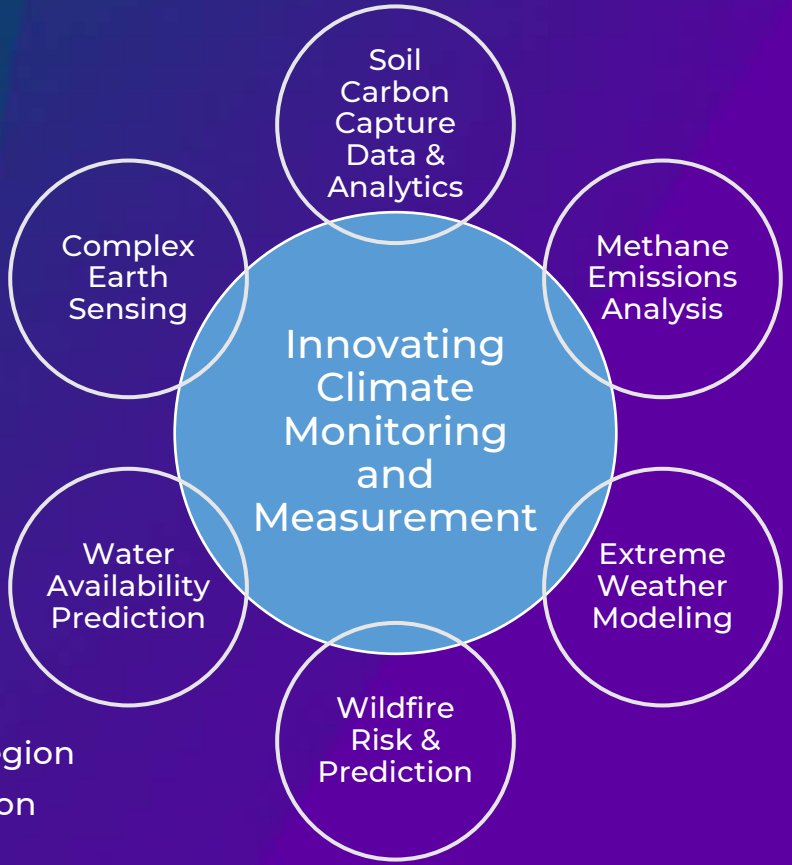
- Stakeholder needs, gaps assessment, and asset mapping
- Engagement of research partners, corporations
- Strategic alignment to environmental markets

UI R&D Grant Program

- Competitive grant selection process
- Awards with 1:1 matching leveraging NSF funding
- Diverse teams are backed and supported

Co-Production Framework

- Connections with users and stakeholders across the CO-WY region
- Formation of cross-sector partnerships within the CO-WY region
- Recruiting new climate tech researchers and companies



Translation to Practice Programmatic **focus** areas

Integrated Translation Approach

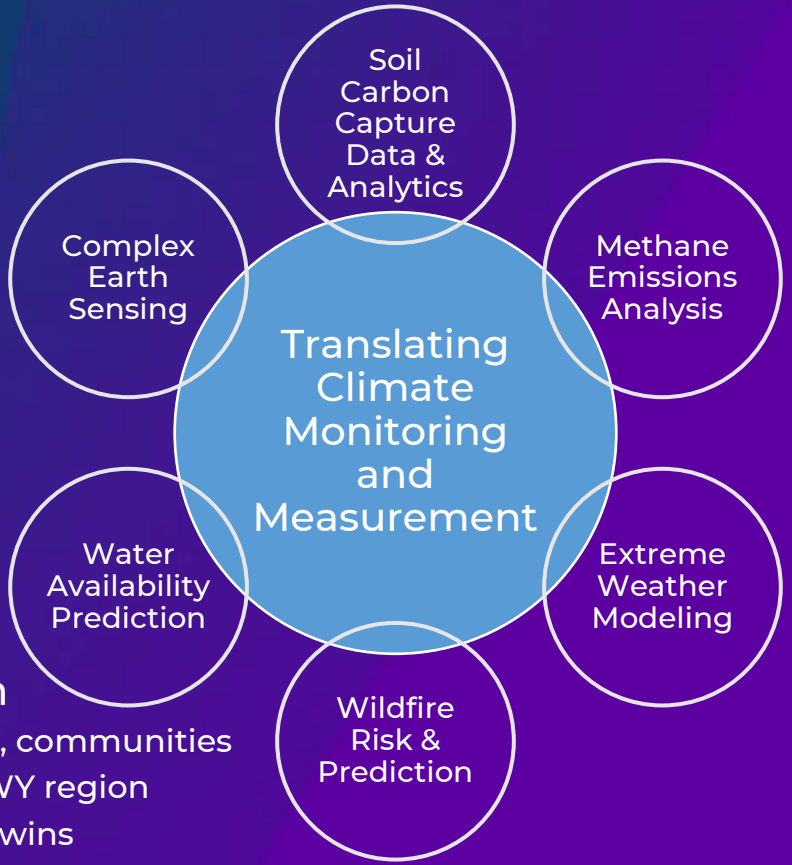
- Innosphere engagement with Engine teams
- Thematic accelerator program & ‘cohort’ recruiting
- Corporate partner mentoring, co-production, early input
- CO-WY venture capital funds

Translation Grant Program

- Competitive grant selection process
- T1/T2 awards with 1:2 matching
- Entrepreneurs in Residence and Entrepreneurial Fellows

Knowledge Deployment & Technology Adoption

- Field testing & at-scale demonstration, National Labs, industry, communities
- Policy analysis, climate policy framework customized for CO-WY region
- Thought leader events to grow the ecosystem, highlight local wins
- Public engagement (Extension, Tribal and Rural Communities)



Soil Carbon Areas of Interest

Pyrolytic Carbon Dynamics in Soil

Scaling BioChar Application

Cost effective and efficient Field Soil Carbon Measurements at Scale

Identified Engine Partners:

CSU Soil Carbon Solutions Center

Engine Ag-Tech Partners (Mars, Trimble, Shell)

USDA-ARS

Start-ups in CO and WY

CO-WY ENGINE

R&D and Translation Activities Update

Site Visit

September 5, 2024

CO-WY ENGINE

Upcoming Engine Events

- October 22 Annoucement of Awards (CO and WY governors)
- November 18 Kickoff Meeting
- December Thematic Accelerator Launch
- Next RFP for Engine Grants Q1 2025
- Ongoing Workforce Development Programs

Alan Rudolph

Innosphere Ventures
1245 Champa Street
Fort Collins, CO. 80204

alan@CO-WYengine.org

Panel: Agricultural Decarbonization Policy and Economics

Jordan Beezley
Colorado Department of Agriculture

Nathan Mueller
CSU

Trish Cozart
NREL

Rachel Rose
Colorado Office of Economic Development and International Trade

Moderated By:
Kristin Wegner Guilfoyle
JISEA/NREL

Agricultural Decarbonization Policy and Economics Panel

Jordan Beezley
Colorado Department of Agriculture

COLORADO
Department of Agriculture

Ag Decarbonization Policy and Economics

October 2024

Jordan Beezley

Deputy Commissioner of External Affairs

Approach

- Voluntary and incentive based programs
- Leveraging limited resources to catalyze larger change
- Creating economic opportunities for producers
- Advocating for and securing funding

Programs and Initiatives

- **Energy**
  - Agrivoltaics research & demonstration grants
  - Technical assistance for USDA renewable energy grant applications
  - ACRE3 matching funds for energy efficiency & renewable energy projects
- **Practices**
  - Soil Health Technical Assistance and Incentives
  - Ag Stewardship Practices Tax Credit
  - Drought and Ecosystem Resilience Grants
- **Markets/Capital**
  - Climate Smart Marketing
  - CAF Loans - Ag Tech and Conservation Projects
  - Local Food Systems
- **Studies**
  - Best practices methane capture/biodigesters
  - Mapping sites solar arrays on agricultural lands
  - GHG reduction and sequestration opportunities

COLORADO
Department of Agriculture

Thank you!

Jordan Beezley

Deputy Commissioner of External Affairs

Colorado Department of Agriculture

jordan.beezley@state.co.us

ag.colorado.gov

All of the photos in this presentation are entries in CDA's "Best in Show" photography contest.

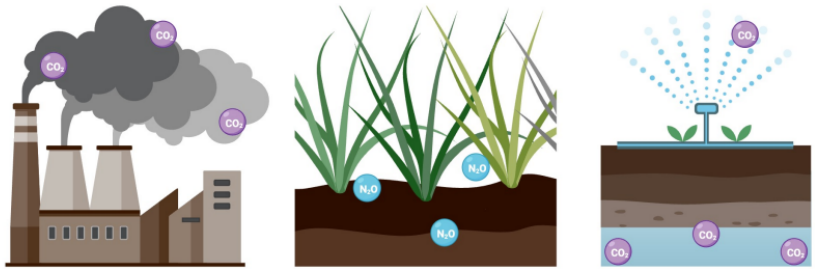
Agricultural Decarbonization Policy and Economics Panel

Nathan Mueller
Colorado State University

COLORADO STATE

Agricultural Sustainability and Climate Impacts Lab

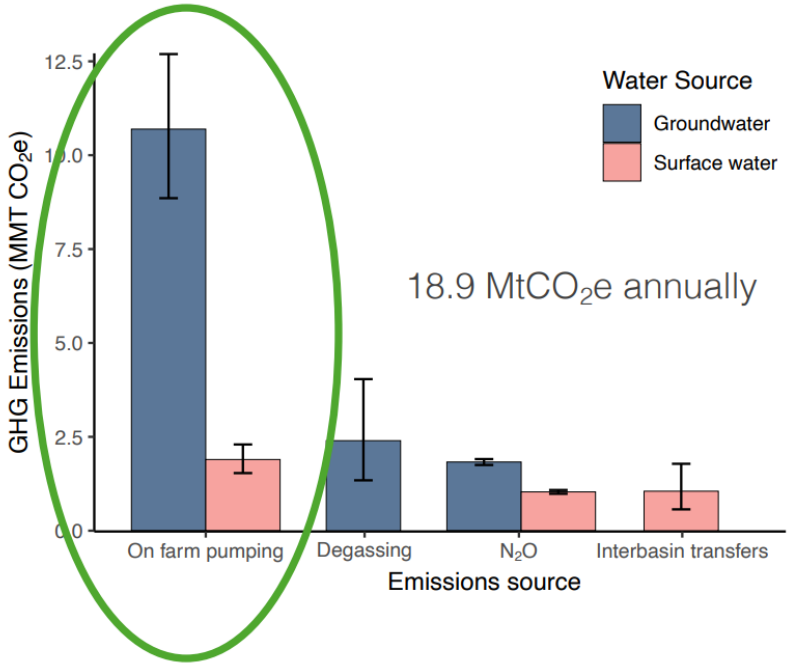
Irrigation-related GHG emissions



Fossil fuels for pumping & conveyance

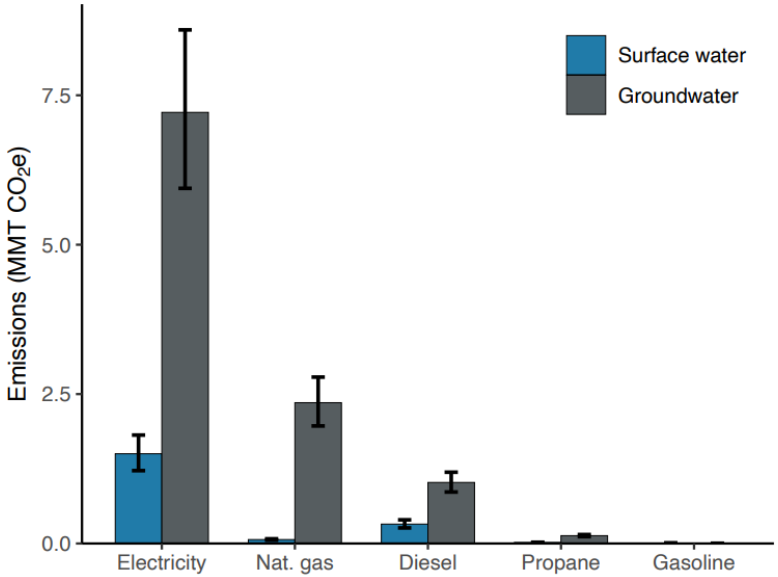
Increased N_2O from elevated soil moisture

Groundwater CO_2 degassing

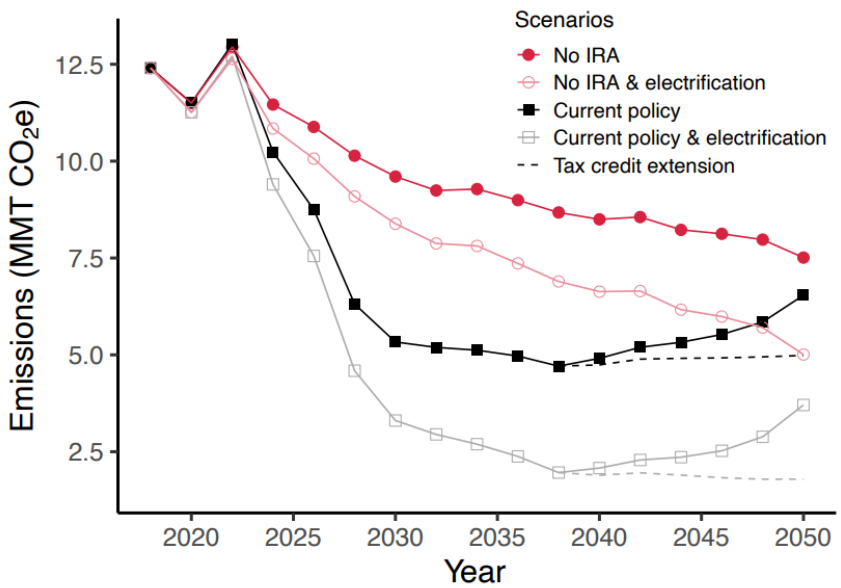


Driscoll et al. 2024 *Nature Water*

On-farm pumping emissions



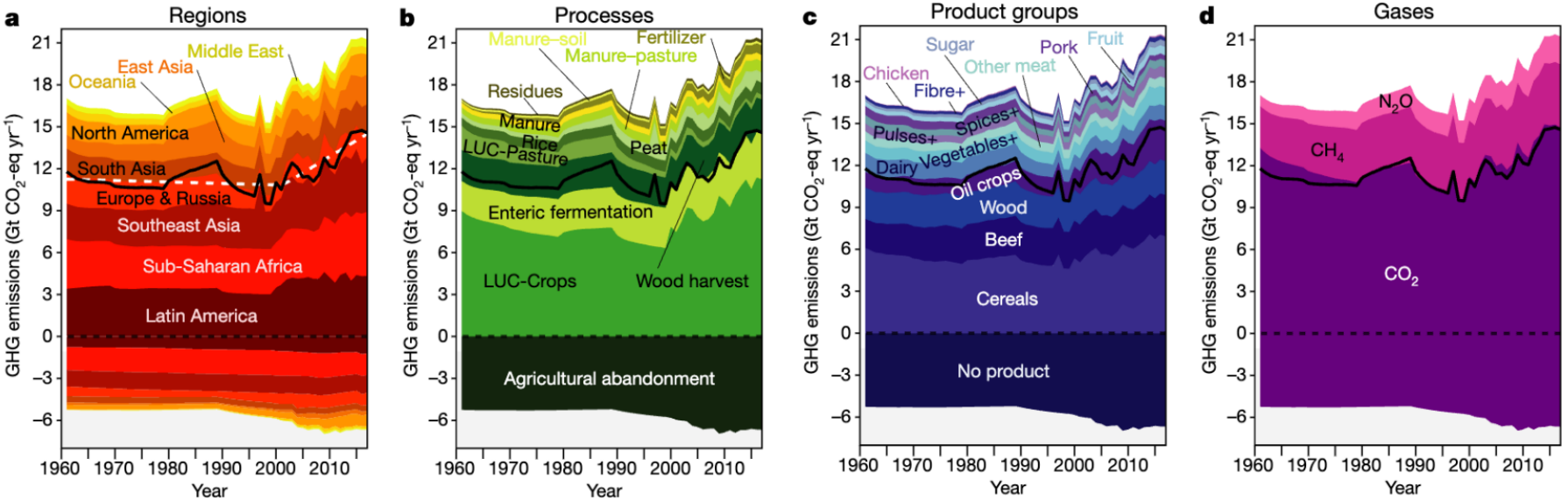
- Groundwater dominated (85%)
- Electricity dominated (72%)



- Strong decarbonization potential!

Driscoll et al. 2024 *Nature Communications*

Global land use emissions



- Land use emissions ~25% global GHGs
- Food system ~1/3 global GHGs

- Increasing emissions since ~2000

Hong et al. 2021 *Nature*

Agricultural Decarbonization Policy and Economics Panel

Trish Cozart
NREL

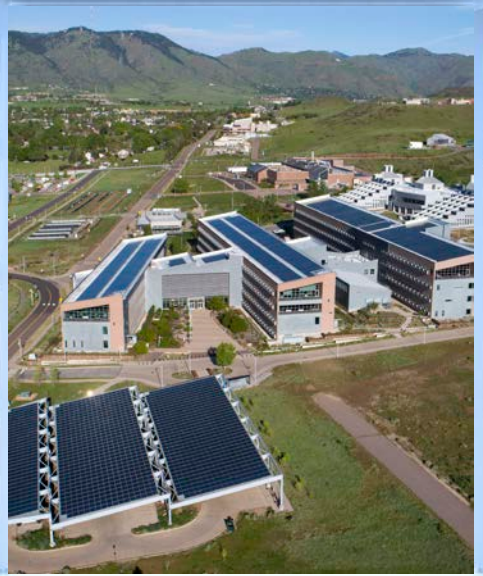
NREL

Innovation & Entrepreneurship Center

Ag Decarbonization Workshop

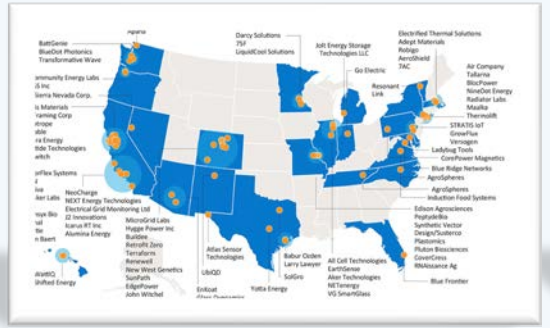
Trish Cozart
Director, Innovation & Entrepreneurship Center
NREL

NREL | Innovation & Entrepreneurship Center



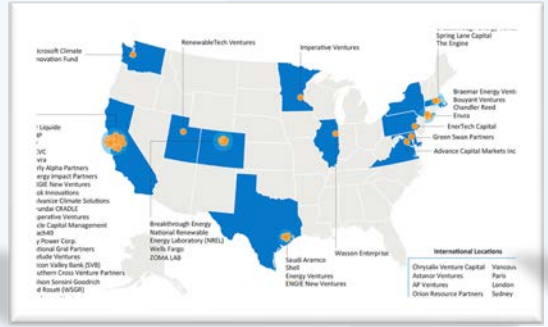
Without Startups, Innovation Stalls

Startups



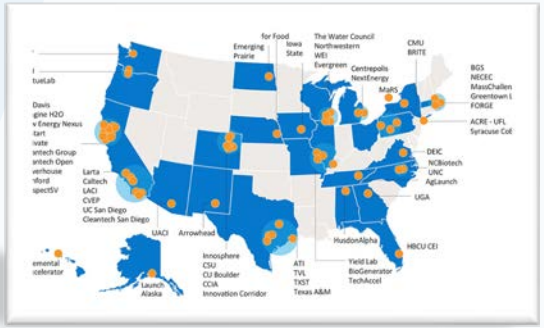
- 107 IEC portfolio companies
- 385 unique applicants to IGF (last 2 years)
- 1100 startups receive our monthly bulletin

Investors



- 51 investor board members
- 300 investors in our broader network

Channel Partners



64 Channel Partners

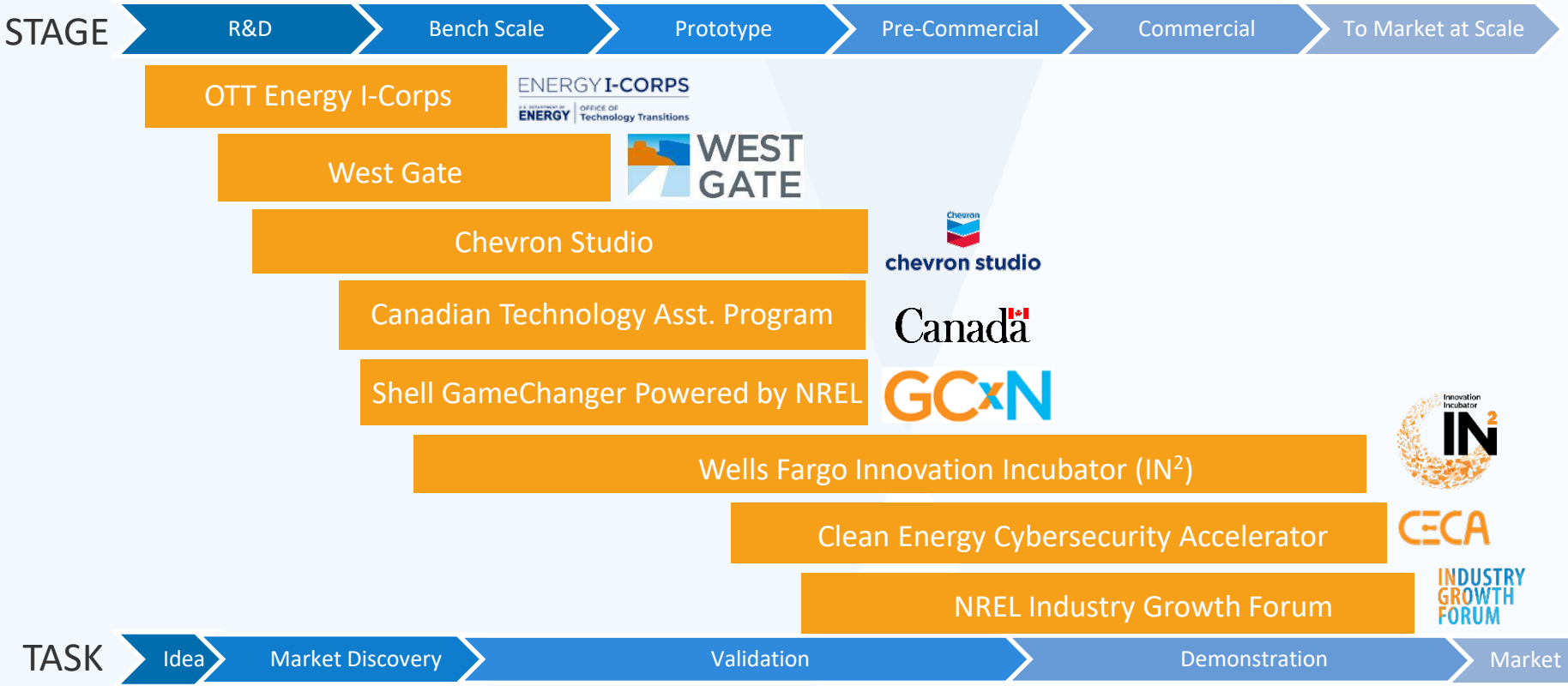
- 30 university programs
- 34 incubators/accelerators
- Represent 6000+ startups

27 University/TTO partners


CAMP
Cleantech
NREL | Innovation & Entrepreneurship Center


NREL
INDUSTRY GROWTH FORUM
WHERE INVESTMENT MEETS INNOVATION
COTTONWOOD TECHNOLOGY FUND
CONGRUENT VENTURES

Accelerating Tech to Market with Tech Incubation Programs



Capabilities for Addressing Innovation Barriers

New Company Formation

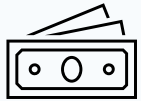
- Mining of IP
- Developing entrepreneurs

Technology Assistance

- De-risk for investment
- Validate tech

Demonstration/Test

- M&V on field testing
- Commercial pilot design support



Investment

- Match making startups with investment
- Early look at early-stage tech

Ag Technology Incubator

- Startups referred to program by our network of partners
- Downselection process involves scientists then industry board
- Startups receive $250,000 in technical assistance

Innovation Incubator IN2

WELLS FARGO | NREL

Types of AgTech Companies in IN^2

Mechanical technologies and services that help with labor, harvest, data collection, farm improvements

Biological technologies that make plants:

- More resistant to pests
- More resistant to disease
- Yield more fruit with same amount of resources

Biological technologies that deliver better products more effectively to plants

New crops with better or new products/ Carbon capture

- Big Ag (Bayer, Syngenta, Corteva, ..)
- Equipment manufacturers
- Suppliers

Ag Startups in IN^2 Program

Crop nutrition/enhancement
Agrospheres
Cytophage Technologies
Intinsyx Bio
Mobius
Plastomics

Crop protection
Aker
Impetus Ag
InnerPlant
Peptyde Bio
Pluton Biosciences
RNAissance Ag
Robigo

New Crops
CoverCress
New West Genetics
Terviva

Precision Ag
EarthSense
HabiTerre
Impossible Sensing
Sentinal Fertigation

Advanced Breeding Tech
Edison Agrosciences

Indoor Ag
Atlas Sensor Technologies
GrowFlux
Mirai Solar
SolGro

CoverCress

Innovation Incubator IN²

WELLS FARGO | NREL

CoverCress, Inc.

Through sophisticated breeding and gene editing, CoverCress converted a common winter annual weed, field pennycress, into a rotational cash crop that allows farmers to grow three crops in two seasons.

Company Stage: Commercial

Target Market: Row-crop agricultural producers

Fundraising Status: Acquired

Accomplishments During IN²

- Joined Cohort 5 in 2019 to investigate transient expression methods to shorten the flowering time in pennycress and improve the breeding process.
- Explored plant antimicrobial peptides to engineer robust and sustainable disease resistance to fungal pathogens.
- Overall, improved the value of CoverCress and the ease of cultivation by farmers.

Impact After IN²

- In 2022, Bayer Crop Science purchased all shares not held by Bunge or Chevron.
- Increases the probability of cover cropping adoption, which reduces erosion rates, increases soil health, and advances agricultural sustainability.
- Projected acreage is ~30 million acres in the U.S. Midwest.

Thank You

Innovation &
Entrepreneurship Center

Agricultural Decarbonization Policy and Economics Panel

Rachel Rose
Colorado Office of Economic Development and International Trade

Choose Colorado

OEDIT and JISEA-CSU Decarbonizing Agriculture

COLORADO
Office of Economic Development & International Trade
Global Business Development

COLORADO
Office of Economic Development & International Trade
Global Business Development

Background on OEDIT

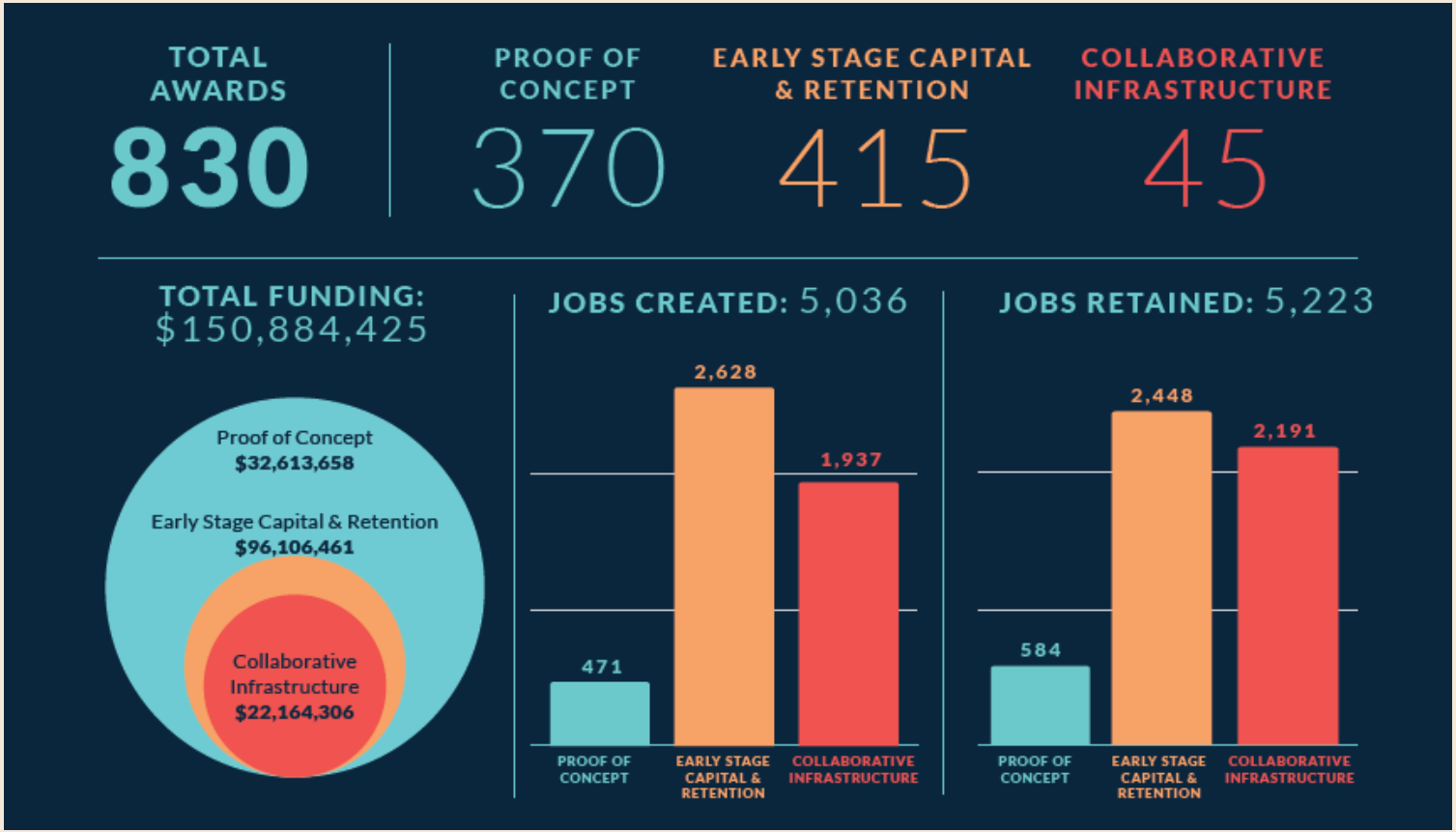
GLOBAL BUSINESS DEVELOPMENT

- The Global Business Development (GBD) division uses a **data-driven approach to recruit, support, and retain businesses** that contribute to a robust and diversified economy.
- GBD regularly **hosts foreign delegations and participates in trade and investment missions** around the world to strengthen global awareness of Colorado.
- GBD works across sectors to **promote development** of Colorado products, **increase Colorado exports, and increase the density** of Colorado's key industries.

COLORADO
Office of Economic Development & International Trade
Global Business Development

Advanced Industries Accelerator Program

IMPACT SINCE 2014



COLORADO
Office of Economic Development & International Trade
Global Business Development

AI Accelerator Program

COMPANY PROFILES

City: Fort Collins

Award Amount: $169,200

Description:
Advanced Environmental Technologies has developed a biogenic coal to fertilizer process that converts low-value, low-rank coal into a higher value and an environmentally and agriculturally beneficials soil amendment product.

City: La Junta

Award Amount: $200,00

Description:
Barn Owl Precision Agriculture develops smart farming technologies, including renewable-energy powered autonomous tractor fleets for weeding and in-field stationary monitoring units to measure soil moisture and plant health.

City: Fort Collins

Award Amount: $97,662

Description:
E-Flux has developed a passive soil gas trap to evaluate the greenhouse gas footprint of agriculture operations, specializing in measuring petroleum biodegradation rates in soil.

City: Boulder

Award Amount: $250,000

Description:
Rooted Robotics has developed a low-cost, fully automated vertical farm for sustainable food production, focusing on hydroponic and greenhouse microgreens, baby greens, and whole head lettuce.

Workshop Conclusion: Next Steps

Blog Post

- Themes/highlights of the workshop
- Types of attendees

Summary Report

Identified research priorities

Online Forum

- Networking
- Partnership Development
- Funding Opportunities
- Webinars/Publications

Journal Article

Co-benefits and tradeoffs of agricultural decarbonization solutions

What else? Quarterly meetings? Informal happy hours?

Thank you!

Presenters, Panelists, and Moderators:

- Liz Doris
- Brittany Staie
- Cathy Stewart
- Jordan Macknick
- Jordan Lambert
- Sherry Stout
- Josie Hart
- Austin Kinzer
- Melissa Brandao
- Steve Decker
- Mark Guttridge
- Eric Gibson
- Alan Rudolph
- Kristin Wegner Guilfoyle
- Jordan Beezley
- Rachel Rose
- Nathan Mueller
- Trish Cozart

Sponsor:

Attendees and Participants

JISEA Catalyzer Team:

- Azine Askarinya
- Daniella Frank
- Kristin Wegner Guilfoyle
- Denise Barber
- Nicole Simoes
- Liz Doris
- Brittany Staie
- Jared Temanson
- Jordan Macknick
- James McCall
- Darlene Steward

NREL Team:

- Thomas Hickey
- Chong Seok Choi

CSU Team:

- Jordan Lambert
- Rachel Sears
- Izzie Butler
- Jennifer Bousselot
- Jake Holley

JISEA Joint Institute for Strategic Energy Analysis

NREL Transforming ENERGY

AG INNOVATION CENTER COLORADO STATE UNIVERSITY

NREL/PR-6A50-91999