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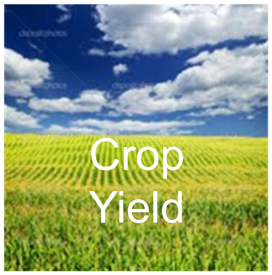
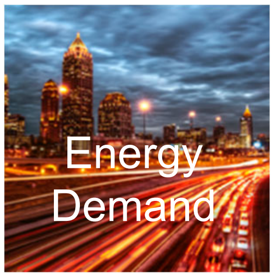
New Technologies to Monitor Nitrogen On Farms

David Lee
Booz Allen Hamilton
Support Contract to Advanced Research Projects Agency - Energy

What Problems are ARPA-E Trying to Solve with Ag/Bio?





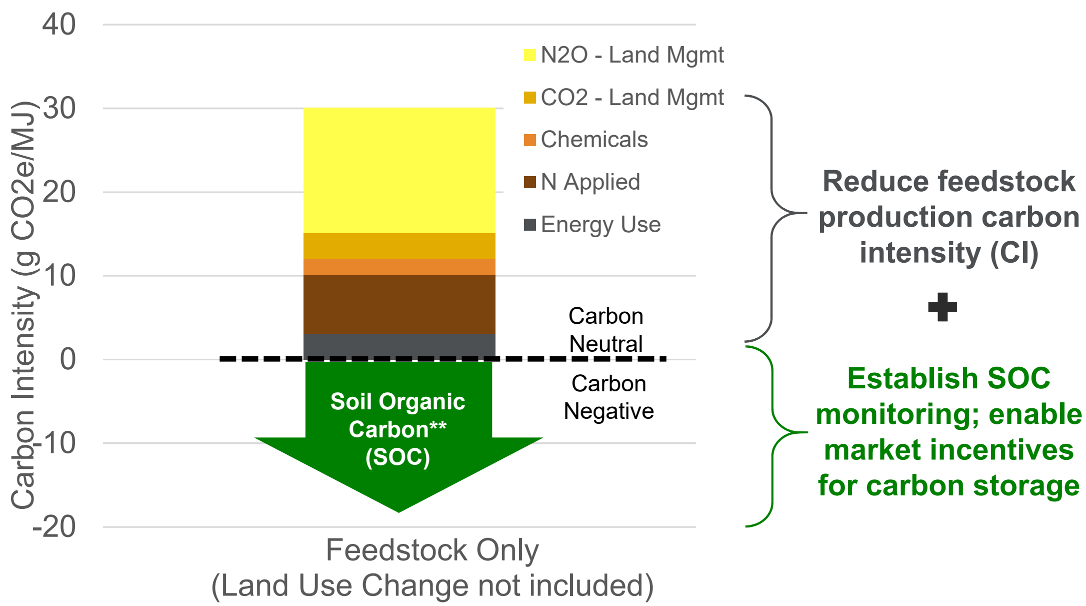
Demand Doubles	2^{o} C	9.9 GtC	70% $H_2$0	120 GtC

- ARPA-E's TERRA and ROOTS programs are deploying phenotyping sensors and platforms to better enable the development of enhanced crops.

- ARPA-E's SMARTFARM program will quantify the baseline of GHG fluxes in agricultural environments, and develop novel tools to determine carbon intensity of crop production.

Set a baseline and track progress toward ***carbon-negative feedstock production***

Positive emissions in the form of nitrogen loss as N_2O, and potentially negative emissions in the form of soil organic carbon (SOC), are the two primary drivers of a feedstock's Carbon Intensity (CI)



***SOC not currently counted in CI*

Argonne Final Report to ARPA-E (2019): *Developing a Framework for Lifecycle Analysis of Biofuels on the Farm Level*

Evaluating Roots & Soils – “The Hidden Half”

New Tools Are Needed!

A phased approach to enable upstream carbon optimization incentives

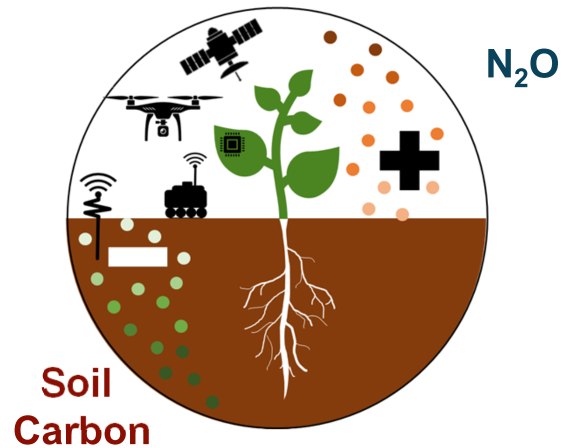
1. Set a Baseline to Validate

- **Establish ground truth in real-world conditions**
- **Pilot market mechanisms**
- **Higher cost, higher resolution**

A phased approach to quantify SOC and nitrogen fluxes in agricultural environments, and establish upstream carbon optimization incentives.

Phase I kicked off in April, 2020, and Phase II projects were selected in in August, 2020.

2. Develop New Methods



- **Directly measure N & C flux**
- **Increase reliability, resilience**
- **Reduce cost and footprint**
- **Incorporate IoT hardware**

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Planned Phase I Sites

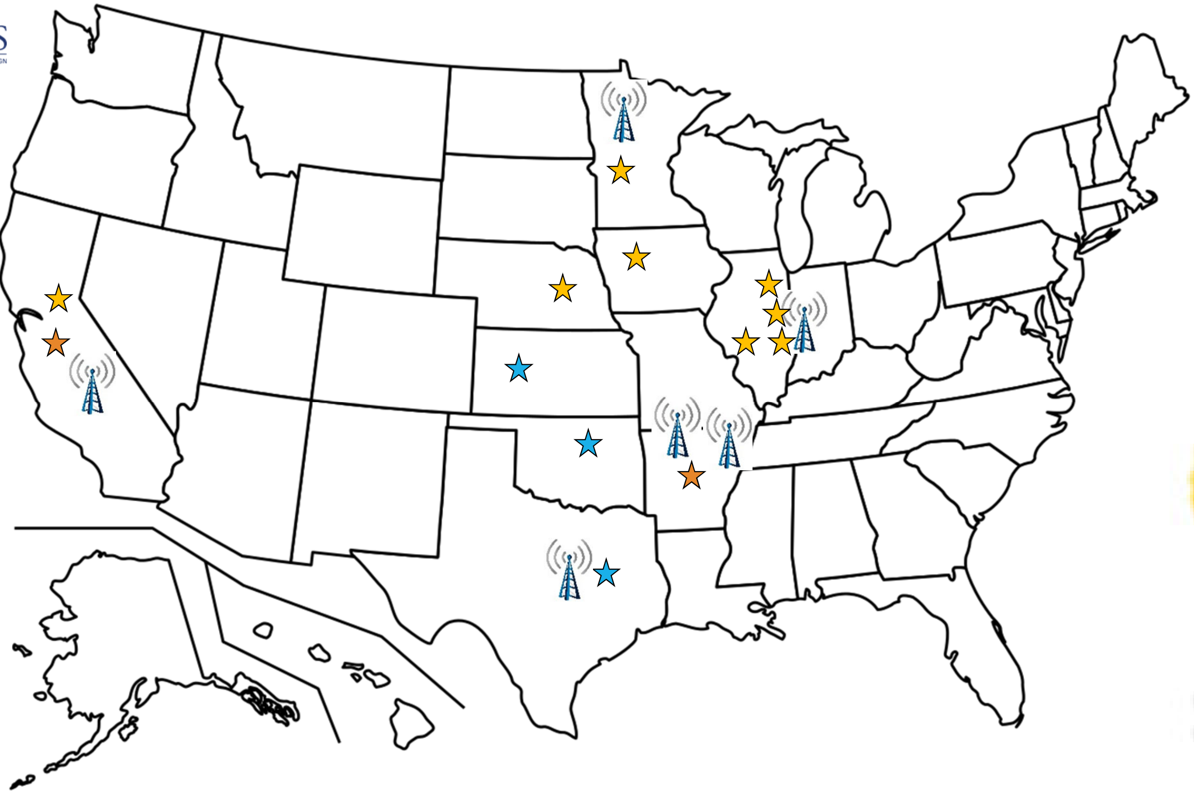
ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

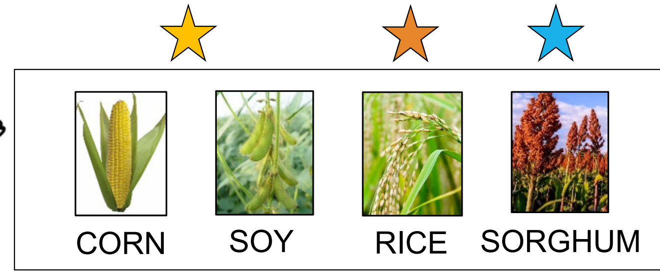
UNIVERSITY of NEBRASKA LINCOLN

OKLAHOMA STATE UNIVERSITY

ARVA INTELLIGENCE

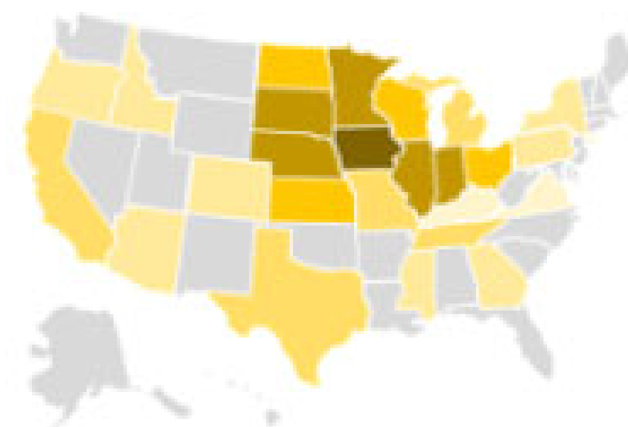
BERKELEY LAB
Lawrence Berkeley National Laboratory





Eddy Covariance tower in place

State Ethanol Production



https://www.eia.gov/todayinenergy/detail.php?id=36892

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Rice n' Grits: SMARTFARM Bioenergy Validation Sites

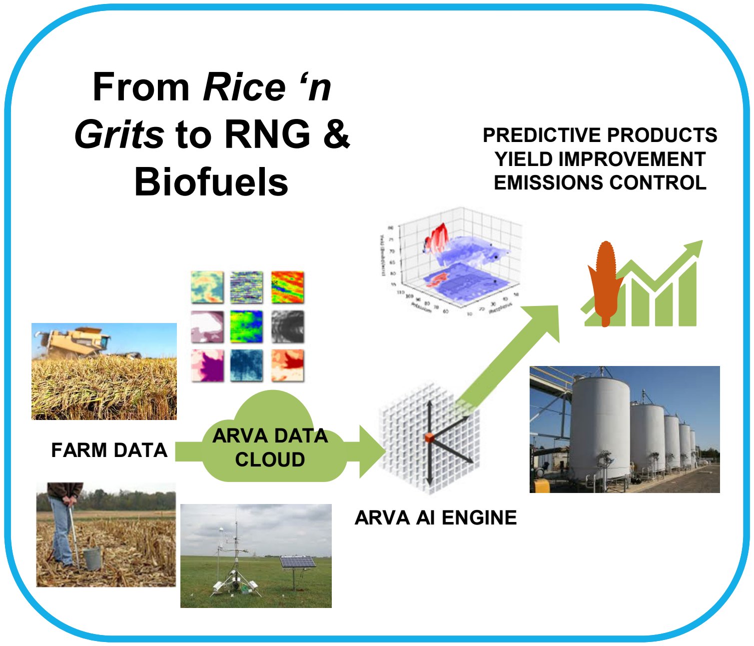
Technology Summary

- *Grid-independent EC Tower combined with microbiome, soil, plant and carbon/nitrogen flux*
- *Crop & crop residue substrates with biofuel fertilizer recycling, tuned to actual demand*
- *AI platform optimizing yield and revenue for carbon negativity and nitrogen emissions*

Technology Impact

Enables crop residue value maximization through novel LCFS pathways, replacing transportation fuel demand with sustainable biofuels, while creating carbon sinks, minimizing fertilizer input, reducing ag emissions

Arva Intelligence Corp.



Proposed Targets
% C, N flux captured
% Variance of C, N flux explained
Reduction in N, P, K fertilizer
Reduction in Emissions
Soil Carbon Sequestration

RT Atmosphere-Soil C-N-PKS Accounting Enables Energy Crop Carbon Sink

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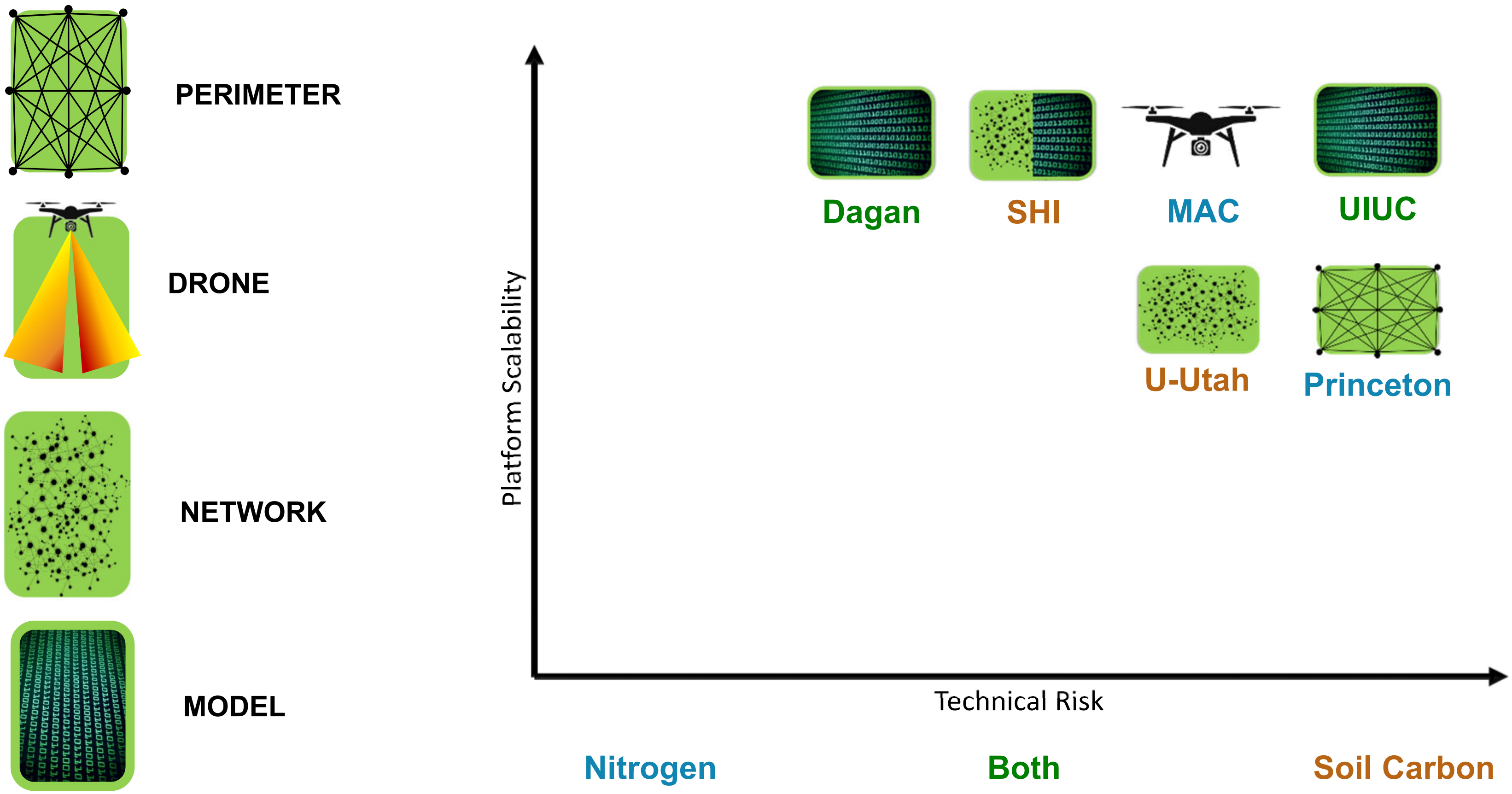
SMARTFARM Phase 2 Selections: $17.5M



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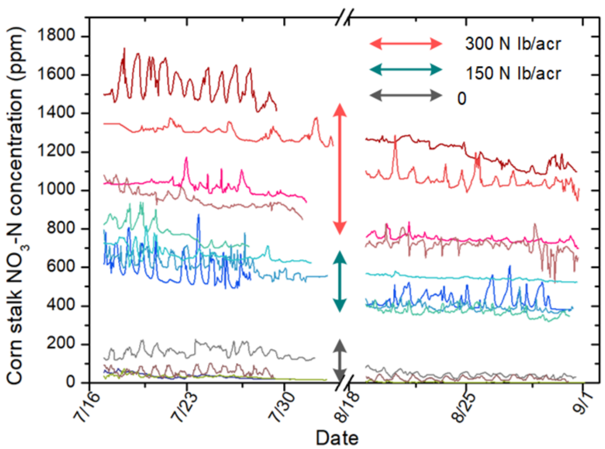
https://arpa-e.energy.gov/document/smartfarm-project-selections

In Field Nitrogen Monitoring (microneedles)

Continual Nitrogen Detection in Plants and Soil

Table 1: Comparison between EnGeniousAg (EGA) sensors and state-of-the-art commercial sensors

	Horiba Ion-Selective Sensor	Hach UV Absorption	Colorimetric Nitrate Strip	EGA Sensor
Direct measurement without sampling	No	No	No	Yes
Dynamic range NO_3-N (ppm)	23–2200	0.1-50	10-50	1-5000
In situ continuous?	No	No	No	Yes
Measurement accuracy % of reading	±10%	±10%	±25%	±8%
Major non-target ion interferences (SO_4^{2-}, Cl^-, K^+, PO_4^{3-}) (% of reading value)	Severe (> ±25%)	No	N/A	±10%
Response time	2 min	15 sec	20 sec	2 sec



The ISU ARPA-E ROOTS team demonstrated continual plant nitrate measurements with the nitrate sensors in maize fields, in Ames, IA during 2019 and 2020. It also has the capacity to measure levels in soil and groundwater.

The sensor allows growers to optimize nitrogen application rates, or breeders to identify crop varieties with improved nitrogen use efficiency.

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Please share your thoughts:

David Babson	David Lee
ARPA-E Program Director	ARPA-E Technical SETA
David.Babson@hq.doe.gov	David.Lee2@hq.doe.gov

Thanks!