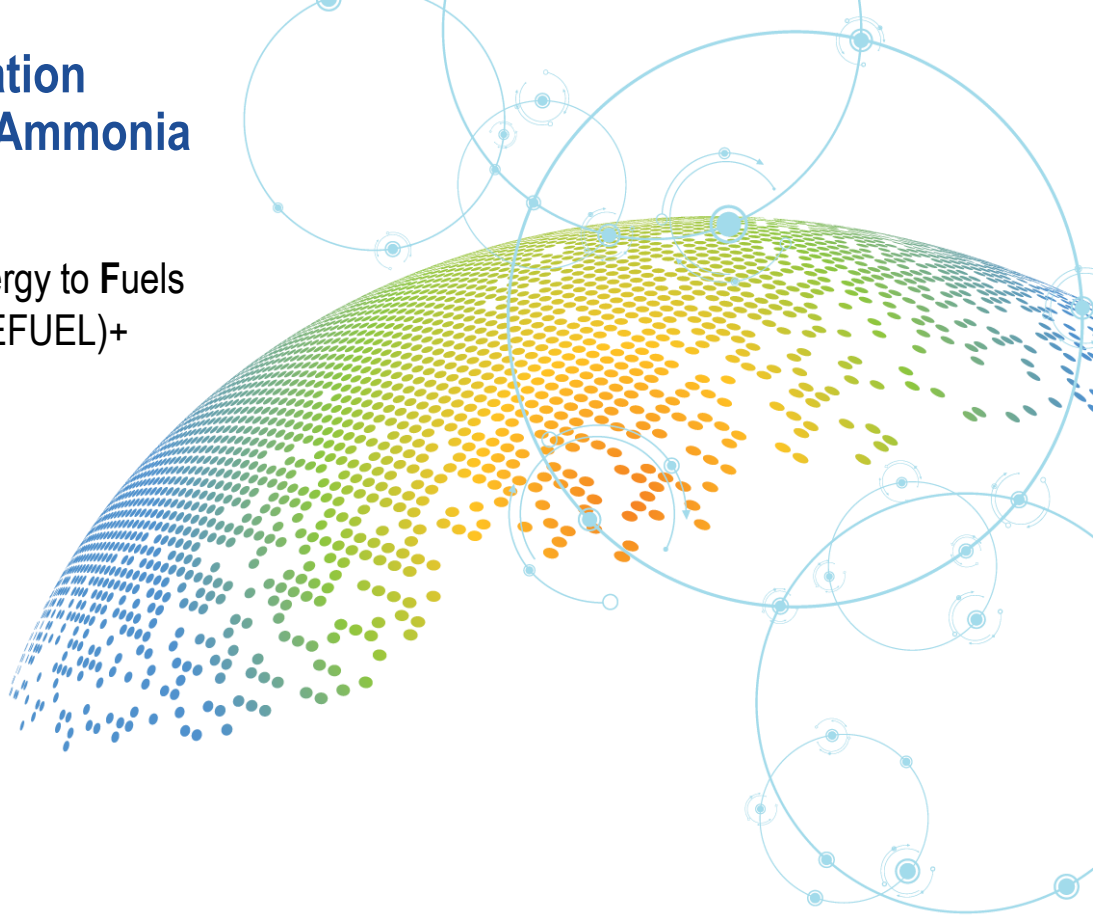
Next Generation Technology Integration Platform for Low- and Zero-Carbon Ammonia Production and Utilization

Funded by U.S. DOE ARPA-E's **R**enewable **E**nergy to **F**uels Through **U**tilization of **E**nergy-Dense **L**iquids (REFUEL)+ Integration Testing (REFUEL+IT) Program*

Sameer Parvathikar, Ph.D.
Technology Advancement & Commercialization (TAC)



RTI INTERNATIONAL

*Contracts under negotiation

RTI is an independent, nonprofit institute that provides research, development, and technical services to government and commercial clients worldwide.

Our mission is to improve the human condition by turning knowledge into practice.

$912M
Revenue

3,990
Projects

1,219
Clients

5,881 Staff Members
Worldwide

90
Languages

250
Degree Fields

94
Nationalities

12
U.S. Offices

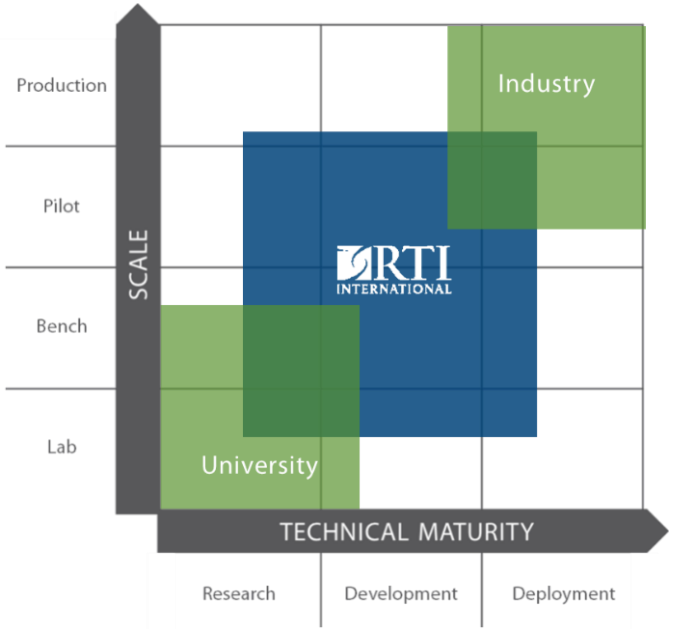
12
International Offices

Areas of Research

- Energy Research
- Environmental Sciences
- Social Policy
- Health
- Food Security and Agriculture
- International Development
- Education & Workforce Development

Technology Advancement and Commercialization Center

Gas Conversions	**Gas Separations**
Carbon Capture & Utilization	**Biomass Conversion**
Industrial Water Treatment	**Advanced Materials**

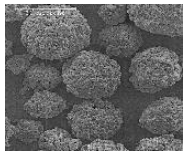


New Technology Development Timeline for Green NH_3

2015-2016

RTI INTERNATIONAL B&P/IR&D

Proof-of-Concept/Feasibility



TRL 0

2017-2020

arpa·e REFUEL RTI INTERNATIONAL CASALE

Small-scale System Development

TRL 4

2021-2024

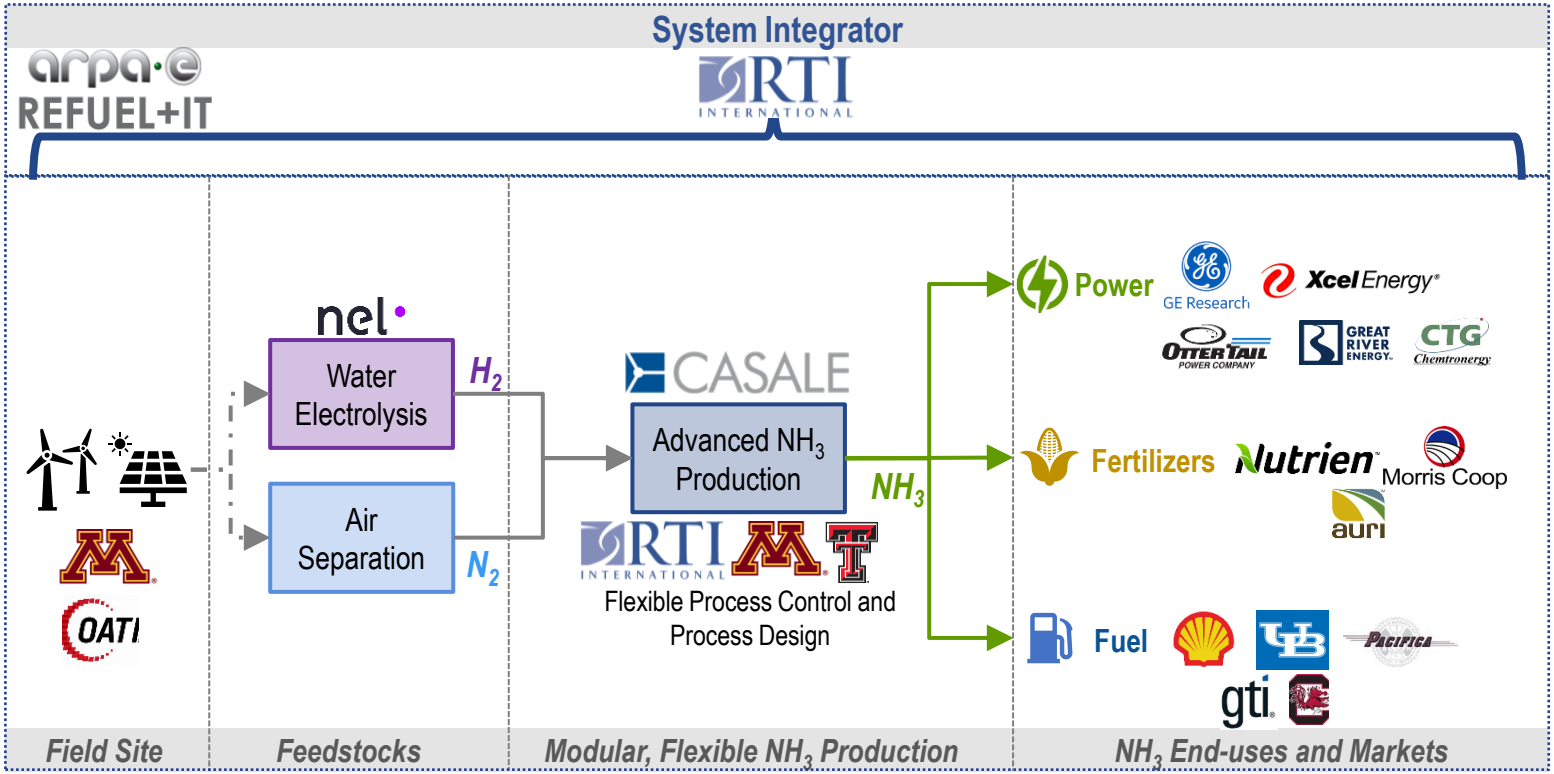
arpa·e REFUEL+IT RTI INTERNATIONAL

Leading a large team

1 MTPD Pilot-scale Real-world Demonstration

TRL 7+

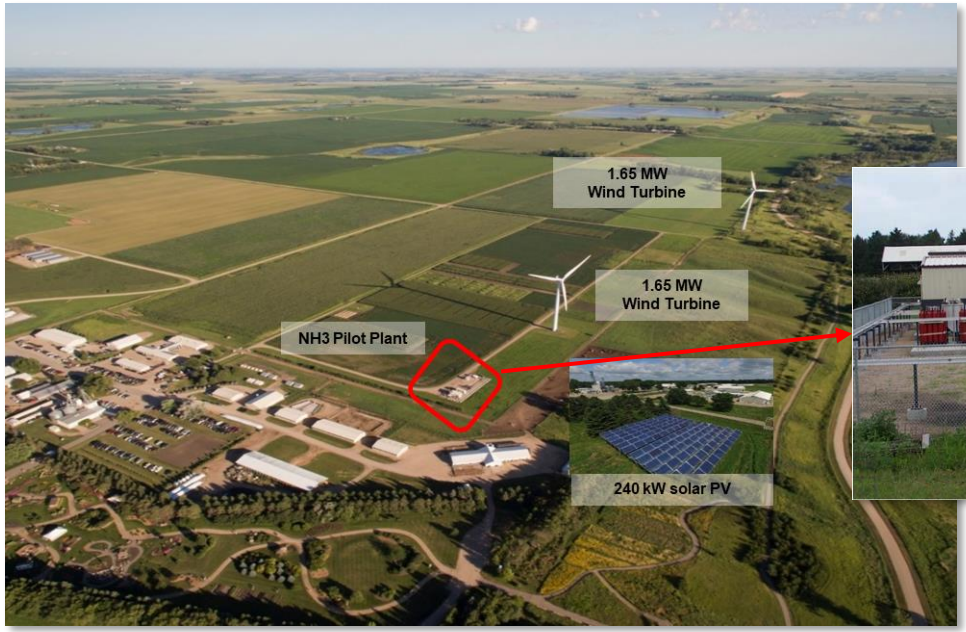
RTI is leading a uniquely qualified team



Contracts under negotiation

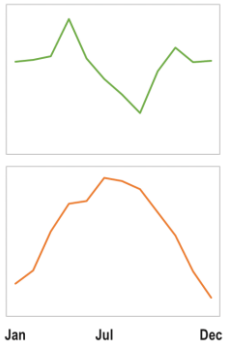
Next-gen NH_3 production and utilization technologies | **Demonstrate under real-world conditions** | **Connect with end-users and markets to accelerate commercialization**

Field Site at the University of Minnesota, Morris, MN



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

Upgrading to a next-gen NH_3 production facility

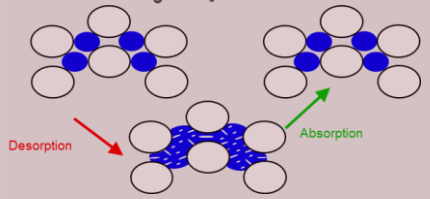


N_2+H_2

NH_3 Synthesis

Patented catalysts for low temperature/pressure operation

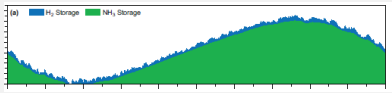
NH_3 Separation



Novel patented sorbents for elevated temperature NH_3 separation

NH_3

NH_3 Production Process Control



Patented process control for flexible production to match LMP (and VRE) fluctuations

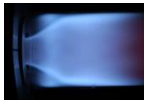
CASALE RTI INTERNATIONAL

Next-gen synthesis, separation, and process control technologies for low-cost production

What are we doing with the Ammonia?

Power

How do we retrofit a gas turbine to burn NH_3?



GE Research

Demonstrate a direct NH_3 fuel cell

CTG Chemtronergy

Fuel

Develop and operate a NH_3-powered forklift

gti.

Pacifica

Fertilizers

Off-take agreement with local fertilizer co-op

Morris Coop

Demonstrating the full value chain of low- and zero-carbon Ammonia

Additional elements to aid commercialization

Carbon Intensity

Technoeconomic Analysis

T2M Advisory

We continue to add more…

Key Takeaways

1. First-of-a-kind pilot-scale testbed for new technologies
2. Offer testing environments in realistic operating conditions
3. TEA and CI platforms to build commercial and policy opportunities
4. Industry-led advisory board to accelerate go-to-market

We welcome new technology developers and end-users!

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