ENERGY I-CORPS

U.S. Department Of Energy

Biannual Report
January 2019

Energy I-Corps is a two-month program that trains national lab researchers in evaluating industry needs and potential market applications for their technologies.

Managed by the National Renewable Energy Laboratory

"Energy I-Corps showed me how I can maximize the benefit of my basic research at Argonne to create technology that has real-world commercial impacts for Americans. That's a very rewarding feeling."

Dr. Ralph Muehleisen
Cohort 1 Grad

"I started my first company with a technology from a national lab...If the program had been around when I started my company, I'm sure I would have saved about two and a half years."

Peter Fiske
Cohort 3 Instructor

Discovering Market Pathways for National Lab Research

About Energy I-Corps

The U.S. Department of Energy (DOE) invests millions of dollars every year in U.S. national labs, but without industry engagement and a business mindset at the labs, that investment has limited economic return. Energy I-Corps pairs teams of researchers with industry mentors for an intensive two-month training in which the researchers define technology value propositions, conduct customer discovery interviews, and develop viable market pathways for their technologies. Researchers return to the lab with a framework for industry engagement to guide future research and inform a culture of market awareness within the labs. In this way, Energy I-Corps is ensuring our investment in the national labs is maintaining and strengthening U.S. competitiveness long-term.

More Information

Energy I-Corps, formerly known as Lab-Corps, is managed by DOE's National Renewable Energy Laboratory (NREL). NREL leads curriculum development and execution, recruits program instructors and industry mentors, and assembles teams from the 17 national labs. To date, teams have come from:

Argonne National Laboratory
Fermi National Accelerator Laboratory
Idaho National Laboratory
Lawrence Berkeley National Laboratory
Lawrence Livermore National Laboratory
Los Alamos National Laboratory
National Renewable Energy Laboratory
Oak Ridge National Laboratory
Pacific Northwest National Laboratory
Sandia National Laboratories
SLAC National Accelerator Laboratory

For each class of Energy I-Corps teams, national labs recruit researchers working on energy technologies that have shown potential for commercial application. Together, these researchers receive comprehensive training and conduct at least 75 customer discovery interviews with industry leaders over the course of the program. Once researchers complete the Energy I-Corps program, they have secured the necessary industry connections and insights to ready their energy technologies for the market, and gained an industry engagement framework to apply to future research and share with fellow researchers.

Curriculum

The Energy I-Corps curriculum was initially developed in 2015 in partnership with the National Science Foundation's (NSF's) Innovation Corps (I-Corps) program. With the support of the national labs and external industry advisors, NREL and DOE's Office of Technology Transitions (OTT) adapted NSF's nationally recognized I-Corps training.

Adjustments made to the I-Corps curriculum address the specific challenges scientists working within the national lab environment face when getting their innovations ready for market, such as navigating the complexities of bundling intellectual property. As more research teams complete the training, NREL and OTT continue to improve and enhance the Energy I-Corps curriculum to best meet participant and industry needs.

Energy I-Corps FAQs

What is Energy I-Corps?
Energy I-Corps is a two-month training where national lab researchers learn about industry needs and evaluate potential market applications for their technologies.

How many teams have gone through the program?
As of January 2019, 89 teams from 11 National Labs have participated in Energy I-Corps over the course of eight training sessions.

What are the benefits?
Participants benefit from workshops taught by industry experts, as well as 75+ customer discovery interviews they conduct over the duration of the program. The training equips national lab researchers with tools to understand the real-world relevance of their technologies and viable pathways to market. These tools help inform future research at the national labs.

Who can participate?
DOE national lab researchers working on eligible technologies can apply. Eligibility requirements may vary by class depending on participating DOE offices, but past areas of interest include a range of renewable and energy efficient technologies, in addition to nuclear, fossil, and environmental management.
Energy I-Corps is also looking for program instructors and industry mentors.

How can I learn more?
Email energyicorps@NREL.gov to learn more about Energy I-Corps and how to get involved. If you are interested in becoming an instructor or mentor, contact Kristin Clary at kristin.clary@nrel.gov.

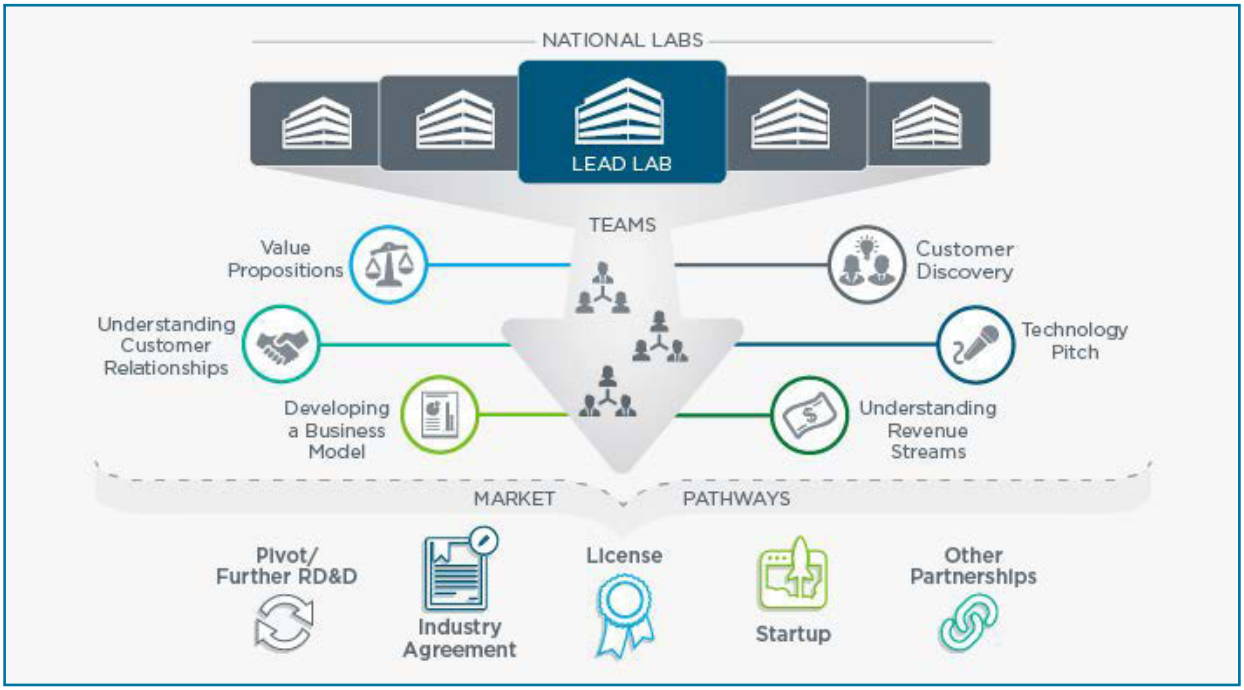
Tech Office Support
Every EERE technology office has supported teams through the training. Participation has also expanded to include lab teams supported by DOE's Fossil Energy, Nuclear Energy, and Environmental Management offices.

Energy I-Corps technologies have reached a point of commercial viability that has attracted more than $20 million in follow-on funding.

Teams from the fourth class analyze market pathways for their early stage technologies. This is just one of many hands-on activities Energy I-Corps participants complete with support from industry mentors and instructors from the clean energy sector.

As of the end of the eighth training session in fall 2018, teams have collectively worked with more than 90 industry mentors to discover the commercial impact of their technologies and have conducted more than 6,000 customer discovery interviews with industry.

Program Structure



Energy I-Corps consists of four key elements:

Node: The National Renewable Energy Laboratory (NREL) serves as the node for this program. The node is responsible for developing and delivering the curriculum, as well as providing program guidance to participating labs. The node hosts both the opening and closing sessions, which involve in person instruction and presentations.

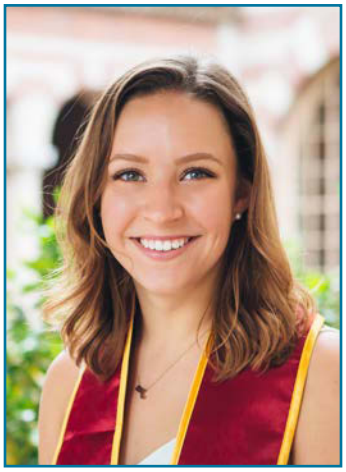
Participating Labs (aka Sites): DOE's Energy I-Corps sites recruit, assemble, and send teams to the node for training, as well as support teams both during and after the program. Support might include assistance in identifying entrepreneurial leads and industry mentors, as well as technology transfer/ technology deployment support for commercialization plans identified by the team during training. Each site collects metrics during and after their team(s) complete the program and distributes them quarterly to the node. These metrics are critical to assessing and improving the program.

Teams: Applicants apply to DOE's Energy I-Corps as a team, composed of a principal investigator with a commercially relevant technology, an entrepreneurial lead, and an industry mentor. Over the course of the training, teams identify potential commercialization pathways for their selected technology, as well as identify opportunities where further development could lead to commercial value.

Training Program: The training program spans seven weeks utilizing a custom-designed curriculum built on the Lean LaunchPad methodology. During these seven weeks, teams attend in-person sessions, participate in weekly webinars, and learn from faculty how to systematically identify the most appropriate market applications and commercialization pathways for their technologies. Participation also requires a considerable amount of time spent outside of the classroom conducting customer discovery interviews.

Our Team

Kristin Clary
Program Manager,
NREL



Megan Gross
Program Coordinator and
Teaching Assistant, NREL

Shelly Curtiss
Director, Colorado Cleantech
Industries Association

Technology Program Office

Energy I-Corps teams are funded by individual technology program offices. Labs also have the opportunity to fund teams or find industry partners to fund teams.

Advanced Manufacturing

Team	Lab	Cohort	Discovery Interviews
BASIC	NREL	5	80
Comba	LBNL	7	79
Electroplate	INL	5	56
E-RECOV	INL	4	57
Fermians	FNAL	3	48
FLO.materials	LBNL	7	78
HyMag ($37.5k) (.5)	ANL	8	107
Laser Sense	ANL	7	74
Micro Miners (.5)	LLNL	2	59
NanoHeatBlock	ANL	2	83
Re-Light	INL	5	75
Saline Solutions	LLNL	2	50
CAN-Coatings	ANL	8	72

TOTAL TEAMS FUNDED
12

INVESTMENT TOTAL
$900,000

FOLLOW-ON FUNDING
$5,665,515

DISCOVERY INTERVIEWS
918

Bioenergy

Team	Lab	Cohort	Discovery Interviews
CuB Fuels	NREL	5	98
Electro-Active ($37.5k)	ORNL	7	80
FiberSAS	ANL	3	76
FUSS: Fuels Synthesized from Sugars	LANL	4	71
GLYCOPLASTICS	NREL	5	48
High-Moisture Pelleting Process	INL	2	86
Nitrilica	NREL	5	77
Optiblend	INL	4	74
WasteNot	ANL	3	70
Fermley	LBNL	8	81
Ecopod	LBNL	8	77

TOTAL TEAMS FUNDED
10.5

INVESTMENT TOTAL
$787,500

DISCOVERY INTERVIEWS
868

Buildings

Team	Lab	Cohort	Discovery Interviews
BEYOND FAULT DETECTION	NREL	5	76
GreenBlox	NREL	6	74
MAIforBldgs	ORNL	3	74
SwitchGlaze ($37.5k)	NREL	3	54
Thermoelectric Dryer	ORNL	4	45
VOLTTRON	PNNL	2	5

TOTAL TEAMS FUNDED
5.5

INVESTMENT TOTAL
$412,500

FOLLOW-ON FUNDING
$750,000

DISCOVERY INTERVIEWS
329

Environmental Management

Team	Lab	Cohort	Discovery Interviews
Gamma Rayality	LBNL	6	77
PureBeam	FNAL	7	78

TOTAL TEAMS FUNDED
2

INVESTMENT TOTAL
$150,000

DISCOVERY INTERVIEWS
155

Fuel Cells

Team	Lab	Cohort	Discovery Interviews
CryoH2	LLNL	4	56
Electro-Active ($37.5k)	ORNL	7	80
Polymer Membranes	SNL	2	41

TOTAL TEAMS FUNDED
2.5

INVESTMENT TOTAL
$187,500

FOLLOW-ON FUNDING
$50,000

DISCOVERY INTERVIEWS
160

Fossil Energy

Team	Lab	Cohort	Discovery Interviews
CO2BOL	PNNL	5	75
MECS	LLNL	4	64

TOTAL TEAMS FUNDED
2

INVESTMENT TOTAL
$150,000

FOLLOW-ON FUNDING
$630,000

DISCOVERY INTERVIEWS
139

Geothermal

Team	Lab	Cohort	Discovery Interviews
GeoCAES	NREL	4	51
Micro Miners (.5)	LLNL	3	59
Sandia Technology Systems	SNL	4	40
TOUGH	LBNL	2	54

TOTAL TEAMS FUNDED
3.5

INVESTMENT TOTAL
$262,500

FOLLOW-ON FUNDING
$600,000

DISCOVERY INTERVIEWS
204

Nuclear

Team	Lab	Cohort	Discovery Interviews
4Cs	INL	6	38
AMAFT	INL	5	76
AxiVis	INL	7	90
Change Detection Systems	INL	4	71
Dry Cask Vital Signs	INL	4	51
ELINA	INL	6	102
EMRLD	INL	5	76
HOT	INL	7	75
Monolith	SNL	3	37
Quake	INL	2	35
M2LD - Mobile Modified Linear Delta	INL	8	116

INVESTMENT TOTAL
$825,000

FOLLOW-ON FUNDING
$3,646,000

TOTAL TEAMS FUNDED
11

DISCOVERY INTERVIEWS
767

Office of Electricity

Team	Lab	Cohort	Discovery Interviews
DCAT	PNNL	6	75
Glass Paper	INL	8	75
EnergyBlox	SLAC	8	27

DISCOVERY INTERVIEWS
177

INVESTMENT TOTAL
$225,000

TOTAL TEAMS FUNDED
3

Solar

Team	Lab	Cohort	Discovery Interviews
Halo	NREL	6	83
Hydro Scanner	LLNL	8	44
SolGuard ($30k)	NREL	8	51

DISCOVERY INTERVIEWS
178

INVESTMENT TOTAL
$180,000

TOTAL TEAMS FUNDED
2.5

"I've spent 29 years in the lab, and I thought I was close to industry. I learned more in the last eight weeks than in those 29 years."

Vehicles

Team	Lab	Cohort	Discovery Interviews
Beyond Lithium Ion Batteries	ANL	7	82
Cellsage	INL	4	44
FAST	PNNL	6	91
Lubricant Engineers	PNNL	4	75
MICROWATTS	NREL	5	75
Smart Charge Adapter	ANL	2	71
routeE	NREL	8	80
BonD-Northwest: Bonding on Demand	PNNL	8	93

INVESTMENT TOTAL
$582,000

FOLLOW-ON FUNDING
$665,349

TOTAL TEAMS FUNDED
8

DISCOVERY INTERVIEWS
611

Wind & Water

Team	Lab	Cohort	Discovery Interviews
Autonomous Concrete Printing	NREL	4	79
DLR	INL	3	72
HyMag ($37.5k)	ANL	8	107
RF Tag	PNNL	4	75
SpiderFloat	NREL	8	77
WindSOCK	NREL	5	75

INVESTMENT TOTAL
$412,500

FOLLOW-ON FUNDING
$600,000

TOTAL TEAMS FUNDED
5.5

DISCOVERY INTERVIEWS
485

"As a former national lab scientist who launched a startup with my lab technology, I could have benefited so much from Energy I-Corps. The tools the program provides have such enormous practical application. Seeing that was one of the reasons I wanted to become an instructor and mentor to these scientists and engineers."

Lab Funded

Team	Lab	Cohort	Discovery Interviews
BioAlchemy	LBNL	2	51
Biolyst Renewables	NREL	2	81
CI-ReClad	ORNL	1	75
Dynamic Aperture	ANL	1	23
Eco-AC	NREL	1	45
Evodia	LBNL	2	45
HYDRA	PNNL	1	40
Oleo Sponge	ANL	6	62
Resin Wafer Electrodeionization	ANL	2	75
SolGuard ($45k)	NREL	2	51
Sub Lambda	PNNL	1	13
SwitchGlaze ($37.5k)	NREL	3	54
Tunation	ORNL	1	86
WISDEM	NREL	1	80

TOTAL TEAMS FUNDED
13

INVESTMENT TOTAL
$982,500

FOLLOW-ON FUNDING
$3,677,000

DISCOVERY INTERVIEWS
781

Pilot

Team	Lab	Cohort	Discovery Interviews
ARAI	INL	1	96
C-Best	LLNL	1	13
Co-Culture Green	PNNL	1	34
Frequency Sensing Load Controller	ANL	0	75
My Green Car	LBNL	0	75
Ring Burner	LBNL	1	71
SonicLQ	ANL	1	11
STARS	PNNL	1	78
Switchable Polarity Solvents	INL	1	78
TwistAct	SNL	0	75

TOTAL TEAMS FUNDED
10

INVESTMENT TOTAL
$750,000

FOLLOW-ON FUNDING
$5,760,000

DISCOVERY INTERVIEWS
606

Privately Funded

Team	Lab	Cohort	Discovery Interviews
Opt-grid	NREL	6	87

TOTAL TEAMS FUNDED
1

INVESTMENT TOTAL
$75,000

FOLLOW-ON FUNDING
$246,861

DISCOVERY INTERVIEWS
87

"It has been a great opportunity to learn how to talk to customers, so you can get an early read on what the market really wants for your product."

Project Budget

Energy I-Corps teams are funded directly by a technology office, their laboratories, or privately funded by industry.

Technology Office Funding

Funding Technology Office	Investment	Follow-on Funding
AMO	$900,000	$5,665,515
BETO	$787,500	-
BTO	$412,500	$750,000
EM	$150,000	-
FCTO	$187,500	$50,000
FE	$150,000	$630,000
GTO	$262,500	$600,000
HTO	-	-
NE	$825,000	$3,646,000
OE	$225,000	-
SETO	$180,000	-
VTO	$582,000	$665,349
WWPTO	$412,500	$600,000
Total	**$5,074,500**	**$12,606,864**

INVESTMENT TOTAL

$6,882,000

FOLLOW-ON FUNDING

$22,290,725

	Investment	Follow-on Funding
Lab Funded	$982,500	$3,677,000
Pilot	$750,000	$5,760,000
Privately Funded	$75,000	$246,861
Total	**$1,807,500**	**$9,683,861**

Laboratory Statistics

Lab	Teams Funded	Investment by Tech Office	Post Program Funding Received	Customer Discovery Interviews
ANL	13	$975,000	$7,901,324	881
FNAL	2	$150,000	-	126
INL	20	$1,500,000	$6,376,000	1444
LANL	1	$75,000	-	71
LBNL	10	$750,000	$250,000	688
LLNL	6	$450,000	$2,829,040	286
NREL	19	$1,407,000	$2,880,361	1400
ORNL	5	$375,000	$4,000	360
PNNL	11	$825,000	$2,000,000	654
SNL	4	$300,000	$50,000	193
SLAC	1	$75,000	-	27
TOTAL	**92**	**$6,882,000**	**$22,290,725**	**6130**

Cohort Statistics

Cohort	Funding Received	Follow-on Funding	Customer Discovery Interviews
0	$225,000	$250,000	225
1	$1,050,000	$6,214,000	743
2	$1,050,000	$8,247,389	787
3	$600,000	$1,350,000	475
4	$1,125,000	$1,280,000	937
5	$900,000	$153,500	916
6	$600,000	$2,856,861	606
7	$600,000	$1,348,975	636
8	$732,000	-	805
TOTAL	**$6,882,000**	**$22,290,725**	**6130**

Project Budget

Energy I-Corps teams are funded directly by a technology office, their laboratories, or privately funded by industry.

Team Follow-on Funding

TEAM	Follow-on Funding Received	Funded Technology Office
4C's	$760,000	NE
AMAFT	$103,000	NE
ARIA	$161,000	Pilot
BaSiC	$17,500	AMO
Biolyst Renewables	$1,166,000	Lab Funded
Change Detection Systems	$650,000	NE
DLR	$600,000	WWPTO
Eco-AC	$200,000	Lab Funded
ELINA	$1,500,000	NE
EMRLD	$33,000	NE
HOT	$600,000	NE
Laser Sense	$748,975	AMO
MECS	$630,000	FE
Micro Miners	$1,200,000	AMO/GTO
My Green Car	$250,000	Pilot
NanoHeatBlock	$3,300,000	AMO
OLEO Sponge	$350,000	Lab Funded
Opt-Grid	$246,861	Private
Polymer Membranes	$50,000	FCTO
RWEDI	$1,457,000	Lab Funded
Saline Solutions	$999,040	AMO
Smart Charge Adapter	$665,349	VTO
Sonic LQ	$1,380,000	Pilot
STARS	$2,000,000	Pilot
SwitchGlaze	$750,000	BTO/Lab Funded
Switchable Polarity Solvents	$1,969,000	Pilot
Tunation	$4,000	Lab Funded
WISDEM	$500,000	Lab Funded
Total	**$22,290,725**	

8 cohorts completed as of Fall 2018

including 89 teams from 11 national labs

90+ industry mentors and instructors involved

Innovations have spanned 13 DOE program areas

Teams have conducted over 6,000 customer discovery interviews with companies like:

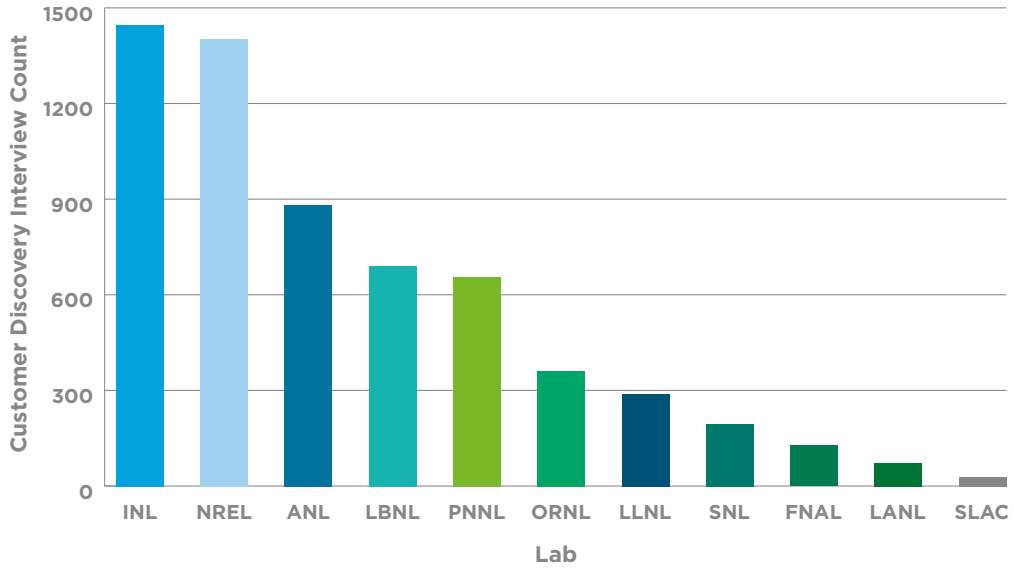
Hitachi, Lowes, Johns Manville, Lego, U.S. Army, Trane, Tesla, GM, Dow Chemical, Yingli, 3M, Whirlpool, GE, Home Depot, ReMax, and Amazon

Quick Stats

Energy I-Corps teams are funded directly by a technology office, their laboratories, or privately funded by industry.

Customer Discovery Interviews Conducted Through Energy I-Corps

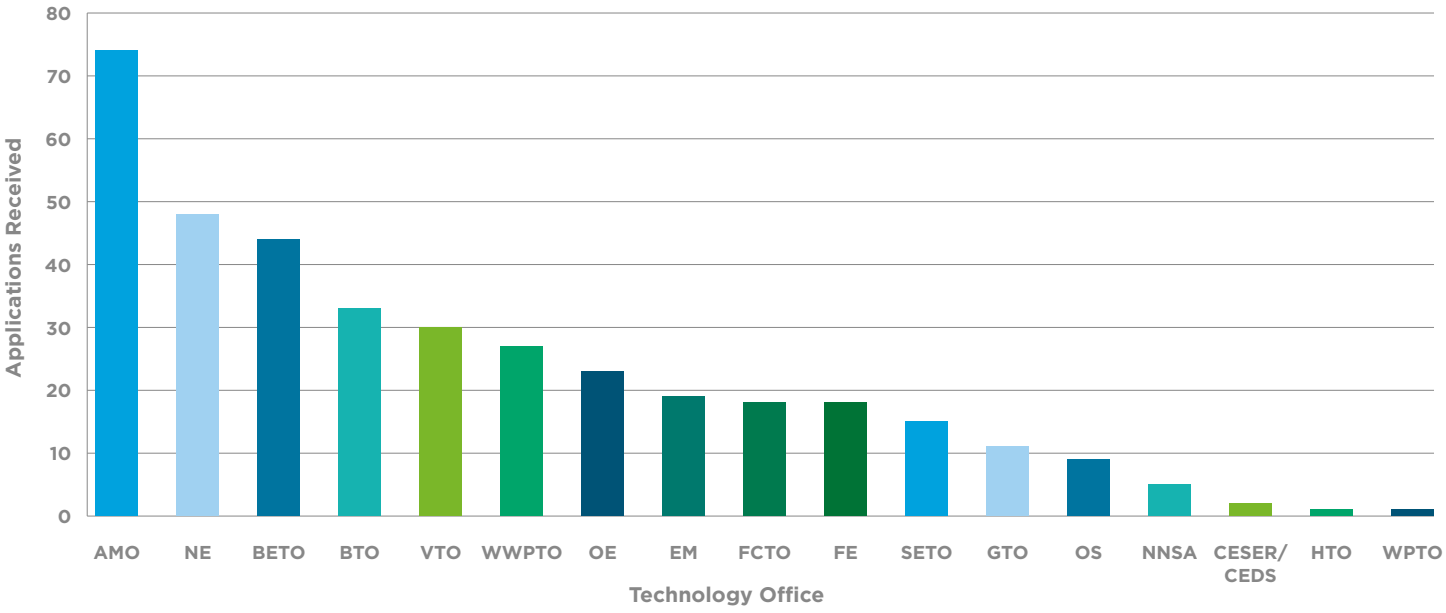
NOTE: Interviews by labs increase based on the number of funded teams.



6,130
Customer Discovery Interviews

378
Applications Received

Applications Submitted to Each Technology Office



ENERGY
I-CORPS
U.S. Department Of Energy

Case Studies

Energy I-Corps aims to accelerate the deployment of energy technologies by granting U.S. Department of Energy (DOE) laboratory scientists and engineers access to direct market feedback on their technology offerings. Inspired by the National Science Foundation Innovation Corps (I-Corps) model, the two-month Energy I-Corps program empowers teams with the tools, resources, and relationships necessary to discover potential market pathways for their innovations. The following pages showcase the success of just a few of the teams who have participated in the Energy I-Corps program.

"This was a rich out-of-the-comfort-zone-type opportunity and it was worth the time investment for us. The instructors really put a lot into it so we knew that our energy and buy-in had to at least match theirs. It's almost mind boggling how much more there potentially is to do as follow-up to this. I can't recommend the experience enough, and I think that it pays for itself just from the eye-opening perspective for people who have never seen the business side of taking tech to market."

MECS

Lawrence Livermore National Laboratory

Cohort 4

Problem

Craft beer is a booming business in the United States. The number of craft breweries operating since 2009 has grown from nearly 1,600 to more than 5,200.

CO_2 is a critical element for craft breweries, needed for both carbonization of the beer and final packaging. It's also a byproduct of the fermentation process. Every brewery, no matter its size, produces three times as much CO_2 as is needed during the fermentation process. Companies with large operations often have CO_2 recovery systems, like those currently used at power plants. But many microbreweries don't have the ability to capture and recycle the gas back into their operations. Because of this, the CO_2 already produced is wasted, and small breweries must purchase additional CO_2 from local suppliers, to meet their CO_2 needs.

If smaller breweries had a way to capture their own gas and recycle or sell it, they could save up to 75% of that expense, increasing efficiency, saving money, and ultimately making them more competitive.

Focus

MECS is a group of researchers from Lawrence Livermore National Laboratory (LLNL) that had previously developed microcapsule technology to efficiently capture CO_2 from power plants. Now they are using their technology to help these craft breweries capture the savings from recovering and reusing CO_2.

Through exploration of new potential markets in the Energy I-Corps program the LLNL MECS team identified significant potential for the microcapsule technology in the beer brewing industry.

To make the system feasible for microbreweries to implement, MECS envisions a tank-swap model in which tanks filled with millions of microcapsules are used to collect carbon dioxide at the brewery and are then picked up and taken to a centralized facility to reclaim the absorbed carbon dioxide.

According to a U.S. Department of Energy article, "Low Carbon Capture Technology Keeps Beer Bubbling," (https://energy.gov/eere/articles/lab-carbon-capture-technology-keeps-beer-bubbling), if the technology is successful, the process could potentially save breweries tens of thousands of dollars a year and prevent millions of pounds of CO_2 produced during fermentation from escaping into the atmosphere.

Solution

This national lab technology, initially designed to capture carbon from power plants, uses microcapsules made of gas-permeable polymer shells. Those shells contain the base ingredient (sodium carbonate) to better absorb and react with carbon dioxide. The microcapsules are then suspended on a mesh structure to allow CO_2 to move in and out of the shells—absorbing carbon dioxide about 10 times faster than encapsulated chemicals.

Where are they now? Post Program Advancements

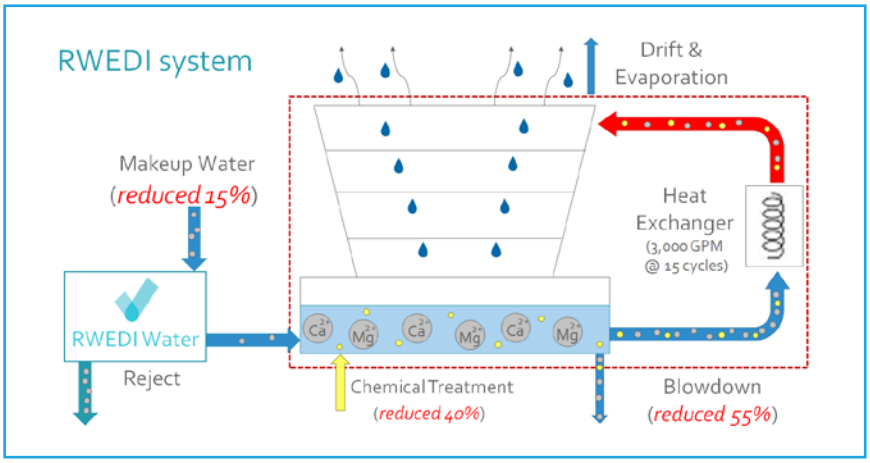
MECS is currently focusing on applying for TCF to commercialize through the brewery route.

MECS intends to install a carbon capture system at the University of California, Davis' pilot winery and brewery. The team is looking to further refine its research by performing more fermentation-related carbon capture studies.

RWEDI Solutions, Inc.

Argonne National Laboratory

Cohort 2



Problem

Combined water and sewer prices increased 5% in 2016 in 30 major U.S. cities and has increased 48% since 2010. Even higher costs are anticipated in the future. In a survey conducted in December 2014, 68% of companies surveyed said that water shortages pose a substantive risk to their business, 2% anticipate that issues around water could limit their business's growth.

Focus

Universities, hospitals, airports, data centers, and large office complexes:

- Operate 4–10 cooling towers, which create the largest demand for water at mid-sized institutions.
- Use 40–200 million gallons of freshwater/year (about the equivalent of 300–1500 average size households)
- Cost $500k–$3.5M/year to operate
- Are run on municipal water, which is causing a considerable increase in operating costs.

Traditional cooling tower water treatment systems require the use of chemicals. However, chemical systems don't improve the water quality, limiting its ability to meet the goals of preventing biological growth, scaling, and corrosion. This limits the cycles of concentration that can be used in the cooling tower system and the amount of water savings.

Solution

RWEDI Water Solutions technology reduces operating costs up to 20% by reducing water, sewer, chemical, and maintenance costs. It reduces water use up to 15% by increasing cycles of concentration. It reduces chemical usage up to 40% by decreasing the total dissolved solids in the water without chemical treatment.

Where are they now? Post Program Advancements

Through the customer discovery process and 200 total interviews, RWEDI Solutions has:

- Launched RWEDI Solutions, Inc., specifically to commercialize the RWEDI technology
- Hired 6 employees and 5 interns
- Received $1,450,000 in follow-on funding through a TCF and Uchicago Pitch Competition

Participating in:

- GSA's Green Proving Grounds program for pilot-testing at a federal building in Ogden, UT
- Chicago Innovation Mentors Program
- University of Chicago's New Venture http://chicagoinno.streetwise.co/2017/02/24/30-startups-move-on-in-uchicagos-2017-new-venture-challenge/
- Cleantech Open Accelerator
- Austin Technology Incubator http://ati.utexas.edu/current-portfolio/water/
- Global Midwest Alliance Innovation: http://www.globalmidwestalliance.org/PR_2017_04_05_PayYourSelfie_Wins_2017_Innovation_Competition.html.

Invited to speak at the Austin Water and Lower Colorado River Authority's Annual Commercial Conservation Workshop, pitch at NREL's Innovation Showcase and Bank of China, and serve as a panelist at the Current Innovation Water Symposium.

Licensing:

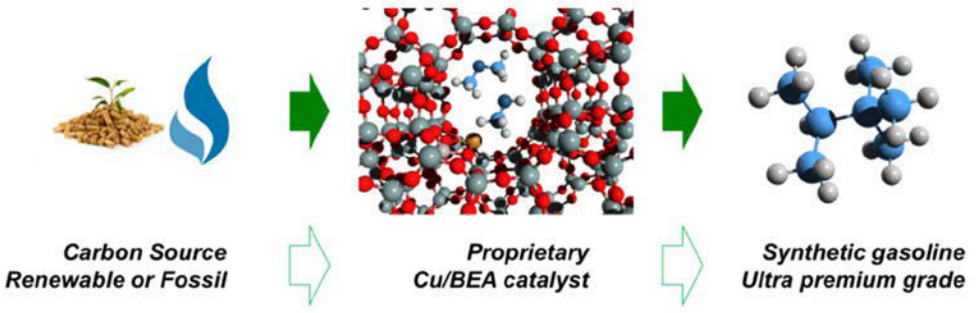
- Signed full license agreement with ANL on 5-core U.S. patents for the RWEDI water system into RWEDI Solutions, Inc.
- Obtained license option on 4-core U.S. patents for the RWEDI water system into Nullam Consulting, LCC (a previously launched company), in negotiation with ANL for full license terms.

For more information or speaking engagements, contact RWEDI Solutions CEO and Founder Jessica Linville at Jessica@rwedisolutionsinc.com or visit www.rwedisolutionsinc.com

CuB Fuels

National Renewable Energy Laboratory (NREL)

Cohort 5



Problem

Mid-sized automotive fuel refiners can have difficulty meeting regulatory mandates while making a profit. By using the high-octane CuB Fuels product, those refiners can increase net revenues by more than $60 MM/year. The CuB Fuels product allows refiners to:

- Produce more premium-grade fuel to address growing demand
- Blend-up lower grades to salable products
- Increase efficiency of reformer operation
- Reduce the volume of crude oil purchased.

All of this is possible while still meeting regulatory mandates (RFS, LCFS, CARB) with cellulosic biofuel RINs.

Focus

CuB Fuels is seeking strategic partnerships and co-operative R&D through:

- Methanol producers targeting the U.S. fuel market and looking to increase demand and value of their product
- Syngas producers targeting a high-value product from gas-to-liquids technology
- Renewable feedstock providers (bio-methanol, bio-syngas, bio-gas) looking to capitalize on RINs with a non-oxygenate product
- Refiners seeking a low- or no-capital source of high-value octane, and those looking to meet regulatory volume mandates
- Automotive OEMs looking to leverage high octane gasoline to meet CAFÉ standards.

Solution

CuB Fuels enables automotive manufacturers and oil refineries to improve fuel economy and meet regulatory mandates while increasing their gross profits through a proprietary catalyst technology that produces a high-octane synthetic gasoline blendstock from domestic resources.

Where are they now? Post Program Advancements

The CuB Fuels team has continued to develop the commercialization plan around their high-octane gasoline blendstock by:

- Meeting with a natural gas company looking for a project in Canada and visits to Tesoro and Haldor Topsoe to discuss potential partnerships
- Making connections to local companies specializing in natural gas projects (i.e., shipping, LNG, CNG, etc.)
- Establishing a non-disclosure agreement to develop a detailed economic model of the CuB Fuels technology with the potential for a project in western Canada
- Developing two technology demonstrations before the end of the calendar year—one is at NREL and one with CuB Fuels partner Enerkem—that will enable the team to directly address the next steps towards commercialization.

EcoSnap

The first window AC without the window

National Renewable Energy Laboratory (NREL)

Cohort 1

Problem

EcoSnap is an R&D 100 Award winning room cooling and heating solution that addresses the major drawbacks of room air conditioners and heat pumps. It uses proven technology in combination with novel engineering to provide convenient and local space conditioning in a low-cost, easy-to-install package. EcoSnap does this without requiring the use of windows, virtually eliminating interior noise, improving energy efficiency and home security while decreasing cooling and heating loads.

Focus

(a) MSHP with EcoSnap integrated joining system and (b) EcoSnap integrated connection system.

Benefits over existing room AC products:

- Window views
- Reduced noise
- Higher efficiency
- More secure
- Install anywhere on exterior walls
- No need to remove seasonally
- DIY installation – saves time and money
- Fewer greenhouse gas emissions.

Solution

The EcoSnap joining system reduces installation time from several hours for a mini-split heat pump system to several minutes for an EcoSnap system. EcoSnap's patent-pending design focuses on the tight integration of the indoor and outdoor sections allowing for a tool-less, weathertight, fast installation after a single hole is drilled in an exterior wall.

Where are they now? Post Program Advancements

Technical development

- Awarded Colorado Advanced Industries Grant for industrial design and product development
- Negotiating with major utility for performance characterization in their service territory.

Licensing

- Active discussions with multiple interested organizations
- In negotiations for full license for multi-national commercialization.

Articles

- R&D 100 Award winner https://www.rd100conference.com/awards/winners-finalists/6131/ecosnap-ac-heat-pump-system/
- U.S. Deptartment of Energy Amped Up! Magazine https://energy.gov/eere/ampedup/articles/new-easy-install-air-conditioning-unit-frees-window-space-snap
- National Lab Impact Summit https://www.energy.gov/sites/prod/files/2016/05/f31/DOE_EERE_Lab%20Impact%20Summit_Packet_FINAL%20FOR%20PRINTING%204-27-16-wdoe-JF-web150.pdf

For more information or speaking engagements, contact co-inventors Chuck Booten (chuck.booten@nrel.gov) and Jon Winkler (jon.winkler@nrel.gov).

General Line Ampacity State Solver (GLASS)

Idaho National Laboratory (INL)

Problem

The nation's electrical grid, which until recently was overbuilt and had the luxury of operating under a relatively static set of principles for more than 100 years, is in the middle of a dramatic transformation. The biggest developments have been communication throughput and computing capacity and the integration of renewable energy resources and reduction in nuclear and coal generation. As utilities consider large investments in replacing aging infrastructure and incorporate renewables from remote locations, unlocking extra capacity within existing transmission lines is likely to offer huge advantages in immediate and cost effective transformation that shore up grid efficiency and reliability.

Focus

Power transfer capacity is affected by three main elements: stability, voltage limits, and thermal ratings. All three are critical, but thermal ratings represent the greatest opportunity to quickly, reliably, and economically improve the grid's capacity.

Static Line Ratings (SLRs) are based on a fixed set of conservative environmental conditions to establish a limit on the amount of current that lines can safely carry without overheating. Dynamic Line Ratings (DLRs) inform system planners and grid operators of available transmission capacity beyond traditionally calculated SLRs.

Accurate and reliable real-time and forecast information about network-wide conductor temperature has been difficult to obtain. The dynamics in power lines make comprehensive predictive mathematical models nearly impossible. Conductor cooling varies with wind speed, direction, ambient air temperature, and solar radiation exposure, all of which must be factored in for operators to quickly and safely make decisions about limiting power flow to avoid inconveniencing customers and forgoing delivered energy revenue.

Solution

INL's GLASS innovation offers the potential to safely provide more robust line ampacities by using real-time information rather than overly conservative SLRs. It uses commercially available weather monitors mounted on industry-informed custom brackets developed by INL in combination with Computational Fluid Dynamics-enhanced weather analysis and DLR software.

Where are they now? Post Program Advancements

Through the customer discovery process and nearly 200 interviews throughout the industry, INL researchers have:

- Collaborated with Idaho Power Company to fully-instrument two test beds with weather stations and line rating software.
- Executed one cooperative research and development agreement (CRADA) and initiated another with WindSim AS.
- Completed one CRADA with AltaLink LLC, Alberta, Canada's largest regulated electric transmission company, on a field study of four transmission line segments.
- GLASS was named a finalist for the 2017 R&D 100 Awards.
- INL was awarded a Technology Commercialization Fund award from the U.S. Department of Energy Office of Technology Transfer, and will be in collaboration with one industry partner for fiscal years 2018 and 2019.

Speaking Engagements: Presenters from INL have engaged in more than 25 speaking opportunities in more than 5 countries.

Licensing: INL has recently executed one license agreement with an industry partner for the use of GLASS.

Articles: "Transmission line ampacity improvements of AltaLink wind plant overhead tie-lines using weather-based dynamic line rating" by Bishnu P. Bhattarai, Jake P. Gentle, Porter Hill, Tim McJunkin, Kurt S. Myers, Alex Abboud, Rodger Renwick, and David Hengst presented at IEEE PES GM 2017.

Video: https://youtu.be/X8IaVYN6tUw

For more information or speaking engagements, contact Jake Gentle at (208) 526-1753 or jake.gentle@inl.gov.

Nitrilica

Enabling automotive carbon fiber through cleaner, cost advantaged chemistry

National Renewable Energy Laboratory (NREL)

Cohort 5

Problem

Replacing steel and aluminum components in automobiles with lightweight carbon fiber composites would have great benefits to society. For example, using existing engine technology, carbon fiber components would enable the average car to see a 20%–40% reduction in greenhouse gas emissions and fuel economy > 50 mpg, and for electric vehicles a range over 300 miles per charge becomes easily achievable. However, in order for lightweight carbon fiber composites to see widespread application in automobiles, the price of carbon fiber needs to be around $4/lb. Today the price of carbon fiber is around $6-$8/lb with 51% of manufacturing cost dominated by the cost of the base chemical acrylonitrile (AN). Thus, in order to lower the price of carbon fiber, cost advantaged routes to acrylonitrile are key to achieving widespread use of carbon fiber composites.

Focus

The average carbon fiber manufacturer focus:

- Purchases ~50 ktons of AN per year totaling ~80 million USD per year.
- Requires 2 lbs of AN to produce 1 lb of carbon fiber making the manufacturer extraordinarily price sensitive to AN.
- AN accounts for 51% of the manufacturing cost of carbon fiber.
- AN prices < $0.50/lb (today AN is ~$0.70/lb) are needed to enable carbon fiber price points < $5/lb.
- Would like to be vertically integrated owning acrylonitrile production capability.

Solution

The conventional petrochemical route produces acrylonitrile from two ingredients, propylene and ammonia. Propylene is a somewhat volatile and expensive chemical that is not helped by the shale gas boom. Thus, the price of acrylonitrile tracks the fluctuation in the price of propylene. Carbon fiber manufacturers need the price of AN to be lower <$0.50/lb and less volatile to realize carbon fiber prices below $5/lb.

Nitrilica, an NREL lab team patented chemistry, allows production of AN from renewable ethanol or petrochemically derived ethylene. Both of these chemicals are cost advantaged, abundant, and price stable compared to propylene. The result of this technology is a cost advantage of ~$0.24/lb AN over the conventional AN. Purchasing AN from Nitrilica's technology over the conventional chemistry on the spot market would result in a saving of $30-$40 million USD per year for the average carbon fiber manufacturer and push carbon fiber prices < $5/lb. Additionally, the compact skid based design of the chemical processing technology allows carbon fiber manufacturers to purchase their own AN manufacturing capability at the 50 kton/yr scale and the potential to become fully vertically integrated.

Where are they now? Post Program Advancements

Through the customer discovery process and 100 total interviews, Nitrilica:

- Won a 2018 R&D 100 award
- Is engaging Novomer on licensing agreements
- Is pursuing funding through the TCF program
- Is currently raising $20-$40k to build robust economic models
- Is partnering with MATRIC to derisk the technology further.

CO_2BOL-NG:

Acid Gas Separation Technology

Pacific Northwest National Laboratory

Problem

Liquefied natural gas demand is ~400 million metric tonnes per annum (MTA), which is expected to increase to 500 MTA by year 2030. This industry is on the order of billions of dollars per year. Toxic acid gas impurities present in parts per million (ppm) levels cause pipeline corrosion and must be removed from gas streams. Large centralized refineries are used to remove these impurities, requiring millions of gallons of solvent per year and costly units of operation.

Researchers at PNNL have developed a reusable organic liquid that can pull harmful gases such as carbon dioxide or H_2S out of industrial processes, natural gas streams, and emissions from power plants. The process could directly replace current methods and capture double the amount of harmful gases in a way that uses no water, less energy, and saves money.

Focus

Gas producers, natural gas refineries, power plants:

- Costly, large centralized processing facilities
- Hundreds of millions of standard cubic feet a day of gas to treat
- Ppm-level impurities are costly to remove (CO_2, H_2S, COS, H_2O)
- Use millions of gallons of solvents annually to treat
- Acid gases and water-based solvents are highly corrosive.

Solution

Separations of ppm level impurities require strong chemical complexing agents, often liquids for their ease of use. These solvent-based processes often use organic bases dissolved in water, which introduces corrosion and the need for high temperatures to release the impurity to regenerate the solvent. PNNL has developed a technology platform known as carbon dioxide binding organic liquid (CO_2BOLs) that uses solvents to absorb acid gas impurities such as CO_2 or H_2S for applications such as carbon capture, and acid gas "sweetening" to remove toxic H_2S. CO_2BOLs can capture twice as much gas as conventional solvents and is readily regenerated under mild conditions, requiring lower energy demands. The CO_2BOL platform can be applied to any acid gas, making it the "Swiss Army Knife" of chemical solvents because of the ability to tailor the specific chemistry to the specific gas separation application.

Where are they now? Post Program Advancements

Through the customer discover process and 77 total interviews, CO_2BOL-NG has:

- Licensed the CO_2 capture technology to an engineering firm.
- Received DOE seed money to further develop the solvent platform for purifying synthesis gas.
- Discussed potential follow-on continued R&D with IP-Group.
- Participated in Energy I-Corps Pitch competition. November 2017.

Speaking Engagements:

- Gordon Research Conference, CO2 capture and conversion. Colby Sawyer College, NH, June 2017.
- Mission Innovation, Carbon Capture Innovation Challenge. Houston, TX, Sept 26–28, 2017.

For more information or speaking engagements, contact David Heldebrant (david.heldebrant@pnnl.gov) or Phillip Koech (phillip.koech@pnnl.gov) or visit www.pnl.gov

Quake (MASTODON)
A Risk-Based Design Optimization Software for Critical Infrastructure

Idaho National Laboratory

Cohort 2

Problem

The United States infrastructure received a D+ rating in the American Society of Civil Engineers infrastructure report card of 2017. Much of the United States' new and existing critical infrastructure such as dams, levees, bridges, power plants, etc., are located in seismically active areas and are analyzed and designed for earthquakes using numerical tools combined with consensus codes and standards that use experience-based empirical factors to account for uncertainties. There is a lack of rigor in accounting for this uncertainty, which leads to large design conservatisms and therefore inflated capital and maintenance costs, while not necessarily making the structures safer. Over the next 30 years the United States will replace its aging infrastructure. It is important that the most at-risk infrastructure be replaced first, and that the replacement designs be optimized.

Focus

Identify the infrastructure that is most vulnerable to earthquakes. Additionally, optimize new construction so that it is not excessively conservative and overly expensive. The current focus is on dams, nuclear facilities, and nuclear power plants. Seismic costs of new nuclear power plants can exceed 30% of the total overnight capital costs and existing structures can require millions of dollars in periodic maintenance. Capital costs and construction delays have virtually halted the nuclear industry and led to the bankruptcy of one of the largest companies.

Solution

The MASTODON technology is built on sophisticated physical models for soils and structures. It also automates and greatly simplifies risk calculations and can intelligently optimize the design to reduce the costs while maintaining required safety margins by keeping the seismic risk below the required threshold level. The risk-based design procedure identifies the most vulnerable parts of the infrastructure system and helps provide the most cost-effective retrofitting solutions like seismic isolation. This enables owners to make decisions on what should be replaced first and reduces overnight capital costs as well as life-cycle costs by up to 30%. It will also allow owners to strategically use risk mitigation tools such as seismic isolation to further reduce capital and life-cycle costs.

Where are they now? Post Program Advancements

Through the customer discovery process, extended discussions and research collaborations with owners of critical infrastructure the QUAKE team has:

- Extended their technology from a risk assessment tool to a risk-based design optimization tool to more directly meet their value proposition: to reduce unnecessary costs while maintaining required safety.
- Filed for a patent on the key technology in the software.
- Been working on an MOU to apply MASTODON to seismic dam analysis and infrastructure decision making.
- Released an open source version of MASTODON.
- Reached out to commercial companies, universities, and international partners to be beta users of MASTODON and provide feedback to improve the code.
- Received $1,420,000 of technology commercialization fund through a competitive proposal process to further development of an analytical optimization process, in MASTODON, for advanced nuclear reactors. The partners are TerraPower, X-energy, and Southern Company.

For more information regarding MASTODON, contact Justin Coleman (justin.coleman@inl.gov) or Chandu Bolisetti (chandrakanth.bolisetti@inl.gov).

RE-Mag

Idaho National Laboratory

Problem

The electrification of modern society has resulted in 8% compound annual growth rate in the rare earth magnet market sector over the past decade; reaching a market value of around $11 billion USD in 2016. Forces driving expansion of the magnet market include 40% growth rate in the U.S. electric vehicle market, which is approaching 10% of all vehicle sales in the United States, and hard drive magnets used for personal computers and cloud computing infrastructure (cloud data c enters) which underpin a $200 billion USD cloud computing market. Over the next decade it is projected that worldwide demand for rare earth metals used in magnets will exceed supplies; thus making magnet recycle a potentially attractive and lucrative business. With magnet scrap currently valued at $1.54/Kg, recovery of rare earths from hard drive and electric motor magnets requires efficient and inexpensive recycling technology if the recycle business is to realize profit. Existing rare earth recovery technologies operate at ~$3/Kg - $6/Kg or higher. Obviously, new and more cost-effective recovery technology is needed.

Focus

RE-Mag (previously known as RE-Light), a team from Idaho National Laboratory. has developed an advanced solvent extraction process that recovers high-value rare earth elements from computer hard drive and electric motor magnets for the following:

- Cloud computing data centers
- Computer hard drive manufacturers
- Electric vehicle motor manufacturers
- Scrap magnet recyclers.

Solution

The RE-Mag process recovers >95% of the rare earth value at a processing cost of less than $3/Kg.

Where are they now? Post Program Advancements

Intellectual Property

- Non-disclosure agreements with six rare earth element recovery companies. Currently in discussion with industry to gain interest and cost share.
- IP is progressing
- Patent application is moving forward
- Developing new IP related to the metalization of rare earth elements
- Driving process costs even lower by developing a new, low-pressure application that reduces capital equipment expenses by 50%.

Speaking Engagements

- Invited to speak at the Argus Americas Rare Earths Summit
- 5th-International Nuclear Chemistry Congress
- International Chemical Congress of Pacific Basin Societies (Pacifichem)
- Northwest Regional Meeting

Publications

- Baek, D. L.; Fox, R. V.; Case, M. E.; Sinclair, L. K.; Schmidt, A. B.; McIlwain, P. R.; Mincher, B. J.; Wai, C. M., Ind. Eng. Chem. Res., 2016, 55, 7154. DOI: 10.1021/acs.iecr.6b00554
- Sinclair, L.K.; Baek, D.L.; Thompson, J.; Tester, J.W.; Fox, R.V., J. Supercrit. Fluids, 2017, 124, 20. DOI:10.1016/j.supflu.2017.01.005
- Case, M. E.; Fox, R. V.; Baek, D. L.; Mincher, B. J.; Wai, C. M., Solvent Extr. Ion Exc., 2017, DOI: 10.1080/07366299.2017.1373984

SonicLQ:
The Sonic Leak Quantifier

Argonne National Laboratory

Cohort 1

Problem

Most commercial and residential buildings have air leaks that waste energy and cost owners as much as 30% too much on their utility bills. To solve this problem they hire air leak testers, but existing technologies are limited for testers.

Focus

SonicLQ uses sound waves to locate and size air leaks in building walls, doors, and windows.

1. A portable speaker inside the building sends sound waves through exterior wall.
2. A digital microphone array outside the building listens to the sound coming through the solid wall and cracks in wall.
3. The microphone array transmits sound data to a tablet with the SonicLQ app that analyzes the data, locates and sizes the cracks, and overlays them on a photo of the wall.

SonicLQ has several benefits over traditional blower doors and thermal cameras:

- SonicLQ can both locate and size specific leaks allowing testers to recommend prioritized sealing
- SonicLQ can be used on both commercial and residential buildings of any size
- SonicLQ can be used on buildings under construction or complete, even when occupied
- SonicLQ can be used at any time of the year, even when inside and outside temps are similar.

These benefits give air leak testers more useful data and far more opportunities for testing which allows them to sell more testing services and save more money for building owners.

Where are they now? Post Program Advancements

- William Shadid, I-Corps Industrial Mentor, has created SonicLQ LLC to commercialize the technology
- Received $285,000 in follow-on funding from DOE Building Technologies Office for additional R&D and $1,050,000 in follow-on funding from DoD ESTCP/ SERDP program for demonstration and testing on DoD sites
- Chicago Innovation Mentors Program
- Invited to several pitch competitions including DOE Lab Accelerator (Sept. 2017); USG-Illinois Corporate Startup Challenge (November 2016); and Clean Energy Trust (April 2016)
- Speaking Engagements: IP Group-Argonne Investment Meetings; Bosch-Argonne Technology Exchange Day; North American Insulation Manufacturer Association (NAIMA); follow-up speaking engagement at USG; pitch at DOE-NYSERDA Laboratory-Investor Knowledge Series; and invited to present at Chicago Innovation Mentors.
- Patents and Licensing: Patent Pending

Articles:

- http://www.greenbuildingadvisor.com/blogs/dept/building-science/soniclq-reconnecting-acoustics-and-airtightness
- http://www.chicagotribune.com/bluesky/originals/ct-soniclq-financing-bsi-20160328-story.html
- http://www.constructrr.com/ep8/
- https://www.anl.gov/articles/shark-tank-argonne-scientists

For more information or speaking engagements, contact Dr. Ralph T. Muehleisen (rmuehleisen@anl.gov).

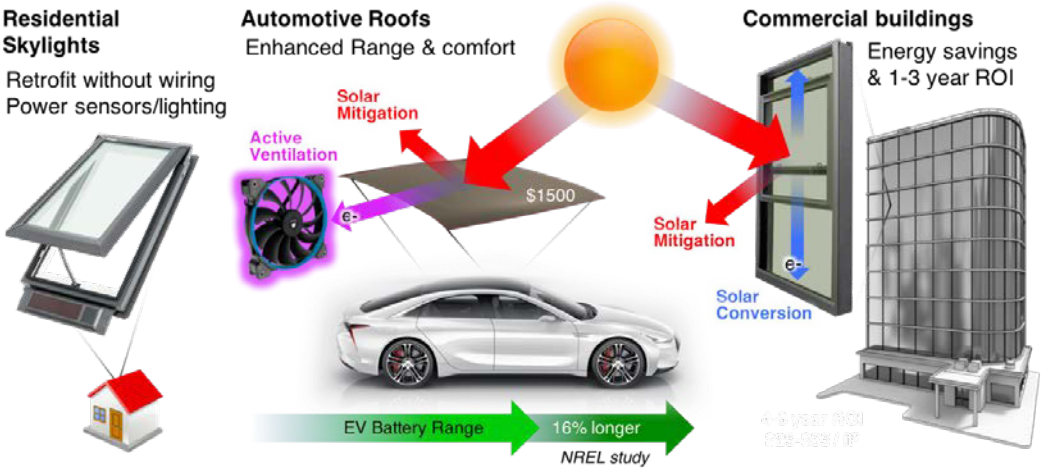
SwitchGlaze:
The window solar panel that responds to sunlight by dynamically switching color

National Renewable Energy Laboratory (NREL)
Cohort 3

Problem

Buildings account for ~75% of electricity use in the United States. Current trends in commercial building design are toward all-glass facades, which place aesthetics and interaction with the external environment ahead of energy efficiency. Dynamic glass shows promise as an exciting solution to this issue by mitigating solar heat gain during times of high solar glare while allowing high visual clarity and light transmittance during other times. However, the return on investment for current dynamic glass technology is too high for widespread adoption.

Focus



Solution

SwitchGlaze couples the energy-savings of dynamic glass with solar energy generation. The technology is poised for immediate impact in skylight retrofits by saving consumers the construction cost of tearing out walls for wiring and enabling integrated designs where SwitchGlaze powers a CPU that controls rain sensors, motors to open/close the window, and powers internal LED lighting. Low-cost production and energy generation in SwitchGlaze technology dramatically reduces the return on investment of dynamic glazing to 1 to 3 years, enabling practical deployment in commercial buildings and automotive industries.

Where are they now? Post Program Advancements

- Received $50,000 in strategic funding from the U.S. Department of Energy to address technological barriers identified during Energy I-Corps customer discovery process.
- Teamed up with commercial partners for fabrication and scale-up of prototype products.
- Proof-of-concept paper accepted for publication in high-impact scientific journal.
- To be featured in Annual issue of Innovative Energy Review Magazine.
- Invited to pitch at NREL's Innovations Showcase and at Pitch! Energy Competition.

AMAFT
Additive Manufacturing as an Alternative Fabrication Technique for Nuclear Fuel

Idaho National Laboratory

Cohort 5

Problem

As the nuclear industry strives to improve passive safety features of nuclear power plants, there is a growing interest in safer and improved performance nuclear fuels.

Traditional fuel manufacturing methods require several steps to convert raw uranium (U) ore into uranium hexafluoride (UF_6), and then again, into the UO_2 that will be used in current light water reactors.

Focus

Both nuclear fuel fabricators (e.g., Westinghouse Engineering, Babcock and Wilcox Technologies) and end users (e.g., LWR commercial market, special fuel production users) will benefit from additive manufacturing as an alternative fabrication technique (AMAFT) technology as described in the following simplistic goals:

- Fuel fabricator: reduce cost of nuclear fuel for fabricators (Westinghouse) from $50/kg U to $40/kg U.
- End user receives benefits from fuel efficiency, reduced operating costs, and reduced capital costs.
- Cost structure: qualification costs, inspection tools, capital and operating costs, licensing, waste handling, and training.

Solution

AMAFT will decrease the number of fabrication steps and eliminate metallic U as a feedstock material. Fabrication yield will increase use of the direct AMAFT approach, also contributing to a more economical process. By the direct AMAFT synthesis of U_3Si_2 fuel pellets using other forms of U (e.g., UF_4, uranium tetrafluoride), it is envisaged that the use of U metal can be avoided and a commercially feasible fabrication process can be delivered.

In traditional manufacturing, changes to pellet design require new tooling and fabrication process parameters. Changes to design parameters for AMAFT pellets can be made quickly, allowing for rapid-prototyping and testing, enabling a shorter time-to-market. Additionally, the successful deployment of this technology will result in the significant use of other U waste products or interim U-based products, which will result in a beneficial environmental effect as well.

Where are they now? Post Program Advancements

Through the customer discovery process, AMAFT has:

- Continued work on technology maturity funded through a Topic 1 Technology Commercialization Fund (TCF) that was awarded 2016
- Completed 76 industry interviews that were helpful in developing INL's rapidly growing advanced manufacturing strategy
- Prepared a Topic 2 TCF proposal to develop the scaled-up process
- Highlighted other products (although already included in the provisional patent) that are now being further explored.

Speaking engagements:

- The 2017 Advanced Manufacturing and Supply Chain Innovation Nuclear Energy Leadership Summit and Showcase
- Guest lecture to Ph.D. students at University of Idaho
- Invited to give technical presentation to researchers of Lawrence Livermore National Laboratory.

Licensing/patent:

- INL is converting the provisional patent into a non-provisional patent (in process).

For more information or speaking engagements, contact the Inventor and Principal Investigator, Isabella van Rooyen at Isabella.vanrooyen@inl.gov or Technology Manager, Art Baker at arthur.baker2@inl.gov.

STARS Technology Corporation (STC): A Pacific Northwest National Laboratory Spinout/Startup

Pacific Northwest National Laboratory (PNNL)

Cohort 1

Problem

In recent years, California sought to reduce its statewide greenhouse gas emissions to 1990 values. This effort appears to be successful as California expects to reach this goal by 2020. However, California has recently imposed a more stringent goal: to achieve another 40% reduction in greenhouse gas emissions by 2030. This will require a much more aggressive approach, and major changes to capital infrastructure.

Focus

STC's opportunity is enhanced by the inclusion of Southern California Gas as a strategic partner and launch customer that plans to propose a major capital project demonstration of the Solar Thermochemical Advanced Reaction System (STARS) technology in their service territory.

The opportunity is defined by increasing demand for affordable, renewable fuels and chemicals; in particular, low-carbon hydrogen (H_2) and methanol (CH_3OH). STC's near-term business opportunity is to provide advanced thermochemical hardware—unavailable elsewhere—that produces hydrogen and/or methanol, at competitive costs but with much lower CO_2 emissions than traditional sources.

Solution

STC is an advanced chemical process technology company providing economical low-carbon fuel and chemical solutions. STC's launch product is low-cost, low-carbon hydrogen supplying a $150B+ annual worldwide market.

STC has licensed STARS™ intellectual property from the U. S. Department of Energy and Battelle Memorial Institute, the operator of PNNL. STC will establish the value chain associated with the manufacturing of STARS components, assembly of STARS systems, and delivery and assembly of STARS hardware. STC will partner with manufacturing entities where appropriate, or alternately establish dedicated manufacturing facilities as needed.

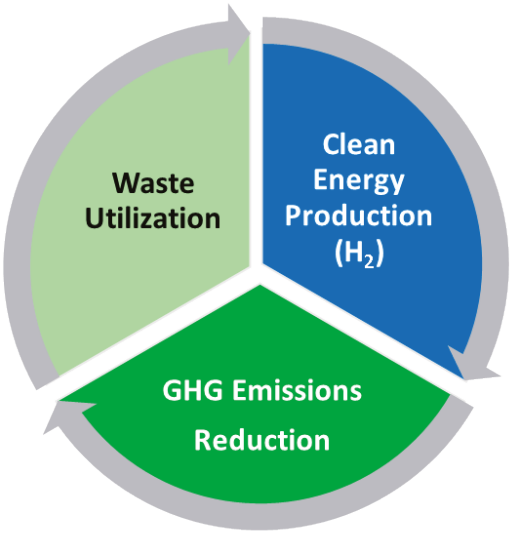
The core product is the STARS™ system—a very efficient, micro- and meso-channel, process intensive thermochemical reactor module that readily enables renewable energy integration/augmentation to cost effectively produce low-carbon fuels and chemicals. Low-carbon hydrogen is the launch product to be closely followed by carbon-neutral hydrogen in combination with methanol, and ultimately by "fuel from thin air" by capturing and utilizing atmospheric CO_2 as a feedstock.

Where are they now? Post Program Advancements

- $8M+ from federal funding sources and strategic partners
- Demonstrated TRL 6 system in Southern California in collaboration with SoCalGas Company
- Received an R&D 100 Award (November 2014)
- Completed DOE's Lab-Corps Program
- 100+ STARS related patents developed.

Electro-Active Technologies

Oak Ridge National Laboratory (ORNL)



Problem

Forty percent of food is wasted today, a huge problem and opportunity. Meanwhile, the high cost of hydrogen and lack of renewable sources is restricting growth of zero-emission fuel cells. Our system provides a solution to both of these issues, converting waste into affordable, renewable hydrogen. Our technology can reduce greenhouse gas (GHG) emissions by 66% compared to SMR, while achieving 2x electrical efficiency compared to water electrolysis. It is a pathway to sustainable economies of the 21st century.

Focus

Enabling hydrogen fueled:

- Forklifts
- Class 8 trucks
- Generators
- Personal vehicles
- City fleets
- Maritime applications

Solution

Key offerings:

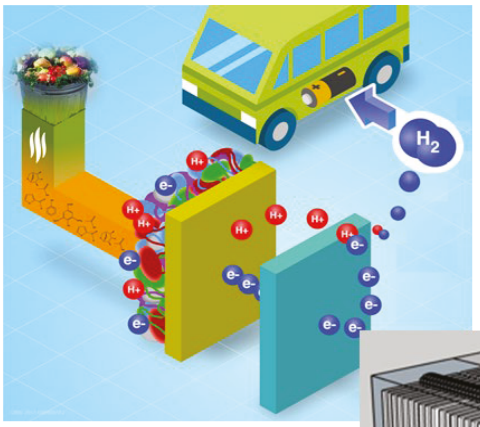
e-H2Gen: Renewable hydrogen generation system using organic waste, adaptable to low and high volume customers.

e-active C: Soil co-products for a sustainable agriculture and a circular food value chain.

Electro-Active integrates biology, electrochemistry, and engineering in these multi-disciplinary applications. Through our expertise in these areas, while working with industry, we are bringing the next generation of clean energy and ag technologies to market.

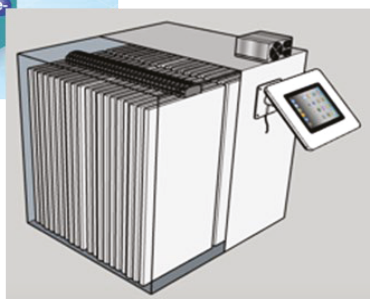
This technology can help bring together the different aspects of hydrogen creation and consumption across agriculture, waste management, transportation, renewables, microgrids, grid services, etc."

-CAISO



Microbial Electrolysis

Modular Scalable



For more information, contact Abhijeet P. Borole at aborole@electroavtive.tech or alewis@electroactive.tech or visit www.electroactive.tech.

Gamma Rayality

Lawrence Berkeley
National Laboratory (LBNL)

Problem

Specialized equipment is required to identify and locate radiological/nuclear material and map contamination. Many currently available commercial systems are static, employ manual location triangulation methods that are error prone, require a human to hold and manually operate the system, and lack contextual sensors (such as visual cameras or LiDAR) which provide environmental information about an area of interest. As a result, users of these systems typically need to take multiple measurements of an area of interest for tens of minutes at a time and track the location of the system manually, potentially risking longer exposure to radioactive material, and are limited to ground measurements.

Focus

This technology has applications in defense, nuclear power plant decontamination and decommissioning, emergency response and homeland security, and international nuclear safeguards.

Solution

The Localization and Mapping Platform (LAMP) is a lightweight, compact, contextual sensor package that integrates commercial off-the-shelf components (e.g. visual camera, LiDAR, GPS, etc.) and Scene Data Fusion software to enable the visualization of radioactive and nuclear sources in 3D and in real-time. The Scene Data Fusion software on LAMP fuses radiation data with 3D models of an area to show the location of radiological/nuclear material and map radioactive contamination.

LAMP is designed to be modular, allowing it to integrate seamlessly with a wide range of radiation detectors, including laboratory prototypes and commercial systems, and can also be deployed in a handheld configuration or on manned or unmanned ground and aerial vehicles. This enables the customer to tailor the LAMP system configuration to meet mission needs and other requirements.

LAMP can significantly enhance traditional radiation detection systems by enabling:

- Faster and more efficient operations: LAMP enables free-moving source localization and mapping (meaning a person or robot can continuously move through the environment with it) and provides a real-time map of the area of interest.
- Improved situational awareness in 3D: LAMP enables visualization of radiological/nuclear material in 3D, which provides greater detail and more information about the size, location, and other characteristics of a radioactive source.
- Configuration customization and safer operation: LAMP is both platform and detector adaptable, meaning it can be integrated with a wide range of radiation detectors (including laboratory prototype and commercial radiation detectors) and on various deployment platforms, including unmanned and manned ground or aerial platforms.

Several different configurations of LAMP, including versions integrated with commercial radiation detectors, have been successfully demonstrated in real-world environments, including in Fukushima Prefecture, Japan and the Chernobyl Exclusion Zone, Ukraine to map radioactive contamination.

Where are they now? Post Program Advancements

Additional funding/awards

- August 2018: Awarded $2.6 M, 2 year projects to LBNL research program by Defense Threat Reduction Agency (DTRA) to continue developing technology
- November 2017: Second Place, inaugural LBNL IPO Pitch Competition ($2500 award for continued customer discovery)

8 speaking engagements

8 demonstrations to potential end users.

Publications:

- A. Haefner, et. al., "3D Gamma-ray Mapping from Unmanned Aerial Systems for Nuclear Decommissioning," Proceedings of the 2018 Waste Management Symposium, March 18-27, 2018, Phoenix, Arizona.
- A. Haefner, et. al. "3D Mapping and Visualization of Radioactive Sources for Nuclear Safeguards Applications." Symposium on International Safeguards: Building Future Safeguards Capabilities, International Atomic Energy Agency. November 5-8, 2018.
- R. Pavlovsky, et. al., "3D Radiation Mapping in Real-time with the Localization and Mapping Platform (LAMP) from Unmanned Aerial Systems and Man-Portable Configurations." Forthcoming 2019 Q1.

Thank You!

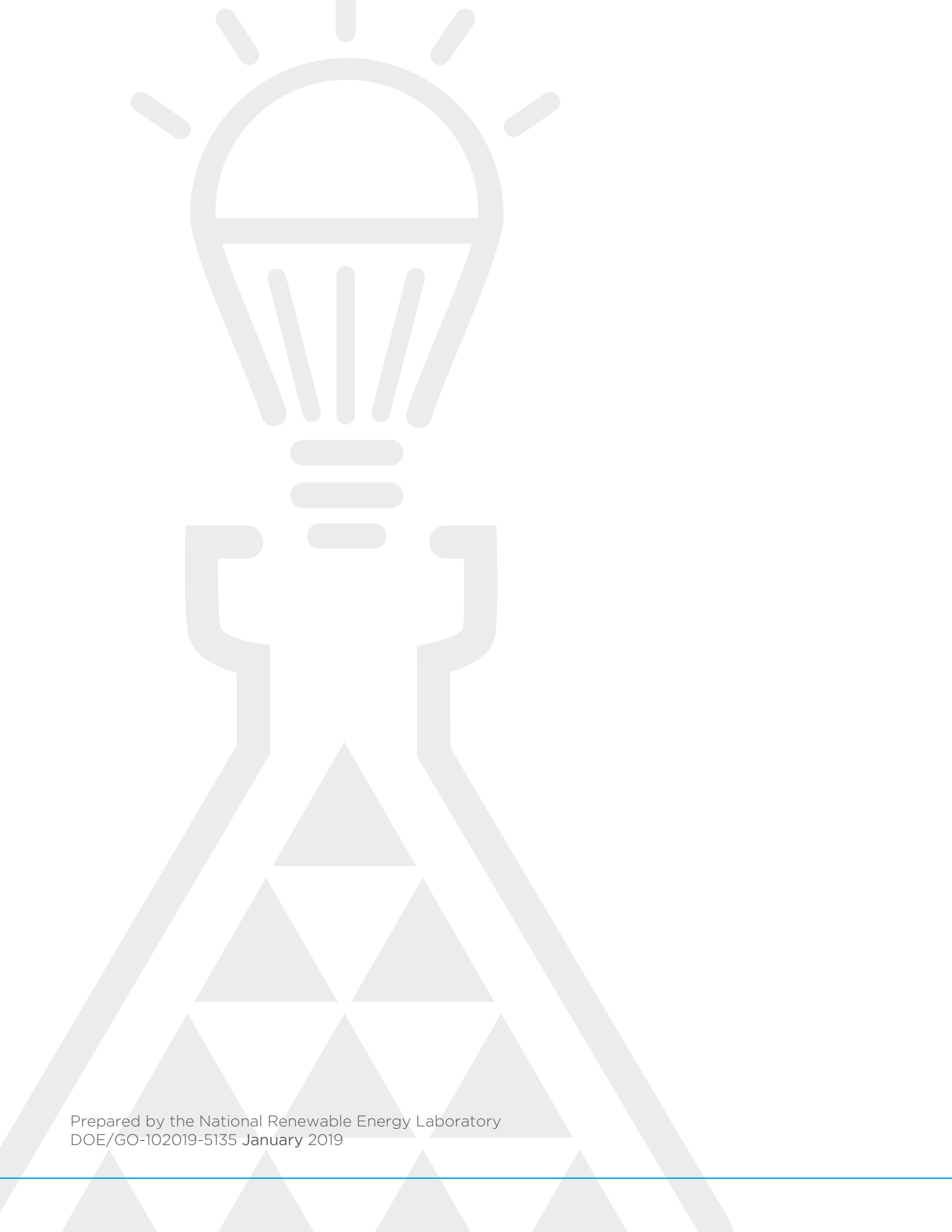
Thank you to the U.S Department of Energy, technology program offices, laboratories, and all who have made Energy I-Corps possible.

"Energy I-Corps helped me learn pretty quickly that people will talk to you if you just pick up the phone... you shouldn't be afraid to ask questions, whether it be from lab techs or CEOs. Through these interviews, we gained three new collaborators, and the eye of a venture capitalist firm that may be interested in co-developing our technology."

David Heldebrandt
Cohort 5, CO_2BOL-NG

"Energy I-Corps taught me to engage industry and understand their needs BEFORE starting research so everything is aligned with genuine demand."

Phillip Koech
Cohort 5, CO_2BOL-NG



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