Energy I-Corps
Annual Report
2021

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

An initiative of the U.S. Department of Energy Office of Technology Transitions

Managed by the National Renewable Energy Laboratory

ENERGY I-CORPS
U.S. Department Of Energy

U.S. DEPARTMENT OF ENERGY
Office of TECHNOLOGY TRANSITIONS

Greetings,

The U.S. Department of Energy (DOE) Office of Technology Transitions (OTT) is pleased to provide you an update on the Energy I-Corps program.

Now in its 7th year, Energy I-Corps is helping fill critical gaps in education by providing meaningful real-world opportunities for the application of commercialization and entrepreneurial skills to DOE technologies. These experiential learning opportunities are critical for bridging the many pitfalls along the research, design, demonstration, and deployment continuum.

Over the last year, OTT has continued its role as stewards of the DOE commercialization mission by expanding the reach of Energy I-Corps model. This year we met our goal of securing the participation of all 17 National Laboratories in our Energy I-Corps Satellite Funding efforts as well as launching a SBIR/STTR track. This is a program that is not only successful but expanding.

We at OTT continue to recognize that Energy I-Corps serves as a strategic equity in fulfilling the DOE mission and bolstering our role as prominent global leaders in technology. Working to support an unbroken path to commercialization of DOE-supported technologies is a key strategy for maximizing the public benefit of not only the entire national laboratory complex, but for DOE as a whole.

As in the past, this year the program has seen the emergence of new companies, new Cooperative Research and Development Agreements (CRADAs), licensing agreements, and other successful outcomes that promote the commercial potential of DOE technologies.

With the activities of Energy I-Corps, the national lab community has increased capacity to ensure that research can have impact on our innovators, in our economy, and ultimately, for the public good. In pursuit of these goals and this program's success, I invite you to connect with us, to share your ideas, and to show us how we can partner with you in this unique research enterprise.

Dr. Vanessa Z. Chan
Chief Commercialization Officer, U.S. Department of Energy
Director, Office of Technology Transitions

Contents

Researchers Avantika Singh and Nic Rorrer representing Team CYCLE during Cohort 10. *Photo by Werner Slocum, NREL.*

Team RouteE collaborates on their Buisness Model Canvas during Cohort 8 openint session. *Photo by Amy Glickson, NREL.*

"The strength of the program is the interviewing process. The Teams talk to everyone they can. They build connections and some of those connections continue long after the program is over, it's a true demonstration of symbiosis ... they learn so much. It's the magic of the program."

– Tim Beranek, Mentor

"This was a humbling experience. The program improved my communication—it was a huge learning opportunity for me. We now have a better perspective of the problem solving in industry. Solving a problem in a national lab is not the same as solving a problem in industry. It was a lot of interviews and a lot of work, but now we have lots of contacts!"

– Carl Iverson, LANL, Principal Investigator

"Energy I-Corps challenged me to think about the problems facing people/users/ stakeholders first, then design research efforts in response, rather than the inverse. This has been invaluable to my career in the national labs and my effectiveness at identifying the highest priority problems to solve."

– Jake Holden, INL, Principal Investigator

Discovering Market Pathways for National Lab Research

About Energy I-Corps

The U.S. Department of Energy invests millions of dollars every year into the national lab complex. This investment allows the national laboratories to tackle the critical scientific challenges of our time—from renewable energy to quantum computing to creating a more resilient energy grid. The discoveries and innovations being developed by the labs have an even greater impact when we invest in bringing these ideas to the market where they can benefit the nation and world. To better arm researchers to collaborate with industry and turn research and development into demonstration and deployment, DOE employs Energy I-Corps to help researchers gain industry insight to guide innovation.

Energy I-Corps invites teams of researchers to participate in an intensive two-month training during which the researchers define technology value propositions, conduct customer discovery interviews, and explore viable market pathways for their technologies. Researchers return to their labs with a framework for industry engagement to guide future research and inform a culture of market engagement within the lab environment. In this way, Energy I-Corps ensures our investment in the national labs and maintains and strengthens long-term U.S. competitiveness.

More Information

Energy I-Corps became a part of the Office of Technology Transitions (OTT) portfolio in 2018. Established within DOE in 2015, OTT is committed to expanding the commercial impact of DOE's research and development portfolio to advance the economic, energy, and national security interests of the Nation. Energy I-Corps is managed by DOE's National Renewable Energy Laboratory (NREL) in Golden, CO.

For each cohort of Energy I-Corps teams, national labs recruit researchers working on energy technologies that show potential for commercial application. Researchers selected for the program receive comprehensive training and conduct at least 75 customer discovery interviews with industry stakeholders during the course of the program. Once researchers complete the Energy I-Corps program, they will have developed important industry connections and insights to better prepare their energy technologies for market acceptance and deployment. In addition, they will have established an industry-engagement framework applicable to future research.

In response to the global COVID-19 pandemic, Energy I-Corps pivoted from its traditional in-person model to a virtual model in 2020. Since then, we've conducted Cohorts 11 through 13 virtually, and the program has continued to thrive. We look forward to returning to the in-person model upon appropriate guidance from the U.S. Department of Energy.

Energy I-Corps Instructors and NREL operations team using a virtual environment to meet during this year's program.

Curriculum

The Energy I-Corps curriculum was initially developed 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 OTT adapted NSF's nationally recognized I-Corps training to meet the needs of the lab participants.

Adjustments made to the I-Corps curriculum address the specific challenges scientists working within the national lab environment face when preparing their innovations for market, such as navigating the complexities of bundling intellectual property, licensing opportunities, and startup development pathways. As more 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 experiential training program where national lab researchers learn about industry needs and evaluate potential market applications specific to their technologies.

How many teams have gone through the program?

As of December 2021, 165 teams from 12 National Labs have participated in Energy I-Corps over the course of 13 cohorts.

What are the benefits?

Participants benefit from workshops taught by industry experts while gaining industry insights gleaned from the 75+ discovery interviews conducted during the duration of the program. The training equips national lab researchers with tools to evaluate the real-world relevance of their technologies and viable pathways to market. These tools help inform future research and potential partnerships at the national labs.

Who can participate?

DOE national lab researchers working on eligible technologies can apply. Areas of interest span the DOE investment portfolio including renewable energy, efficiency, advanced materials, nuclear energy, fossil energy, environmental management, national security, and others.

Program Office support

Submitted applications are reviewed by relevant DOE program offices. The offices of Energy Efficiency and Renewable Energy, Fossil Energy, Nuclear Energy, and Environmental Management, as well as the National Nuclear Security Administration, have supported teams.

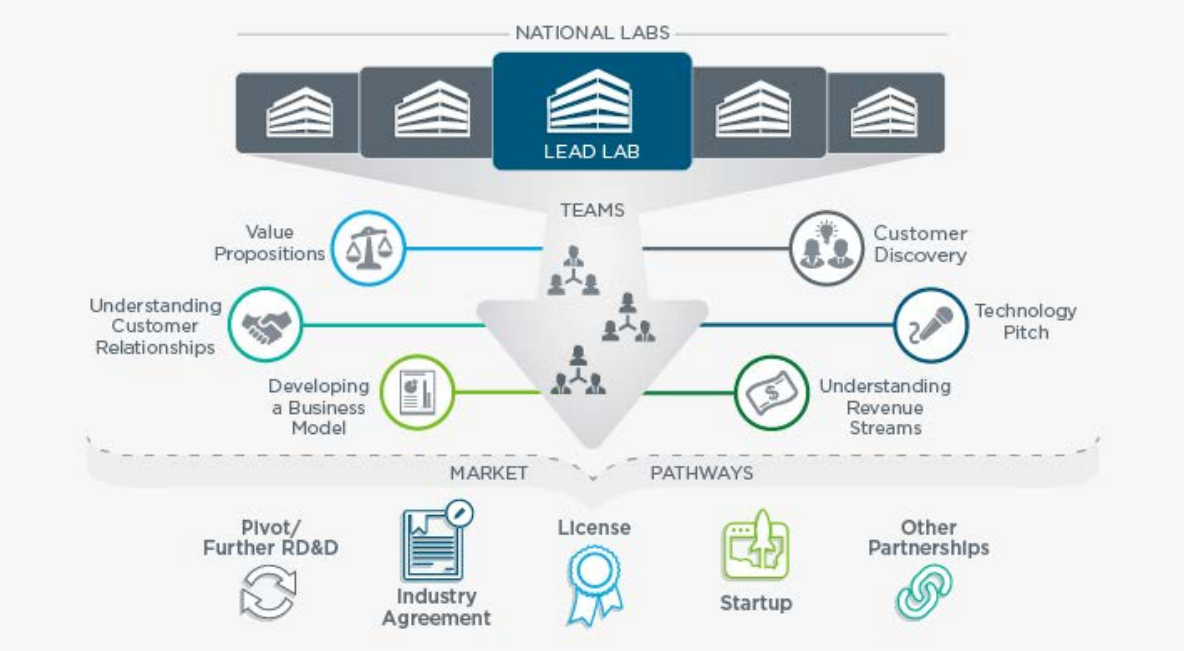
How can I learn more?

Email energyicorps@hq.doe.gov to learn more about Energy I-Corps and how to get involved.

Teams in the program 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.

Energy I-Corps technologies have collectively attracted more than $110 million in post-program funding. As of the end of the 13th training session in the fall of 2021, teams have collectively worked with more than 160 industry mentors and conducted more than 11,500 discovery interviews to determine the commercial impact of their technologies.

Program Structure



Energy I-Corps consists of four key elements:

Node: 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 and virtual instruction and presentations.

Participating Labs (aka Sites): Sites recruit, assemble, and send teams to the node for training. The Sites play an integral role in supporting teams before, 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.

Teams: Applicants apply to Energy I-Corps as a team, composed of a principal investigator with a commercially relevant technology, an entrepreneurial lead, and an industry mentor. The team works together to identify potential commercialization pathways for their selected technology, as well as opportunities where further development could lead to commercial value.

Training Program: Energy I-Corps spans seven-to-ten weeks, utilizing a custom-designed curriculum. During the program, teams attend in-person and/or virtual 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 requires a considerable amount of time spent outside of the classroom conducting customer discovery interviews.

To date, teams have participated from:

- Argonne National Laboratory (ANL)
- Fermi National Accelerator Laboratory (FNAL)
- Idaho National Laboratory (INL)
- Lawrence Berkeley National Laboratory (LBNL)
- Lawrence Livermore National Laboratory (LLNL)
- Los Alamos National Laboratory (LANL)
- National Energy Technology Lab (NETL)
- National Renewable Energy Laboratory (NREL)
- Oak Ridge National Laboratory (ORNL)
- Pacific Northwest National Laboratory (PNNL)
- Sandia National Laboratories (SNL)
- SLAC National Accelerator Laboratory (SLAC).

Energy I-Corps Teaching Team

The Teaching Team brings the Energy I-Corps curriculum to life. Energy I-Corps instructors are truly the backbone of the program and provide the time, energy and intensity needed to successfully shepherd 12-18 teams through each cohort. Instructors bring critical industry expertise to the program and introduce the language of innovation and commercialization to the participating teams. By leveraging deep technical backgrounds and advanced business experience, instructors bring their industry knowledge to each session – sharing lessons learned while incorporating program elements, professional development and commercialization pathways. Instructors leverage their business and startup experience to the benefit of the Energy I-Corps teams through instruction, one-on-one advisory sessions, presentation coaching, customer discovery review, team building and network expansion.

Alice Nichols
Entrepreneurship & Research Commercialization Specialist

Grant Warner
Director of Innovation, College of Engineering & Architecture, Howard University

Jean Redfield
CFO & Co-Founder, Fordsell Machine Products

Latane Brackett
Principal Manager, Innovation Programs, GEM i4

Max Green
Founder & Managing Member, Ratio Flux

Nakia Melecio
Senior Research Faculty, Senior Startup & Deep-Tech Catalyst, Georgia Institute of Technology

Sally Hatcher
General Partner, Buff Venture Fund

Rebecca Kauffman
Principal, Sun Raven

Tom Teynor
CEO, Bell Plumbing & Heating

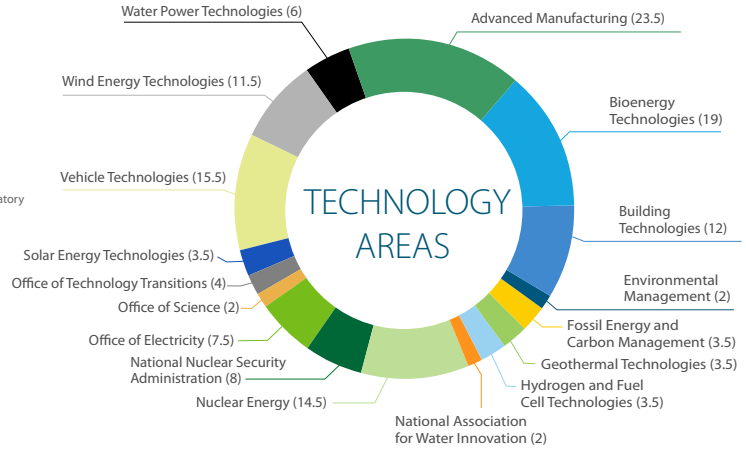
Not pictured: Steve Albers, Co-Founder & CTO, Living Ink Technologies

Quick Stats

13 COHORTS **of** ENERGY I-CORPS

165 TEAMS | **12** NATIONAL LABORATORIES

BRINGING **ENERGY INNOVATIONS** TO



LEARNING FROM

162+ Industry Mentors **and** 11,500+ 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, RE/MAX, Amazon

13 New Businesses

Thirteen teams launched new businesses based on their Energy I-Corps Technology

$110M+ Post Program Funding

Post Energy I-Corps, technologies have attracted **over $110M in post-program funding**

11,500+ Customer Discovery Interviews

70+ Licenses Executed

Our Team

Zack Baize
Energy I-Corps
Program Manager, Office
of Technology Transitions

Shelly Curtiss
Energy I-Corps
Program Manager, NREL

Lauren Magin
Energy I-Corps
Project Manager, NREL

Steve Christensen
Energy I-Corps
Project Support, NREL

Participation by Technology Program Offices

Energy I-Corps teams are funded by individual technology program offices within the U.S. Department of Energy. Labs also have the opportunity to fund teams or find industry partners to fund teams. Information provided in the following pages incorporates reporting from the first cohort pilot through Cohort 13, ending in December 2021.

Teams are denoted as half-funded by a technology office, indicated by (0.5),

Advanced Manufacturing Office (AMO)

Team	Lab	Cohort	Discovery Interviews
Micro Miners (.5)	LLNL	2	59
NanoHeatBlock	ANL	2	83
Saline Solutions	LLNL	2	50
Fermians	FNAL	3	48
E-RECOV	INL	4	57
BASIC	NREL	5	80
Electroplate (.5)	INL	5	56
Re-Light	INL	5	75
Comba	LBNL	7	79
FLO.materials	LBNL	7	78
Laser Sense	ANL	7	74
HyMag (.5)	ANL	8	107
CAN-Coatings	ANL	8	72
Shakti Power Systems	ANL	9	71
C-CHiRP	ANL	10	78
E-Ionsorb	LLNL	10	61
ARME	PNNL	11	77
Sustainability Integrators	INL	11	70
EMEE	INL	11	75
RE-Metal	INL	11	75
EC-Leach	INL	12	69
RECOVER (0.5)	PNNL	12	77
WESAP	PNNL	12	93
CO2 Converters (0.5)	ANL	12	75
Wolfram Plating	SNL	13	65
GALILEO	ANL	13	80

TOTAL TEAMS FUNDED
23.5

INVESTMENT TOTAL
$1,762,500

POST-PROGRAM FUNDING
$12,359,151

DISCOVERY INTERVIEWS
1,884

Bioenergy Technologies Office (BETO)

Team	Lab	Cohort	Discovery Interviews
High-Moisture Pelleting Process	INL	2	86
WasteNot	ANL	3	70
FiberSAS	ANL	3	76
Bio-Blend aka OptiBlend	INL	4	75
FUSS	LANL	4	71
Nitrilica	NREL	5	77
Glycoplastics	NREL	5	77
CUB Fuels	NREL	5	98
Electro-Active (.5)	ORNL	7	80
Fermley	LBNL	8	81
EcoPod	LBNL	8	77
Embodied Carbon	NREL	9	78
Grab-X	ANL	9	83
CYCLE	NREL	10	86
Scrum Ranchers	SNL	10	78
BETTER	NREL	11	73
UltraSep	LANL	12	76
Bio-NIPU (.5)	NREL	12	78
BioPack-ML	LANL	12	76
REVAMP	NREL	13	81

TOTAL TEAMS FUNDED
19

INVESTMENT TOTAL
$1,425,000

POST-PROGRAM FUNDING
$3,727,000

DISCOVERY INTERVIEWS
1,577

Participation by Technology Program Offices

Building Technologies Office (BTO)

Team	Lab	Cohort	Discovery Interviews
VOLTTRON	PNNL	2	33
MAIforBldgs	ORNL	3	74
SwitchGlaze (.5)	NREL	3	54
Thermoelectric Dryer	ORNL	4	45
Beyond Fault Detection	NREL	5	76
GreenBlox	NREL	6	74
Amber LEDs	NREL	9	77
ThermaStor	LBNL	9	78
EB Treement	FNAL	11	56
Bio-NIPU (0.5)	NREL	12	78
FreeSpace Tank Team	NREL	12	77
UBEM	LBNL	12	77
EnStore for BTMS	NREL	13	88

TOTAL TEAMS FUNDED
12

INVESTMENT TOTAL
$900,000

POST-PROGRAM FUNDING
$3,750,000

DISCOVERY INTERVIEWS
887

Office of Environmental Management (EM)

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

TOTAL TEAMS FUNDED
2

INVESTMENT TOTAL
$150,000

POST-PROGRAM FUNDING
$6,972,500

DISCOVERY INTERVIEWS
155

Hydrogen and Fuel Cell Technologies Office (HFTO) *Formerly known as Fuel Cells Technology Office (FCTO)*

Team	Lab	Cohort	Discovery Interviews
Polymer Membranes	SNL	2	41
CryoH2	LLNL	4	56
Electro-Active (.5)	ORNL	7	80
High Flying Hydrides	NREL	13	75

TOTAL TEAMS FUNDED
3.5

INVESTMENT TOTAL
$262,000

POST-PROGRAM FUNDING
$2,200,000

DISCOVERY INTERVIEWS
252

Participation by Technology Program Offices

Fossil Energy and Carbon Management (FECM)

Team	Lab	Cohort	Discovery Interviews
MECS	LLNL	4	64
CO2BOLONG	PNNL	5	75
Memzyme	SNL	5	81
CO2 Converters (0.5)	ANL	12	78

TOTAL TEAMS FUNDED
3.5

INVESTMENT TOTAL
$262,500

POST-PROGRAM FUNDING
$3,360,000

DISCOVERY INTERVIEWS
298

Geothermal Technologies Office (GTO)

Team	Lab	Cohort	Discovery Interviews
TOUGH	LBNL	2	54
Micro Miners (0.5)	LLNL	3	59
GeoCAES	NREL	4	51
Sandia Technology Systems	SNL	4	40

TOTAL TEAMS FUNDED
3.5

INVESTMENT TOTAL
$262,500

POST-PROGRAM FUNDING
$1,050,000

DISCOVERY INTERVIEWS
204

National Alliance for Water Innovation – LBNL (NAWI)

Team	Lab	Cohort	Discovery Interviews
Water-TAP3	NREL	11	72
WaterDAMS	NREL	11	82

TOTAL TEAMS FUNDED
2

INVESTMENT TOTAL
$150,000

POST-PROGRAM FUNDING
$4,000,000

DISCOVERY INTERVIEWS
154

Participation by Technology Program Offices

Office of Nuclear Energy (NE)

Team	Lab	Cohort	Discovery Interviews
Quake	INL	2	35
Monolith	SNL	3	37
Change Detection Systems	INL	4	71
Dry Cask Vital Signs	INL	4	51
AMAFT	INL	5	76
Electroplate (.5)	INL	5	56
EMRLD	INL	5	76
4Cs	INL	6	38
ELINA	INL	6	102
AxiVis	INL	7	90
HOT	INL	7	75
M2LD - Mobile Modified Linear Delta	INL	8	116
Rotoro EH?	INL	9	77
Thermal Sound On	INL	10	73
Mesofluidics	PNNL	13	63

TOTAL TEAMS FUNDED
14.5

INVESTMENT TOTAL
$1,087,500

POST-PROGRAM FUNDING
$8,538,000

DISCOVERY INTERVIEWS
1,036

National Nuclear Security Administration (NNSA)

Team	Lab	Cohort	Discovery Interviews
Enduring Advantage	SNL	10	75
UXI	SNL	10	81
HECATE	SNL	11	81
CAP Fastener	SNL	11	60
MAD3	SNL	12	74
EPDR	SNL	12	71
ThermaSET	SNL	13	102
Fractured	SNL	13	76

TOTAL TEAMS FUNDED
8

INVESTMENT TOTAL
$600,000

POST-PROGRAM FUNDING
$6,155,000

DISCOVERY INTERVIEWS
620

Office of Electricity (OE)

Team	Lab	Cohort	Discovery Interviews
DCAT	PNNL	6	75
Glass Paper	INL	8	75
EnergyBlox	SLAC	8	59
EcoBlock	LBNL	9	75
DER-CAM	LBNL	9	78
TRAST	PNNL	11	78
THERMS (.5)	SNL	12	68
C3D	INL	13	87

TOTAL TEAMS FUNDED
7.5

INVESTMENT TOTAL
$562,500

POST-PROGRAM FUNDING
$1,770,000

DISCOVERY INTERVIEWS
595

Participation by Technology Program Offices

Office of Science (OS)

Team	Lab	Cohort	Discovery Interviews
SuperChips	LBNL	11	72
INN-Design	NREL	12	69

TOTAL TEAMS FUNDED
2

INVESTMENT TOTAL
$150,000

POST-PROGRAM FUNDING
$600,000

DISCOVERY INTERVIEWS
141

Solar Energy Technologies Office (SETO)

Team	Lab	Cohort	Discovery Interviews
SolGuard	NREL	2	51
Hydro Scanner	LLNL	3	44
HALO	NREL	6	83
THERMS (.5)	SNL	12	68

TOTAL TEAMS FUNDED
3.5

INVESTMENT TOTAL
$262,500

POST-PROGRAM FUNDING
$28,605,000

DISCOVERY INTERVIEWS
246

Vehicle Technologies Office (VTO)

Team	Lab	Cohort	Discovery Interviews
Smart Charge Adapter	ANL	2	71
Cellsage	INL	4	44
Lubricant Engineers	PNNL	4	75
MicroWatts	NREL	5	75
FAST	PNNL	6	91
Beyond Lithium Ion Batteries	ANL	7	82
routeE	NREL	8	80
BonD-Northwest: Bonding on Demand	PNNL	8	93
Resilicoat	ANL	9	82
HeadCount	NREL	10	74
SWaP Electronics	SNL	11	47
RECOVER (0.5)	PNNL	12	77
e-Mission	NREL	12	78
Athena	NREL	13	82
DFI	SNL	13	76
Lithium Battery	INL	13	75

TOTAL TEAMS FUNDED
15.5

INVESTMENT TOTAL
$1,162,500

POST-PROGRAM FUNDING
$3,228,323

DISCOVERY INTERVIEWS
1,202

Participation by Technology Program Offices

Wind & Water Power Technologies Office (WWPTO)

Team	Lab	Cohort	Discovery Interviews
DLR aka GLASS	INL	3	72
Autonomous Concrete Printing	NREL	4	79
RF Tag	PNNL	4	75
WindSOCK	NREL	5	75

TOTAL TEAMS FUNDED
4

INVESTMENT TOTAL
$300,000

POST-PROGRAM FUNDING
$2,315,000

DISCOVERY INTERVIEWS
301

Water Power Technologies Office (WPTO)

Team	Lab	Cohort	Discovery Interviews
IHESS-2020	INL	11	72
SLIC	PNNL	11	61
IrrigationViz	PNNL+INL	12	96
GLIDES	ORNL	13	75
Lab-on-a-Fish	PNNL	13	52

TOTAL TEAMS FUNDED
5

INVESTMENT TOTAL
$375,000

POST-PROGRAM FUNDING
$2,746,000

DISCOVERY INTERVIEWS
356

Wind Energy Technologies Office (WETO)

Team	Lab	Cohort	Discovery Interviews
HyMag (0.5)	ANL	8	107
SpiderFloat	NREL	8	77
MADe3D	NREL	9	78
SAND	INL	9	77
ThermalTracker-3D	PNNL	9	56
HOPP	NREL	11	44
OpenOA	NREL	11	44
RBLO	NREL	12	57
TAP	NREL	12	76

TOTAL TEAMS FUNDED
8.5

INVESTMENT TOTAL
$637,500

POST-PROGRAM FUNDING
$3,870,000

DISCOVERY INTERVIEWS
616

Participation by Technology Program Offices

Lab Funded Teams

Team	Lab	Cohort	Discovery Interviews
CI-ReClad	ORNL	1	75
Dynamic Aperture	ANL	1	23
Eco-Snap	NREL	1	45
HYDRA	PNNL	1	40
Sub Lambda	PNNL	1	13
Tunation	ORNL	1	86
WISDEM	NREL	1	80
BioAlchemy	LBNL	2	51
Biolyst Renewables	NREL	2	81
Evodia	LBNL	2	45
Resin Wafer Electrodeionization	ANL	2	75
SolGuard (0.5)	NREL	2	51
SwitchGlaze (0.5)	NREL	3	54
Oleo Sponge	ANL	6	62

TOTAL TEAMS FUNDED
13

INVESTMENT TOTAL
$975,000

POST-PROGRAM FUNDING
$11,409,114

DISCOVERY INTERVIEWS
781

Office of Technology Transitions

Team	Lab	Cohort	Discovery Interviews
UTS - Ultrasonic Technology Solutions	ORNL	10	76
Microwave Assisted Catalysis (MAC)	NETL	12	69
memQ	ANL	13	87
Hyper Team	NETL	13	75

TOTAL TEAMS FUNDED
4

INVESTMENT TOTAL
$300,000

POST-PROGRAM FUNDING
$1,290,000

DISCOVERY INTERVIEWS
307

Participation by Technology Program Offices

First Cohort Pilot (Pilot)

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

TOTAL TEAMS FUNDED
10

INVESTMENT TOTAL
$750,000

POST-PROGRAM FUNDING
$2,897,000

DISCOVERY INTERVIEWS
606

Privately Funded

Team	Lab	Cohort	Discovery Interviews
Opt-grid	NREL	6	87

TOTAL TEAMS FUNDED
1

INVESTMENT TOTAL
$75,000

POST-PROGRAM FUNDING
$246,861

DISCOVERY INTERVIEWS
87

Participation by Technology Program Offices

Energy I-Corps teams have been funded by the Pilot, individual National Laboratories, various DOE offices, and private entities. The data shown below highlights the initial funding entities' investments to enable teams to participate in Energy I-Corps, and the post program funding teams have reported.

Technology Office Funding

DOE Funding Office	Investment	Post-Program Funding
AMO	$1,762,500	$12,359,151
BETO	$1,425,000	$3,727,000
BTO	$900,000	$3,750,000
EM	$150,000	$6,972,500
HFTO	$262,000	$2,200,000
FECM	$262,500	$3,360,000
GTO	$262,500	$1,050,000
NAWI-LBNL	$150,000	$4,000,000
NNSA	$600,000	$6,155,000
NE	$1,087,500	$8,538,000
OE	$562,500	$1,770,000
OS	$150,000	$600,000
SETO	$262,500	$28,605,000
VTO	$1,162,500	$3,228,323
WWPTO	$300,000	$2,315,000
WPTO	$375,000	$2,746,000
WETO	$637,500	$3,870,000
OTT	$300,000	$1,290,000
Total	**$10,612,000**	**$96,535,974**

INVESTMENT TOTAL

$12,412,000

POST-PROGRAM FUNDING

$111,088,949

	Investment	Post-Program Funding
Lab Funded	$975,000	$11,409,114
First Cohort Pilot	$750,000	$2,897,000
Privately Funded	$75,000	$246,861
Total	**$1,800,000**	**$14,552,975**

Laboratory Statistics

Lab	Teams Funded	Post-Program Funding Received	Customer Discovery Interviews
ANL	20	$6,703,224	1440
FNAL	3	$950,000	182
INL	30.5	$13,704,000	2242
LANL	3	$577,000	147
LBNL	15	$13,047,500	1068
LLNL	7	$5,240,000	347
NETL	2	$0	144
NREL	39	$48,485,975	2867
ORNL	7	$6,044,000	511
PNNL	19.5	$9,232,250	1287
SNL	18	$7,105,000	1228
SLAC	1	$0	59

Cohort Statistics

Cohort	Teams Funded	Post-Program Funding	Customer Discovery Interviews
Pilot	3	$250,000*	225
1	14	$3,701,000	743
2	14	$19,385,338	815
3	8	$3,615,000	475
4	15	$35,575,000	937
5	12	$1,248,000	916
6	8	$10,244,361	606
7	8	$11,457,000	636
8	10	$5,165,000	837
9	12	$2,795,000	910
10	10	$7,370,000	763
11	17	$7,671,000	1139
12	18	$2,862,250	1359
13	16	$0	1237

For more information, visit: energyicorps.energy.gov

* Pilot Post-Program funding not included in Total Post-Program Funding.

Post-Program Funding

Team Post-Program Funding Reported through December 2021

Team Name	Post-Program Funding Received	Funded through Energy I-Corps by:
ARAI	$161,000	Pilot
Eco-Snap	$200,000	NREL
SonicLQ	$285,000	Pilot
STARS	$2,001,000	Pilot
Switchable Polarity Solvents	$450,000	Pilot
Tunation	$154,000	ORNL
WISDEM	$450,000	NREL
Biolyst Renewables	$7,404,114	NREL
High-Moisture Pelleting Process	$1,400,000	BETO
Micro Miners	$900,000	AMO; GTO
Resin Wafer Deionization	$1,701,000	ANL
NanoHeatBlock	$1,567,026	AMO
Polymer Membranes	$700,000	FCTO
QUAKE	$2,820,000	NE
Saline Solutions	$1,500,000	AMO
Smart Charge Adapter	$1,393,198	VTO
GLASS aka DLR	$1,315,000	WWPTO (wind)
SwitchGlaze	$2,300,000	BTO, NREL
MECS	$2,840,000	FECM
e-Recov	$280,000	AMO
GeoCAES	$600,000	GTO
Change Detection Systems	$775,000	NE
HALO	$28,480,000	SETO
RF Tag	$1,000,000	WWPTO (water)
Thermoelectric Dryer	$1,600,000	BTO
EMRLD	$625,000	NE
AMAFT	$103,000	NE
CO2BOLONG	$520,000	FECM
Gamma Rayality	$6,022,500	EM
Opt-grid	$246,861	IP Group (Private)
4Cs	$1,500,000	NE
ELINA	$2,115,000	NE
DCAT	$10,000	OE
Oleo Sponge	$350,000	ANL
PureBeam	$950,000	EM
HOT	$600,000	NE
Electro-Active	$3,000,000	FCTO + BETO
COMBA	$3,600,000	AMO

Post-Program Funding

Team Post-Program Funding *(continued)*

Team Name	Post-Program Funding Received	Funded through Energy I-Corps by:
LaserSense	$807,000	AMO
FLO.materials	$2,500,000	AMO
CAN-Coatings	$600,000	AMO
Glass Paper	$1,560,000	OE
routeE	$855,000	VTO
Fermley	$250,000	BETO
SpiderFloat	$1,900,000	WETO
Amber LEDs	$1,000,000	BTO
EcoBlock	$75,000	OE
MADe3D	$800,000	WETO
ThermalTracker-3D	$920,000	WETO
UTS – Ultrasonic Technology Solutions	$1,290,000	OTT
Enduring Advantage	$380,000	NNSA
UXI	$5,700,000	NNSA
Water-TAP3	$4,000,000	NAWI-LBNL
OpenOA	$250,000	WETO
ARME	$75,000	AMO
Team SLIC	$2,746,000	WPTO
Superchips	$600,000	OS
UltraSep	$577,000	BETO
RECOVER	$1,960,250	AMO + VTO
THERMS	$250,000	SETO + OE
MAD3	$75,000	NNSA
Total	**$111,088,949**	

13 cohorts completed as of Fall 2021

Innovations have spanned 18 DOE program areas

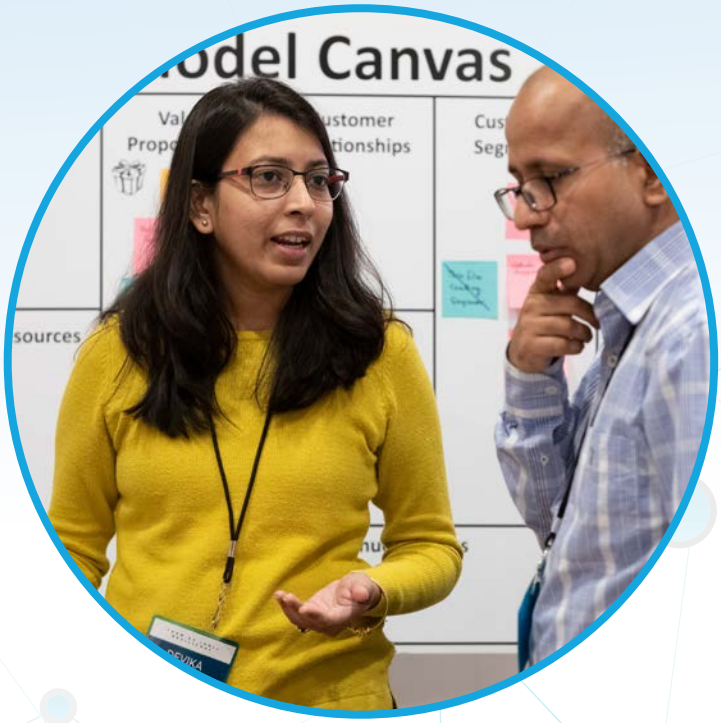
including 165 teams from 12 National Labs

Teams have conducted more than 11,500 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, RE/MAX, and Amazon

160+ industry mentors and instructors involved

Case Studies

Energy I-Corps aims to accelerate the deployment of energy technologies by encouraging U.S. DOE laboratory scientists and engineers access to direct market feedback for their technology offerings. 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 that have participated in the Energy I-Corps program.



Biolyst Renewables

National Renewable Energy Laboratory
Cohort 2

Problem/Opportunity

The original Biolyst Renewables team developed technologies to produce adipic acid renewably at a competitive cost with a smaller environmental footprint than petroleum-derived adipic acid. While the project did not materialize for Biolyst, other opportunities emerged. One team member, Derek Vardon, left NREL to become the chief technical officer of Alder Fuels, developing sustainable aviation fuel; another, Chris Johnson, is developing breakthrough biological processes for plastics recycling; and the third, Steven Christensen, is pursuing solutions for energy storage with hydrogen.

Industry Focus

Using the Energy I-Corps approach, in 2017, Christensen secured an award offered through a DOE Hydrogen and Fuel Cell Technology Office (HFTO) consortium on materials for hydrogen storage to fund a seed project. That project yielded results that have the potential to develop into a low-cost hydrogen fuel source.

Recognizing a market opportunity, Christensen partnered with colleague Katherine Hurst, a Cohort 13 graduate with the High Flying Hydrides team, to identify companies with applications for solid hydrogen fuel sources. Notably, they connected with Honeywell Aerospace and received a DOE TCF award to qualify the technology for development as fuel for hydrogen-powered drones. The project, titled FueL Additives for Solid Hydrogen or FLASH, launched in December 2021.

Solution

Developing a hydrogen rechargeable FLASH would address potential market needs for hydrogen storage. Thus, at the same time the TCF with Honeywell was awarded, team members from Biolyst Renewables and High Flying Hydrides secured internal funding at NREL to develop renewable pathways to regenerate FLASH with hydrogen. Energy I-Corps training enabled the team to write a proposal demonstrating the value of a reversible FLASH to NREL reviewers, a process substantially different than connecting with industry.

The Energy I-Corps entrepreneurship training made another significant project possible in 2021. The HFTO program in materials hydrogen storage asked for researchers who could secure industry participation. Hurst and Stevenson connected with GKN Powder Metallurgy in an effort to validate their metal hydride technology for stationary energy storage.

Original Biolyst Renewables team members (from left to right): Chris Johnson, Steve Christensen, and Derek Vardon.
Photo by John De LaRosa, NREL.

The team partnered with GKN to win a HFTO CRADA (cooperative research and development agreement) project for $2.6 million to validate the technology at 20 MWh scale with the newly-developed ARIES (Advanced Research on Integrated Energy Systems) platform at NREL. In addition, Southern California Gas Company, a major California utility, asked to join the project and will contribute funding to the CRADA.

The influence of Energy I-Corps can be felt from discussions with industry partners to improved proposal writing, to the incorporation of a customer discovery process into the demonstration phase of the project. Although Biolyst's initial project did not move forward, the process opened many other doors for the researchers.

Where are they now? Post-Program Advancements

Patents

Nanostructured Composite Metal Hydrides. U.S. Patent 10,751,795, issued August 25, 2020.

Catalysts, Systems, and Methods for the Conversion of Biomass to Chemicals. U.S. Patent 10,894,760, issued January 19, 2021.

For more information or to request speakers, Steve Christensen, steven.christensen@nrel.gov.

CO2BOL-NG Acid Gas Separation Technology

Pacific Northwest National Laboratory
Cohort 5

Problem

Global demand for liquefied natural gas is around 400 million metric tonnes per year and is expected to increase to 500 tonnes by 2030. The industry is valued in the billions of dollars per year and toxic acid gas impurities present at parts per million (ppm) levels can 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 to operate the costly facilities.

Researchers at PNNL have developed a reusable organic liquid that can pull harmful gases such as CO_2 or H_2S (hydrogen sulfide) out of industrial processes, natural gas streams, and emissions from power plants. The process could directly replace current methods and capture double the volume of harmful gases in a way that uses no water, consumes less energy, and saves money.

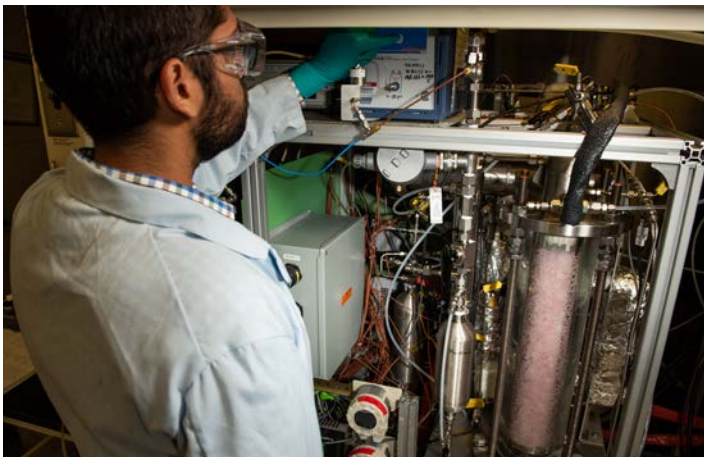
Industry Focus

Producers, natural gas refineries, power plants:

- Need costly, large, centralized processing facilities to remove impurities from gas streams
- Produce hundreds of millions of standard cubic feet a day of gas requiring treatment
- Use highly corrosive acid gases and water-based solvents
- Currently remove ppm-level impurities (CO_2, H_2S, COS [carbonyl sulfide], H_2O) with costly processes that use millions of gallons of solvents annually

Solution

Separating ppm-level impurities requires strong chemical complexing agents, often liquids for their ease of use. These solvent-based processes most commonly 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



PNNL researcher Dushyant Barpaga operates the Laboratory Continuous Flow System, which can evaluate typical, analogous industrial absorption and stripping operations such as novel CO_2 capture solvents, packing materials, and a wide range of process conditions at a much smaller scale than previously possible. *Photo by Andrea Starr, PNNL.*

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 readily regenerate under mild conditions, reducing energy demands. The CO_2BOL platform can be applied to any acid gas, making it the "Swiss Army knife" of chemical solvents because of its ability to tailor the specific chemistry to the specific gas separation application.

Where are they now? Post-Program Advancements

Through the customer discovery process and a total of 77 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 post-program continued R&D with IP-Group
- Participated in National Lab Pitch Competition at LLNL in November 2017.

Speaking Engagements:

- Gordon Research Conference, CO_2 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 to request speakers, contact David Heldebrant (david.heldebrant@pnnl.gov), Phillip Koech (phillip.koech@pnnl.gov), or visit www.pnl.gov.

Electro-Active Technologies

Oak Ridge National Laboratory
Cohort 7

Problem/Opportunity

Forty percent of food is wasted today, which is both a huge problem and a huge opportunity. Meanwhile, the high cost of hydrogen and lack of renewable sources is restricting growth of zero-emission fuel cells. The Electro-Active system provides a solution to both issues, converting waste into affordable, renewable hydrogen. This technology can reduce greenhouse gas emissions by 66% compared to steam methane reforming, and can provide a negative carbon pathway to hydrogen, with the potential to remove 82 tons of CO_2e per ton of hydrogen generated. Additionally, the system can achieve twice the electrical efficiency of water electrolysis. It is a pathway to the sustainable economy of the 21st century.

Industry Focus

This technology enables hydrogen-fueled equipment such as forklifts, class 8 trucks, generators, personal vehicles, city fleets, and maritime applications.

Solution

Key offerings:

e-H_2Gen: Modular renewable hydrogen generation system using organic waste, adaptable to low- and high-volume customers that can be deployed on-site with large waste generators, waste haulers, and municipalities. Additional coproducts include a residual solids stream for use in composting, animal feed, and regenerative agriculture, as well as a nutrient-rich liquid that can also be utilized in regenerative agriculture or for urban greenspaces.

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

Alex Lewis and Abhijeet P. Borole (speaking), representing Oak Ridge National Laboratory, present Electro-Active, a modular system that can be placed on-site to convert waste into renewable hydrogen.
Photo by Amy Glickson, NREL.

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

-Peter Klauer, CAISO

Where are they now? Post-Program Advancements

- Accepted into the Innovation Crossroads program at Oak Ridge National Lab
- Raised $1.6 million in private capital and recently received another DOE grant working with Southern Company on further scale-up and demonstration
- Participated in a number of accelerators, including IndieBio, H_2 Refuel, Plug and Play, Valley Ventures, Scale For ClimateTech, Smarty City X, and Startup Bootcamp
- Currently seeking further investment and pilot demonstration opportunities.

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

Electronic Instructions for Nuclear Applications (ELINA)

Transitioning From Paper to a Dynamic Instructions Solution

Idaho National Laboratory

Cohort 6

Problem/Opportunity

Many nuclear power plants rely on inefficient and bulky paper copies of procedures and work instructions. Some have adopted electronic work packages—paper documents converted to PDFs or similar digital formats—in an attempt to streamline work processes, improve efficiency, and reduce costs. Unfortunately, the industry did not experience the anticipated human performance improvements of transitioning from paper to digital information.

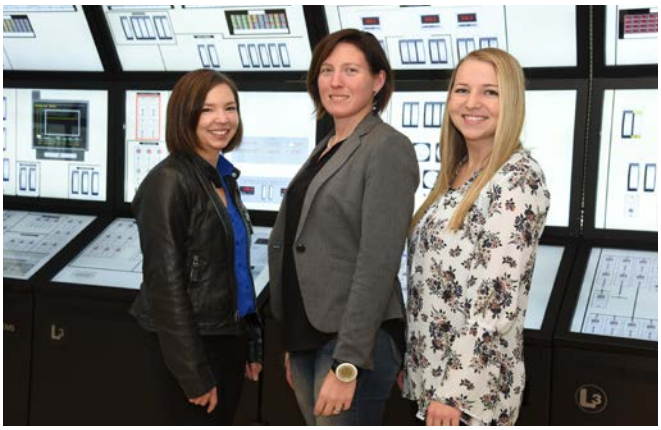
Industry Focus

INL and NextAxiom Technology, Inc. formed a partnership in 2018 to develop a dynamic instructions solution that guides workers through correct task paths based on decisions and inputs recorded as the work proceeds. Additional relevant information is available at the worker's fingertips whenever it is needed. This strategy increases the time employees devote to work and reduces waiting time and administrative burdens. A mature, commercially available dynamic instructions technology enables more effective and efficient completion of work in nuclear power plants, which reduces costs. This work was funded through the U.S. Department of Energy Office of Technology Transitions Technology Commercialization Fund.

Where are they now? Post-Program Advancements

Patents

- Method To Convert Written Instructions To Structured Data, And Related Computer Based Context Sensitive Procedures That Use The Same. U.S. Patent 11,126,789, issued September 21, 2021.
- Systems, Devices, and Methods for Performing Augmented Reality Responsive to Monitoring User Behavior. U.S. Patent Application. 62/741,359, filed October 4, 2018. Patent Pending.



The ELINA team: Katya LeBlanc, Johanna Oxstrand and Rachael
Photo by Chris Morgan, INL.

Copyrights

- CW-17-09-SEIDR. Computer-Based Procedure Execution Software (SEIDR). Copyright asserted July 2017.
- CW-20-20-OPENS. Operating Procedure Extender for Novel Systems (OPENS). Copyright asserted February 2021.

Standards

- Oxstrand, J., and Hargett, D. (Eds.) 2017. PPA AP-907-005.001, Rev. 0. Functional Requirements For Advanced And Adaptive Smart Documents. Procedure Professionals Association.
- Hargett, D., and Oxstrand, J. (Eds.) (2020) PPA AP-907-005.002, Rev. 0. Dynamic Instruction Set Editor Functional Requirements and Implementation Considerations. Procedure Professionals Association.
- Hargett, D., and Oxstrand, J. (Eds.) (2020) PPA AP-907-005.003, Rev. 0. Common Dynamic Instruction Model (CDIM). Procedure Professionals Association.

Industry Initiatives

- INL initiated and led two large industry initiatives
  - Nuclear Electronic Work Packages-Enterprise Requirements (NEWPER)
  - Dynamic instructions editing tool requirements (DIRECTOR)
- Co-developed a solution with NextAxiom that was deployed at NextEra Energy and Ontario Power Generation, and NextAxiom is expected to sign with a large North American nuclear utility this month
- INL team participated in Trailhead East, INL's incubator and follow-up opportunity to Energy I-Corps.

For more information or to request speakers, contact Johanna Oxstrand, johanna.oxstrand@inl.gov, (208) 526-2064.

Gamma Reality Inc.

Safer, more efficient radiation detection

Lawrence Berkeley National Laboratory
Cohort 6

Background

"Where can I get one?"

This is a question that the Lawrence Berkeley National Laboratory (Berkeley Lab) team developing 3D radiation mapping technologies heard repeatedly from potential end users at demonstrations and measurement campaigns all over the world. At the time, only a single research prototype existed, but the question stuck with team members as they conducted R&D and explored commercialization pathways.

In fall 2017, Team Gamma Rayality from Berkeley Lab participated in Cohort 6 of the Energy I-Corps program. The team consisted of Principal Investigator Dr. Andy Haefner and Entrepreneurial Lead Erika Suzuki. Both went on to co-found Gamma Reality Inc. (GRI), which launched in early 2020. Dr. Andy Haefner developed the scene data fusion and 3D radiation mapping software as part of his Ph.D. research before growing it into a research portfolio at Berkeley Lab and leading development of the LAMP (Localization and Mapping Platform) system with a team of researchers, including co-founders, Dr. Ryan Pavlovsky and Dr. Kai Vetter.

Problem/Opportunity

Specialized equipment is required to identify and locate radiological/nuclear material and map contamination. Most available commercial systems require static measurements (you have to place the system in a single location and wait for it to collect data), employ manual location-triangulation methods that are error-prone, require a human to hold and operate the system, and lack contextual sensors (such as visual cameras or LiDAR [light detection and ranging]) that provide environmental information about an area of interest). As a result, users of these systems typically need to take multiple measurements of an area for tens of minutes at a time and track the location of the system manually—risking longer exposure to radioactive material—and are limited to ground measurements.

Erika Suzuki at a demonstration of the research prototype on an unmanned system. *Photo by Erika Suzuki.*

Industry Focus

This technology has application opportunities in defense, nuclear power plant operations, 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 off-the-shelf components (e.g., visual camera, LiDAR, GPS [global positioning system]) and scene data fusion software to visualize radioactive and nuclear sources in 3D and in real time. The scene data fusion software on LAMP fuses and automatically correlates radiation data with 3D models of an area in real time to show the location of radiological/nuclear material and map radioactive contamination. The intuitive 3D mapping shows features in the local environment, such as cars, buildings, people, and other objects in addition to highlighting the location of the radioactive source and doesn't require a scientist to interpret and communicate. Development of this technology is supported by the Defense Threat Reduction Agency and enables:

- **More efficient operations.** LAMP is fully mobile and provides actionable information in real time, enabling faster decision making.
- **Safer operations.** LAMP can be remotely deployed on both ground robots and unmanned aerial systems (UAS—drones, for example) to map radioactive hazards.
- **Improved situational awareness.** LAMP enables visualization of radiological/nuclear material in 3D, which provides greater detail about the size, location, and other characteristics of a radioactive source.

Gamma Reality Inc.

(continued)

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.

Two versions of LAMP are currently commercially available for different applications. LAMP-Imager features higher resolution gamma-ray imaging and LAMP-Mapper provides nonimaging gamma-ray mapping as well as a dual gamma-ray and neutron mapping option.

Where are they now? Post-Program Advancements

Post-Program Advancements

GRI is now a company with seven employees and the LAMP system is commercially available. GRI has several government-funded projects, including a Small Business Innovation Research grant, and is also pursuing commercial sales. GRI has licensed the LAMP technology from Berkeley Lab, where research in this area continues. GRI provides real-time, mobile, 3D radiation mapping capabilities deployable in handheld mode, on unmanned robotic platforms (unmanned aerial vehicles or unmanned ground vehicles), and on other vehicles to enable safer, more efficient, and more dynamic radiation detection missions. The company's core capabilities include multi-sensor data fusion and data analysis, 3D radiation mapping with situational awareness sensors, and integration of multi-sensor 3D radiation mapping systems with robotic platforms. GRI provides gamma-ray imaging, non-imaging, and dual neutron and gamma-ray mapping capabilities based on user needs for applications including nuclear security, emergency response, safeguards, defense, decontamination, and more. The GRI team has more than a decade of experience developing and integrating hardware and software for multi-sensor systems, as well as designing and building custom radiation mapping systems.

For more information, visit www.gammareality.com.

Gamma Reality's LAMP-Imager. *Photo by Gamma Reality Inc.*

General Line Ampacity State Solver (GLASS)

Idaho National Laboratory
Cohort 3

Problem /Opportunity

The U.S. electrical grid is in the middle of a dramatic transformation. As utilities consider replacing aging infrastructure and incorporating renewables from remote locations, unlocking extra capacity within existing transmission lines can immediately and cost-effectively increase the capacity, efficiency, and reliability of existing power lines.

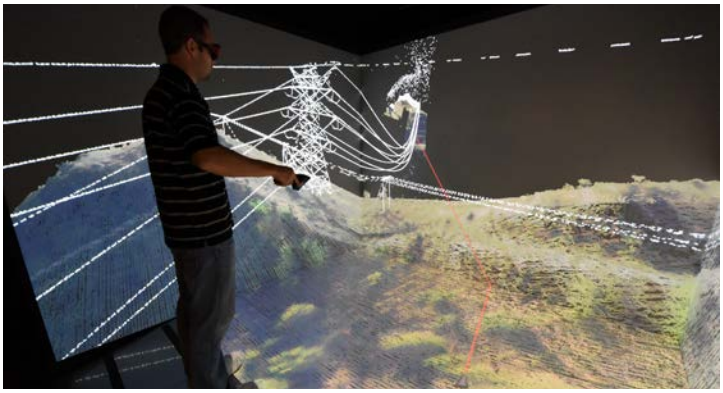
Industry Focus

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 improve grid capacity. Static line ratings use 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 inform system planners and grid operators about available transmission capacity beyond traditionally calculated static line ratings.

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 these must be factored in for operators to quickly and safely make decisions about limiting power flow.

Solution

INL's GLASS innovation offers the potential to safely provide more robust line ampacities by using real-time operating conditions and predicted weather information rather than overly conservative static line rating assumptions. It uses commercially available weather monitors mounted on industry-informed brackets developed at INL, in combination with computational fluid dynamics-enhanced weather analysis and dynamic line rating software.



INL researcher Jake Gentle conducts critical infrastructure analysis using INL's General Line Ampacity State Solver (GLASS) software. *Photo by Chris Morgan, INL.*

Where are they now? Post-Program Advancements

- 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, the largest regulated electric transmission company in Alberta, Canada, on a field study of four transmission line segments
- GLASS named a finalist for the 2017 and 2018 R&D 100 Awards
- INL awarded a TCF award from DOE's OTT, and collaborated with an industry partner during fiscal years 2018–2020
- GLASS awarded Idaho Innovation Award's "Early-Stage Innovation of the Year" for 2021.

Speaking Engagements:

- INL speakers have given more than 65 presentations in more than seven countries.

Licensing:

GLASS has been exclusively licensed to WindSim Power. They recently launched their "WindSim Power Line" product, which is based on GLASS. More information can be found at https://windsim.com/power-line/windsim-power-line/.

Video:

https://youtu.be/X8IaVYN6tUw

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

High Temperature Irradiation Resistant Thermocouple (HTIR-TC)

Idaho National Laboratory

Cohort 7

Problem /Opportunity

Nuclear reactor designs are embracing new developments such as utilizing process heat for advanced manufacturing, hydrogen production, and desalination—all while maintaining a low carbon footprint. The critical temperatures necessary to drive each of these concepts, such as those within the protective fuel cladding, need to be measured directly, accurately, and reliably. To date, there is no direct method of sustainably (i.e., no signal drift) measuring the temperatures of nuclear fuel.

Between now and 2030, new reactors from at least three companies are expected to come online, operating at lower pressures, but much higher temperatures than those in current operation. These new reactor designs offer safer and more economical power production, but will require new fuels, cladding, and structural materials.

With temperatures exceeding 1,100°C radiation-tolerant and/or hardened materials must be utilized to prevent the signal drift (or decalibration) of instruments. Further, the constant shutdown and restarting of nuclear reactors for refueling or reactor tests puts sensors through large temperature transients, leading to breakage of wires, as repetitive thermal expansion cannot keep up with the demand.

Industry Focus

Reactor engineers will need detailed data to characterize fuels and materials in extreme conditions, and the Nuclear Regulatory Commission will require exact and exhaustive test data before certifying that they are safe to use. Also, once in operation, to maintain the safety and long-term reliability of these reactors, new temperature sensors and methods for in situ measurements will be necessary.

Solution

High Temperature Irradiation Resistant Thermocouples (HTIR-TCs) are sophisticated thermocouples developed at INL's High Temperature Test Laboratory that measure temperature in the world's harshest environments. The HTIR-TC has been experimentally proven to withstand temperatures up to 1,510°C and neutron flux levels 10 times that of a typical commercial pressurized water reactor. This experiment is still ongoing at the time of this writing, but over the past year, the HTIR-TCs in current use have shown very little signal drift. Further, reactor shutdowns and restarts have put the HTIR-TCs through the most extreme temperature transients—to no avail, because the HTIR-TCs keep reporting reliable and consistent temperatures.

A test module with simulated fuel pins containing HTIR-TCs installed
Photo by Richard Skifton.

Where are they now? Post-Program Advancements

INL researchers have:

- Been awarded the prestigious "R&D 100" award for 2019 www.rdworldonline.com/2019-rd-100-award-winners-unveiled/
- Been awarded a TCF with Idaho Laboratories Corporation through the U.S. Department of Energy Office of Technology Transitions
- Completed a US-EURATOM International Nuclear Energy Research Initiative to work internationally with University of Cambridge's Department of Materials Science and Metallurgy to discuss the direct application of HTIR-TCs on Gen IV reactor designs
- Collaborated with Boise State University's Micron School of Materials Science and Engineering over the past two years to continually improve upon the HTIR-TC's past performance
- Licensed HTIR-TC to an industry partner, as well as two post-program technologies.

Video:

www.youtube.com/watch?v=L4gtwJsKKx4

For more information or to request speakers, contact the inventor and principal investigator, Richard Skifton, at Richard.Skifton@inl.gov or (208) 526-2696.

Iris Light Technologies, Inc. (formerly LaserSense)

Argonne National Laboratory

Cohort 7

Problem/Opportunity

Light chips are booming, but the lasers aren't cutting it.

Silicon photonics ("light chips") are an enabling technology platform powering applications in optical communications, autonomous vehicles, drone sensing, and the Internet of Things (IoT). The technology in these markets is evolving from large, expensive systems towards photonic integrated circuits (PICs), which contain full optical systems on thumbnail-size chips and cost a fraction of their bulky predecessors. PICs leverage the tremendous manufacturing infrastructure of semiconductor electronics to produce huge volumes compared to traditional optics manufacturing. These cost benefits have resulted in >45% year-on-year growth in the past decade.

However, the silicon photonics industry is held back by complicated manufacturing and a constrained supply chain. Today, chip-design companies are required to source silicon photonic chips from one foundry and separate laser chips from a second foundry due to lack of on-chip laser integration. There is no open-access foundry with on-chip lasers. Moreover, a single laser typically comprises at least 25% of the total module cost, limiting the number of lasers per chip, and therefore chip value, due to limited functionality. This bottleneck holds back broad adoption of light chips in high volume applications demanding lower price points.

"Unless this [laser] gap is resolved in the next 5-10 years, a showstopper will arise for major sectors of the silicon photonics markets." - **2020 IPSR Roadmap**

Industry Focus

Iris integrates lasers on-chip, with broad spectral coverage

Iris Light's mission is to accelerate broad adoption of light chips by lowering manufacturing barriers. Iris Light's "secret sauce" is an on-chip laser technology created from printed nanomaterial 'inks' enabling high-volume, wafer-scale production of photonic chips. In an industry where access to laser colors drives business opportunity and market segments, Iris Light hits the whole rainbow with color-tunable inks. With these two core differentiators of broad spectrum and on-chip laser production, Iris Light is the only company positioned to cover the growing needs of spectral coverage in silicon photonics.

Iris Light founder Chad Husko holding a 12-inch (300-mm) silicon wafer composed of hundreds of chips. Iris Light on-chip lasers are made by depositing proprietary photonic ink onto the surface of a pre-patterned wafer like the one shown here. *Photo by: Mary Reid Ervin.*

Iris solves the most critical unmet industry need and is positioned to capture a significant share of the current $4 billion/year market that is expected to exceed $18 billion by 2025.

Solution

Native silicon cannot emit light efficiently (efficiency is <0.0001%). Thus, a hybrid approach with a partner light-emitting material coupled to silicon is required to make lasers. The Iris Light approach consists of printing light-emitting nanomaterial inks on state-of-the-art 300-mm silicon substrates. The solution takes advantage of the separation of the nanomaterial synthesis and subsequent deposition, an advance representing a fundamental shift in silicon photonics manufacturing. Specifically, nanomaterial "inks" are produced off-site with different emission properties that are then delivered as different laser "colors" to the foundry. The impact of this streamlined manufacturing is light chips with increased functionality, and therefore value, all at the wafer-scale.

Where are they now? Post-Program Advancements

- Financing received: $1.7M –SBIR/STTR, Chain Reaction Innovations, angel funding, revenue, and non-dilutive (grant) opportunities
- Accepted into Cohort 2 Chain Reaction Innovations (Argonne), a unique two-year fellowship for innovators focusing on clean energy and science technologies
- CRADA with the Air Force Research Lab (AFRL) following on from SBIR/STTR Phase 2 funding
- Licenses: Exclusive Option with Argonne and Northwestern University
- One new patent filed.

Speaking engagements: Entrepreneur panel at Optica—Frontiers in Optics 2020 conference.

MECS

Lawrence Livermore National Laboratory

Cohort 4

Problem /Opportunity

Craft beer is a booming business in the United States. Since 2009, the number of craft breweries 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 during the fermentation process as it needs. Companies with large operations often have CO_2 recovery systems, like those currently used at power plants. Many microbreweries, however, don't have the ability to capture and recycle CO_2 back into their operations. Because of this, the CO_2 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.

Industry Focus

MECS (micro-encapsulated CO_2 sorbents), is the work of a group of researchers from LLNL who previously developed microcapsule technology to efficiently capture CO2 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 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. Tanks filled with millions of microcapsules collect CO_2 at the brewery and are then taken to a centralized facility to reclaim the absorbed CO_2.

According to a DOE article, "Lab Carbon Capture Technology Keeps Beer Bubbling," if the technology is successful, the process could save breweries tens of thousands of dollars a year and prevent millions of pounds of CO_2 produced during fermentation escaping into the atmosphere.

LLNL Researcher Congwang Ye (right) visits with professors at UC Davis to see their pilot-scale winery and brewery and learn about fermentation tank operations. *Photo by LLNL.*

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 CO_2. The microcapsules are then suspended on a mesh structure to allow CO_2 to move in and out of the shells—absorbing CO_2 approximately ten times faster than encapsulated chemicals. Once the capsules are saturated, the trapped CO_2 is recovered and the capsules can be reused.

Where are they now? Post-Program Advancements

- Awarded the Innovation Development Fund from LLNL-IPO to pursue risk reduction for the beer application
- Won a TCF from OTT award to integrate MECS into a start-up company's commercial product for indoor CO_2 removal, conversion, and air purification
- Working with the University of California, Davis Enology/ Chemical Engineering and Trumer Pils Brewery for experimental validation of using MECS with fermentation gas
- Inventing and optimizing LLNL's patented capsule mass-production tool, called In-air Drop Encapsulation Apparatus (IDEA), which can be used to make MECS and other capsules/particles.

For more information, contact Congwang Ye at ye4@llnl.gov.

QUAKE (MASTODON)

A Risk-Based Design Optimization Software for Critical Infrastructure

Idaho National Laboratory

Cohort 2

Problem/Opportunity

Much of U.S. critical infrastructure, such as dams, levees, bridges, and power plants, are located in seismically active areas, hence the "QUAKE" characterization of this project. QUAKE is 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 these uncertainties, which—without necessarily making the structures safer—leads to large design conservatisms and therefore inflated capital and maintenance costs. 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.

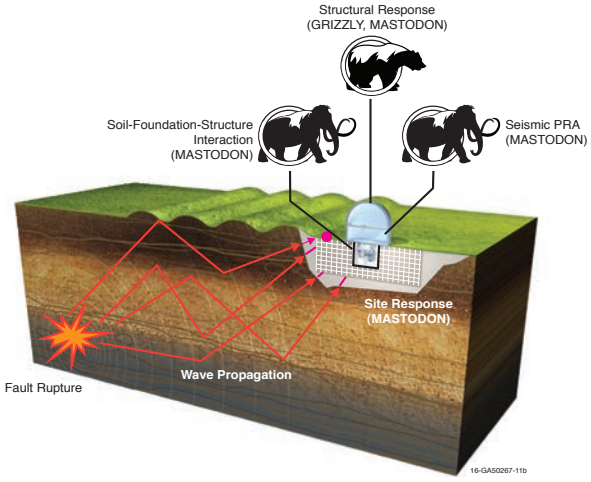
Industry Focus

Identify the infrastructure that is most vulnerable to earthquakes. Additionally, optimize new construction so that it is not excessively conservative and expensive. The current focus is on dams, facilities containing radioactive materials, such as research reactors and nuclear production and handling facilities, and nuclear power plants. Seismic costs of new nuclear power plants can exceed 30% of the total overnight capital costs. Capital costs and construction delays have virtually halted the nuclear industry and led to the bankruptcy of one of its largest U.S. companies.

Solution

Renamed MASTDON (Multi-hazard Analysis of STOchastic time-DOmaiN) the technology is built on sophisticated physical models for soils and structures. MASTODON is an application developed in a framework called MOOSE at INL. All MOOSE applications are named after animals (current or prehistoric) found in the Idaho region of the United States. MASTODON was chosen for a seismic analysis code because these animals were so large and the ground likely vibrated when they walked.

MASTODON automates and greatly simplifies risk calculations while optimizing the design to reduce costs.



MASTODON approach to seismic analysis and risk assessment.

The application maintains 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 retrofit solutions such as seismic isolation. This enables owners to make decisions about what should be replaced first while reducing life-cycle costs by up to 30%. It also allows 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 and research collaborations with owners of critical infrastructure, the team has:

- Extended their technology from a risk assessment tool to a risk-based design optimization tool
- Worked on a **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
- Concluded a $1,420,000 **TCF** project to develop a seismic design optimization process in MASTODON for advanced nuclear reactors; the partners were TerraPower, X-energy, and Southern Company.

For more information regarding MASTODON, contact Chandu Bolisetti, chandrakanth.bolisetti@inl.gov.

RECOVER

Pacific Northwest National Laboratory

Cohort 12

Market Problem/Opportunity

Efforts to address climate change can focus on clean energy sources, energy efficiency, and/or waste reduction/recycling. Lightweight polymer materials that are highly recyclable will be increasingly critical for many applications. For example, in the transportation sector, polymer composites are increasingly replacing higher-weight metals while offering satisfactory performance. The major barriers for such lightweight polymers include the cost of both manufacturing and recycling, the hazardous chemicals associated with traditional polymer materials, and inadequate material properties for structural applications.

Industry Focus

The RECOVER team's technology is a process for producing high performance, reformable polymers, called vitrimers, particularly from carbon dioxide, which is a common waste gas. The process enables a green pathway to form the chemical building blocks for the vitrimer material. Thanks to the unique chemistry, the CO_2-derived vitrimer can achieve excellent reprocessability and reformability, improving manufacturing rate, reducing manufacturing cost, all while valorizing an abundant greenhouse gas.

Solution

While this technology has many potentialapplications, RECOVER's focus during Energy I-Corps was a likely early adopter of the CO_2-derived, non-petroleum based vitrimer. The team explored addressing needs and demands of high-performing athletes looking for lightweight, environmentally friendly sports equipment. For example, the CO_2-derived vitrimers can replace petroleum-based, non-recyclable thermosets in high-end bicycles to provide the impact resistance at a low-carbon footprint while being able to be easily recycled at the end of the product's life—making it possible to retrieve and reuse the higher-value carbon fibers impregnated within the polymer.

Photo by Senthil Subramaniam, PNNL.

The current carbon fiber bike market is a $2.6 billion addressable market. RECOVER's target would be small to medium-sized custom bicycle manufacturers, representing an approximately $260 million market.

Where are they now? Post-Program Advancements

In parallel to the Energy I-Corps market exploration, PNNL, the University of Akron, and Raytheon Technologies Research Center have jointly been awarded a $1.9 M grant by the Department of Energy's Advanced Manufacturing Office and BioEnergy Technology Office through the Bio-Optimized Technologies to keep Thermoplastics out of Landfills and the Environment (BOTTLE™) program. The overall goal of the team's BOTTLE™ project is to create recyclable carbon fiber composites using vitrimer resins that are more energy efficient to produce and have improved properties over baseline technology. This project shares common ground with the CO_2-derived vitrimer technology described above. The targeted composites will retain their tensile strength after multiple recycling and reprocessing steps. In addition, monomer will be recoverable through depolymerization and re-usable carbon fibers will be retrieved.

For more information contact Suh-Jane Lee, Suh-Jane.Lee@pnnl.gov.

RouteE

Eco-friendly travel planning

National Renewable Energy Laboratory

Cohort 8

Background

The RouteE project grew out of a program funded by ARPA-E (Advanced Research Projects Agency-Energy) called TRANSNET (Traveler Response Architecture using Novel Signaling for Network Efficiency in Transportation). NREL researchers developed a successful TRANSNET proposal in partnership with Metropia Inc., a transportation technology solutions and consulting firm, and performed the work with support from the University of Kansas and the University of Washington.

Problem/Opportunity

Working with Metropia, the team developed RouteE, an energy-informed trip planner, to incentivize or disincentivize changing departure times, taking alternative routes, or choosing different modes of transportation to avoid traffic congestion. Exiting the TRANSNET program and leading into Energy I-Corps, the team recognized broader transportation energy savings potential for RouteE but struggled with:

- How to scale for larger energy impacts
- Prioritizing expansion of RouteE core functionality.

Industry Focus

Energy I-Corps participants commit to a customer discovery process during which they determine the needs and pain points of stakeholders in a particular ecosystem and use the information to guide research. In the case of RouteE, after talking to some 100 industry stakeholders, team members familiar with the vehicle routing and navigation space used that knowledge to chart a path forward for RouteE.

Initially, they were attracted to potential opportunities to integrate RouteE into platforms like Google Maps and Apple Maps. However, when they investigated financial incentives, they determined RouteE made more sense for fuel-intensive medium- and heavy-duty vehicles like UPS and FedEx vans or Walmart semis.

RouteE can help drivers avoid bumper-to-bumper traffic jams like this November 30, 2017, backup on I-25 in Denver, Colorado. *Photo by Dennis Schroeder, NREL.*

Solution

Energy I-Corps greatly impacted how the RouteE team approached future proposal development and influenced their published research to highlight how their work addresses industry and consumer challenges. Fast forward to 2020—Google makes sweeping sustainability commitments and tasked a team with adding sustainability features to their mapping platform. After learning about NREL's mobility research and transportation analysis capability, Google approached the RouteE team. Launched in 2021 on Android and iOS devices, Google Maps uses RouteE to default to the route with the lowest carbon footprint when the arrival time is roughly the same as the fastest route. If the more eco-friendly route increases travel time, Google Maps displays the relative CO2 impact between the routes, allowing users to make informed choices about which to take.

Where are they now? Post-Program Advancements

NREL continues to collaborate with Google as the company grows and develops the eco-friendly routing feature. Researchers are also involved in using RouteE in other industry partnerships as well as with several U.S. Department of Energy projects, including the SMART Mobility program, Big Data Solutions for Mobility, and Regional Mobility.

For more information or to request speakers, contact Jacob Holden, Jacob.Holden@nrel.gov.

SonicLQ

The Sonic Leak Quantifier

Argonne National Laboratory

Cohort 1

Problem /Opportunity

Most commercial and residential buildings have air leaks that waste energy and increase owners' utility bills by as much as 30%. To solve this problem, they hire air leak testers, but the technologies that testers use are currently limited.

Industry Focus

The Sonic Leak Quantifier (SonicLQ) uses sound waves to locate and size air leaks in building walls, doors, and windows by means of:

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

Solution

SonicLQ has several advantages over traditional blower doors and thermal cameras, notably that SonicLQ can:

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

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

Where are they now? Post-Program Advancements

- William Shadid, I-Corps Industrial Mentor, created SonicLQ LLC to commercialize the technology

The Sonic Leak Quantifier (SonicLQ) uses sound waves to locate and size air leaks in building walls, doors, and windows. *Photo Dr. Ralph T. Muehleisen, ANL.*

- SonicLQ LLC and Argonne received $285,000 in post-program funding from DOE's Building Technologies Office for additional R&D and received $1,050,000 in post-program funding from the U.S. Department of Defense's Strategic Environmental Research and Development Program/Environmental Security Technology Certification Program for demonstration and testing on U.S. Department of Defense sites. That project terminated prematurely because the technology was not quite ready for demonstration
- Argonne researchers participated as part of the Chicago Innovation Mentors Program, obtaining additional mentoring on commercializing technology coming out of the labs
- Ralph Muehleisen and Energy I-Corps mentor Bill Shadid responded to several invitations to pitch competitions, including Argonne Chain Reaction Innovations Program (Feb. 2020), University of Chicago Shultz Fund (June 2019), U.S. Department of Energy Lab Accelerator (Sept. 2017); USG-Illinois Corporate Startup Challenge (Nov. 2016); and Clean Energy Trust (April 2016).

Speaking Engagements:

IP Group-Argonne Investment Meetings; Bosch-Argonne Technology Exchange Day; North American Insulation Manufacturer Association; follow-up speaking engagement at USG; pitch at DOE-New York State Energy Research and Development Authority Laboratory-Investor Knowledge Series; and invitation to present at Chicago Innovation Mentors.

Patent pending.

For more information or to request speakers, contact Dr. Ralph T. Muehleisen at rmuehleisen@anl.gov.

STARS

A Pacific Northwest National Laboratory Spinout/Startup

Pacific Northwest National Laboratory

Cohort 1

Problem /Opportunity

In recent years, California sought to reduce its statewide greenhouse gas emissions to 1990 values. This effort appears to be successful, as California accomplished this goal in advance of its deadline, but now has targeted zero-net fossil carbon emissions by 2045. This requires a much more aggressive approach, as well as major changes to capital infrastructure.

Industry Focus

STARS' opportunity is enhanced by the inclusion of Southern California Gas Company (SoCalGas) 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). STARS' near-term business opportunity is to provide advanced thermochemical hardware—unavailable elsewhere—that produces hydrogen and/or methanol at competitive costs but with fewer CO_2 emissions than traditional sources.

Solution

STARS is an advanced technology company providing process-intensive chemical reactors and heat exchangers that can be used for a variety of applications. A near-term interest is the production of clean hydrogen (H2), an economical low-carbon fuel and feedstock for chemical/materials products. A number of sources are now projecting that H2 demand will grow substantially over the next 30 years, from around 70 million metric tons per year to perhaps more than 500 million metric tons per year.

Aided by the use of additive manufacturing (3D printing), STARS compact H2 Generator is expected to attain a high degree of process intensification through the use of micro- and meso-channel reactors and heat exchangers and low capital costs through economies of hardware mass

PNNL researchers Paul Armatis, Bob Wegeng, and Richard Zheng shown with the Solar Thermochemical Advanced Reactor System, which uses concentrated solar power to convert natural gas into more valuable fuels, including hydrogen for fuel cell cars. *Photo by PNNL.*

production. STARS' initial commercial demonstration is now planned for early 2022, where in conjunction with SoCalGas and SunLine Transit Agency, STARS' hardware will produce H2 for SunLine's fleet of buses.

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

Where are they now? Post-Program Advancements

- Received $8 million+ from federal funding sources and strategic partners
- Demonstrated technology readiness level 7 system in Southern California in collaboration with SoCalGas Company
- Received an R&D 100 Award (November 2014)
- Featured in March 2018 article in CEP Magazine (the American Institute of Chemical Engineers): "Realize the Potential of Process Intensification"
- Invited speaker at the 2019 NREL Industry Growth Forum.

For more information or to request a speaker, please contact Bob Wegeng, robert.wegeng@starsh2.com.

SwitchGlaze

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

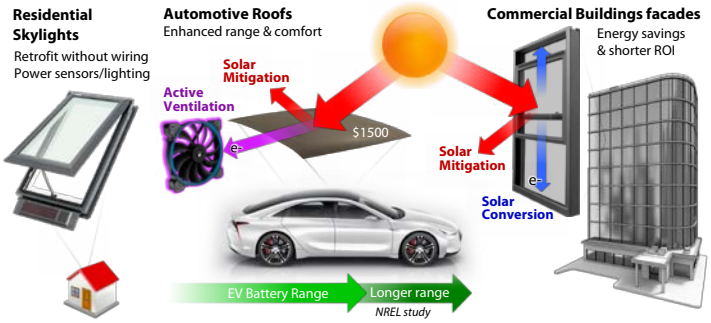
National Renewable Energy Laboratory

Cohort 3

Problem/Opportunity

Buildings account for ~75% of electricity use in the United States. Current trends in commercial building design are toward all-glass facades, which prioritize aesthetics and interaction with the external environment over 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 not attractive enough to support widespread adoption.

Industry Focus



Solution

SwitchGlaze couples the energy savings of dynamic glass with solar energy generation, dramatically improving the return on investment of dynamic glazing. The technology is poised for immediate impact in skylight retrofits; it will save consumers the cost and disruption of tearing out walls for wiring and enable integrated designs in which SwitchGlaze powers internal LED lighting as well as a CPU that controls rain sensors and motors to open and close the window. SwitchGlaze technology's low production costs, energy generation benefits, and attractive return on investment enable practical deployment in commercial buildings and automotive industries.

Researchers Rob Tenent, left, and Lance Wheeler make up the SwitchGlaze team, which created a product that turns glass into photovoltaic panels. *Photo by Werner Slocum, NREL.*

Where are they now? Post-Program Advancements

- Received $2.25 million in funding from EERE Buildings Technologies Office in recent lab call funding opportunity announcement award
- 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
- Performed ongoing research that resulted in multiple high-impact publications, including two articles in Nature Communications
- Will be featured in annual issue of Innovative Energy Review magazine
- Invited to pitch at NREL's Innovations Showcase and at Pitch! Energy Competition
- Currently negotiating with 2qV Technology Company to license and commercialize the technology.

Ultra-Fast X-Ray Imager (UXI)

Sandia National Laboratories

Cohort 10

Problem

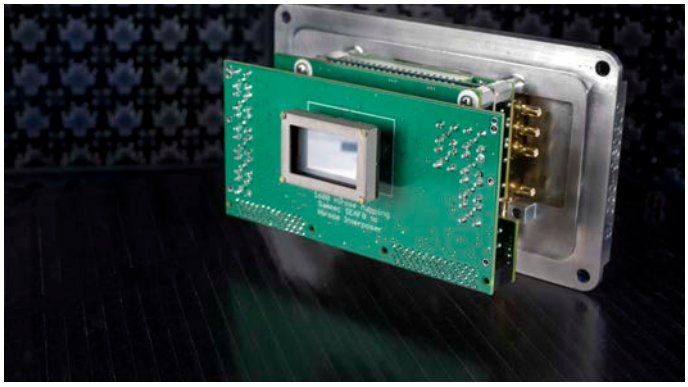
High-speed cameras are powerful tools for visualizing fleeting events in the natural world. Digital high-speed camera technology has made it commonplace to record images down to the microsecond timescale with exquisite spatial detail. This has enabled photos and video sequences of fast-moving objects, from speeding bullets to a hummingbird's wing. To capture events at faster timescales, options are limited. Complex transient phenomena happening at the nanoseconds timescale have been recorded, but the imaging systems used to capture these events utilize high-voltage electron-tube-based instruments that are bulky (benchtop scale or larger), expensive, and complex (requiring frequent calibration of multiple instruments). This leaves the visualization of many events in science and nature—from chemical reactions in cells to visible phenomena occurring near the speed of light—beyond the reach of all but large, well-funded research centers.

Industry Focus

- High Energy Density Physics research
- Inertial Confinement Fusion research
- Laser diagnostics
- High-speed explosives imaging.

Solution

The UXI Focal Plane Arrays (FPAs) have the potential to provide an affordable, high performance, solid state imaging solution in a single sensor that is affordable to universities, physics laboratories, free electron laser facilities, commercial companies, and other research centers. The FPAs are currently fabricated in a government-owned, strategically radiation-hardened technology, which limits the use of the sensors due to U.S. export laws. Commercialization of the FPAs (porting the design to a commercial fabrication process) is needed to satisfy the increasing demand to provide these sensors to nongovernment facilities.



A UXI SNL Z-Machine camera system. *Photo by the UXI program, SNL.*

Where are they now? Post-Program Advancements

- Additional $2.4 million in funding over FY20 and FY22
- Deployment of Gen-IV sensor to LLNL National Ignition Facility and SNL Z-Machine
- Development of Gen-V sensor fabricated in Tower Jazz 130nm commercial process
- Invited panel member at National Lab Entrepreneurship Academy
- Issued Patent No. 10,547,805
- UXI team members are using Sandia's Entrepreneurial Separation for Technology Transfer program to leave Sandia and found Advanced hCMOS Systems LLC, a start-up to commercialize the technology.

For more information or to request speakers, contact Marcos Sanchez (marcos@hcmos.com) or Liam Claus (liam@hcmos.com).

Water Energy Systems for Advanced Purification (WESAP)

Pacific Northwest National Laboratory

Cohort 12

Problem/Opportunity

Wastewater management is an expensive and unsustainable problem due to the cost associated with its handling, energy intensity, and water scarcity. Traditional wastewater treatment technologies such as anaerobic digestion do not remove diluted recalcitrant organic contaminants from wastewater, resulting in their discharge into the environment. Aeration ponds and lagoons are used to treat wastewater but have large area requirements, are energy inefficient, and do not completely remove the organic contaminants. If wastewater producers such as food processing and agricultural industries had a way to clean their own wastewater, they would be able to decrease costs associated with disposal, as well as lower their freshwater consumption, ultimately making them more sustainable.

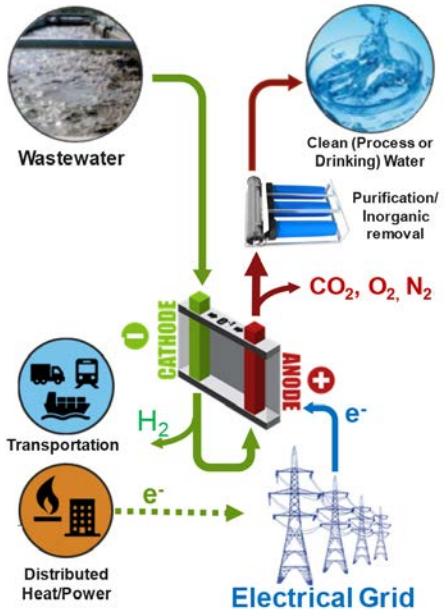
Industry Focus

A team of researchers from PNNL have developed electrochemical systems that convert organic compounds present in diluted aqueous systems while simultaneously generating hydrogen (H_2) as a side product using electricity as the only driving force.

In the Energy I-Corps program, the WESAP team identified potential markets and applications for this electrochemical technology such as cleaning wastewater generated in the wine and dairy industries to recover clean water for irrigation and cleaning purposes while in-situ generating electricity from the H_2 co-product. If successful, the process could save wineries and dairy farms tens of thousands of dollars in wastewater disposal costs, decrease their consumption of freshwater for cleaning and irrigation, and improve the sustainability of their process.

Solution

The PNNL technology uses solid electrodes to oxidize organic pollutants present in the wastewater into CO_2 while generating H_2 as a side product. The H_2 can be utilized onsite to power H_2 vehicles or converted into electricity (using fuel cells) that can be fed into the electrical grid. The electricity generated can be used to power the electrochemical wastewater treatment and improve the energy efficiency of the process. The technology is modular, operates at room temperature and atmospheric pressure, so it can be easily scaled and co-located with the wastewater management system at the generation point.



Process diagram for the on-site generation of clean water, H2, and electricity via the electrochemical oxidation of wastewater *Graphics by Juan A. Lopez-Ruiz, Ph.D., PNNL.*

Where are they now? Post-Program Advancements

- The WESAP team currently has a BETO project with Princeton University and University of Illinois Urbana-Champaign in which they are integrating the technology with biomass-liquefaction processes (for biofuel production) to simultaneously clean wastewater and generate H_2 at community scale (5 dry ton/day)
- Patents have been submitted for the technology, and it has been licensed to a company that will process biomass-derived organic and aqueous streams
- In discussion with multiple industrial partners for development of the technology in other applications
- This technology was recently discussed at the Electrochemical Society (ECS) 240th meeting and it will be further discussed at the TCBiomass 2022 conference.

Contact Juan A. Lopez-Ruiz for more information, juan.lopezruiz@pnnl.gov.

Energy I-Corps for Small Business Innovative Research (SBIR)/Small Business Technology Transfer (STTR)

Through a competitive awards-based program, SBIR and STTR enable small businesses to explore their technological potential and provide the incentive to profit from its commercialization. By including qualified small businesses in the nation's R&D arena, high-tech innovation is stimulated, and the United States gains entrepreneurial spirit as it meets its specific research and development needs. In 2020, the Office of SBIR/STTR Programs worked with the Office of Technology Transitions to develop a version of Energy I-Corps training aimed specifically at DOE SBIR/STTR Phase I awardees.

Overview:

Energy I-Corps for SBIR is designed as an I-Corps "Short Course" intended to provide hands-on experience in customer development and business model generation for DOE SBIR Phase I awardees. An optional program, Energy I-Corps for SBIR allows participants to gain a practical understanding of fundamental principles and processes that support the successful management and discovery of innovations across the technology lifecycle. This includes an introduction to key elements of entrepreneurship designed to help craft a viable business model, illuminate opportunities and risks, and design a strong go-to-market strategy. Phase I awardees that participate in the program are able to develop a more refined and strategic commercialization strategy within their SBIR Phase II applications and thus, increase the overall impact of the SBIR program within the Department of Energy. As of year-end 2021, 96 companies have participated in one of three cohorts.

SBIR·STTR
America's Seed Fund

U.S. DEPARTMENT OF ENERGY | Office of SBIR/STTR Programs

Program Design:

The program includes distinct lessons to help support a structured understanding of innovation management, and the steps necessary to translate a technical idea into a commercial product. Participant companies are expected to conduct (target: 30) interviews across a broad spectrum of ecosystem stakeholders, and to participate in eight virtual workshops spanning six weeks. During the Fall 2021 program, training was expanded to include integration with the SBIR's CAP (Commercialization Assistance Program) to offer more direct leverage between both programs in support of participant companies.

Contact Zack Baize, OTT, for more information, zack.baize@hq.doe.gov.

OTT Entrepreneurship Program

In June 2021, OTT introduced the pilot "Summer Entrepreneurship Program" internship effort.

The Entrepreneurship Program provided paid opportunities for undergraduate students to explore and contribute to advances at the intersection of business and innovative technologies like machine learning, artificial intelligence, computing, data science, and biofuels. Students participated in and contributed to OTT mission-related research, as well as technical and policy activities under the guidance of technology transfer experts and/or OTT staff.

Unique to the program was the inclusion of introductory Energy I-Corps curriculum. Participants were provided EIC lectures and resources with instructors offering workshops to tie the lab work to the EIC framework. In support of the summer program, the EIC team developed a library of training videos for the students. The videos covered elements from the Business Model Canvas as well as topics specific to laboratory commercialization.

Fourteen students participated in the first year of the program, representing universities and colleges from across the country.

OTT Entrepreneurship Program

Projects

BERKELEY LAB	• Tech assessment for a new invention: Ultra-thin and conductive composite membranes via atomic layer deposition • Methods for pretreating ensiled biomass for efficient extraction of sugars and lignin.
Brookhaven National Laboratory	• Reconfigurable Computing Platform • TrapIn: Brookhaven technology that allows capturing noble gases in silicate nanocages.
INL Idaho National Laboratory	• Explore market opportunities for INL Supercritical Solid Catalyst Biodiesel technology • Linear Differential Mechanism.
KANSAS CITY NSC National Security Campus	• Marketability Study for Compressing Sampled Data.
Lawrence Livermore National Laboratory	• Commercialization Plan for Sense-and-Avoid Technology in Autonomous Ground Vehicles.
NREL Transforming ENERGY	• BOTTLE™ technology-industry mapping to promote technology commercialization.
OAK RIDGE National Laboratory	• Additive Manufacturing of Bonded Permanent Magnets.
Sandia National Laboratories	• Finding Life After LDRD (or When the R&D Dollars Run Out) • Partner Validation and Verification • Science and Technology Advancing Resilience for Contested Space Multi-Use Commercialization Identification • Security System of the Future Technology Environmental Scan.
Pacific Northwest NATIONAL LABORATORY	• Assessment of Commercialization Value in Linking Datasets with Software Licenses.

Planning for the Summer 2022 program is now underway. More information at https://www.energy.gov/technologytransitions/ott-entrepreneurship-program

Nomenclature

AMO	Advanced Manufacturing Office
ANL	Argonne National Laboratory
BETO	Bioenergy Technologies Office
BTO	Building Technologies Office
CRADA	Cooperative Research & Development Agreement
DOE	U.S. Department of Energy
EM	Office of Environmental Management
FECM	Fossil Energy and Carbon Management
FNAL	Fermi National Accelerator Laboratory
GTO	Geothermal Technologies Office
HFTO	Hydrogen and Fuel Cell Technologies Office
INL	Idaho National Laboratory
LANL	Los Alamos National Laboratory
LBNL	Lawrence Berkeley National Laboratory
LLNL	Lawrence Livermore National Laboratory
NE	Office of Nuclear Energy
NNSA	National Nuclear Security Administration
NREL	National Renewable Energy Laboratory
NSF	National Science Foundation
OE	Office of Electricity
ORNL	Oak Ridge National Laboratory
OEM	Original Equipment Manufacturer
OTT	Office of Technology Transitions
PNNL	Pacific Northwest National Laboratory
R&D	Research and Development
SETO	Solar Energy Technologies Office
SLAC	SLAC National Accelerator Laboratory
SNL	Sandia National Laboratories
TCF	Technology Commercialization Fund
VTO	Vehicle Technologies Office
WETO	Wind Energy Technologies Office
WWPTO	Wind & Water Power Technologies Office

Publications

Energy I-Corps teams have authored or featured in several publications related to their work. Sample materials are provided below:

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Energy I-Corps Cohort 9 participants listen to the presentations on the final day of their workshop at the Buffalo Rose in Golden, Colorado. *Photo by Werner Slocum, NREL.*

"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, PNNL, Principal Investigator

"The methodology we have now, the rational thinking we've learned … we're going to benefit for many years to come."

- Chen Wang, NREL, Entrepreneurial Lead

Researcher Kristin Alberi presents during graduation of Cohort 9. *Photo by Werner Slocum, NREL.*

Thank You!

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Photos courtesy of Werner Slocum, INL, and Amy Glickson.
All in-person Cohort photos were taken during in-person Cohorts 1-10, prior to January 2020.