2023 Energy I-Corps Annual Report

ENERGY I-CORPS

OTT Office of Technology Transitions

Energy I-Corps 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

Greetings,

The U.S. Department of Energy (DOE) Office of Technology Transitions (OTT) hosted its eighth year of the Energy I-Corps program with unequivocal success. This annual report presents the program's latest impacts.

Energy I-Corps delivers intensive workforce development training and funding to our National Lab researchers to support clean energy technology commercialization. Delivering National Laboratory-developed technologies to market is critical in meeting our climate goals, making this program's entrepreneurial experience invaluable. The on-the-job training allows our researchers to avoid the "valleys of death" often faced along the research, design, demonstration, and deployment continuum.

Since its inaugural year, Energy I-Corps has trained more than 450 DOE researchers. That's 450 researchers returning to their National Labs with top-tier frameworks for industry engagement. The impact extends far past these participants as they bring their learnings back to their teams to inform a culture of market awareness, in turn boosting the viability of lab technologies.

In 2023, OTT welcomed its inaugural set of Topic 3 awardees. We've restructured the Energy I-Corps program and added this completely new offering for the first time. Beyond the successful 10-week entrepreneurial training cohorts (now referred to as Topic 2), there are two additional topics that make up the program. Energy I-Corps Topic 1 is a pipeline development opportunity that funds selected National Labs to develop programming that can directly encourage their researchers to apply and participate in future Energy I-Corps Topic 2 training cohorts. The program's new Topic 3 funds Energy I-Corps cohort graduates and their projects toward their next steps in the commercialization process. This new topic is a way for OTT to even further support researchers in avoiding valleys of death.

This year we also incorporated OTT's new "Adoption Readiness Level" framework into Energy I-Corps training, which gives the participants the language for commercialization at the start of the program. This is a complement to Technology Readiness Levels and expands the view beyond technology hurdles to market barriers that must be overcome for successful commercialization.

OTT's mission is to expand the public impact of the department's research, design, demonstration, and deployment portfolio. By investing in our lab researchers through Energy I-Corps, we are increasing capacity for impactful innovation and building a strong research foundation for the economy and greater public good of the nation. Each continued year of this program, we enable success for the clean energy transition and the national security interests of the nation. In the history of the program, all 17 National Labs have participated in at least one Energy I-Corps topic, and at least 15 program offices have provided funding to teams going through the Energy I-Corps program, further demonstrating the program's value.

Energy I-Corps' reach continues to lengthen. I encourage you to be ambassadors for both the program and technology commercialization. It's only when the technology is transferred to the public that its full impact can be realized.

Dr. Vanessa Z. Chan

Chief Commercialization Officer, U.S. Department of Energy
Director, Office of Technology Transitions

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Program Overview

About Energy I-Corps

The U.S. Department of Energy (DOE) invests billions of dollars every year into the National Lab complex. This investment allows the DOE National Laboratories and DOE plants and sites 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.

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, development, demonstration, and deployment portfolio to advance the economic, energy, and security interests of the nation.

To better arm researchers to collaborate with industry and turn research and development into demonstration and deployment, DOE employs a suite of efforts under the Energy I-Corps portfolio to help researchers gain industry insight to guide innovation and advance energy-related technologies toward commercialization.

Since 2015, DOE has offered the immersive 10-12 week Energy I-Corps training program, also known as "Training Cohorts," across the DOE National Lab system. In 2023, the program expanded to include a pre-Training Cohort offering, introduced as Topic 1: Pipeline Development, and a post-Training Cohort offering, named Topic 3: Post Energy I-Corps. Under Topic 1: Pipeline Development, DOE National Labs and DOE plants and sites propose projects aimed at increasing their researchers' applications for future Topic 2: Training Cohorts. Under Topic 3: Post Energy I-Corps, graduates of the training cohorts apply for funding to aid their next step toward commercialization (Figure 1).

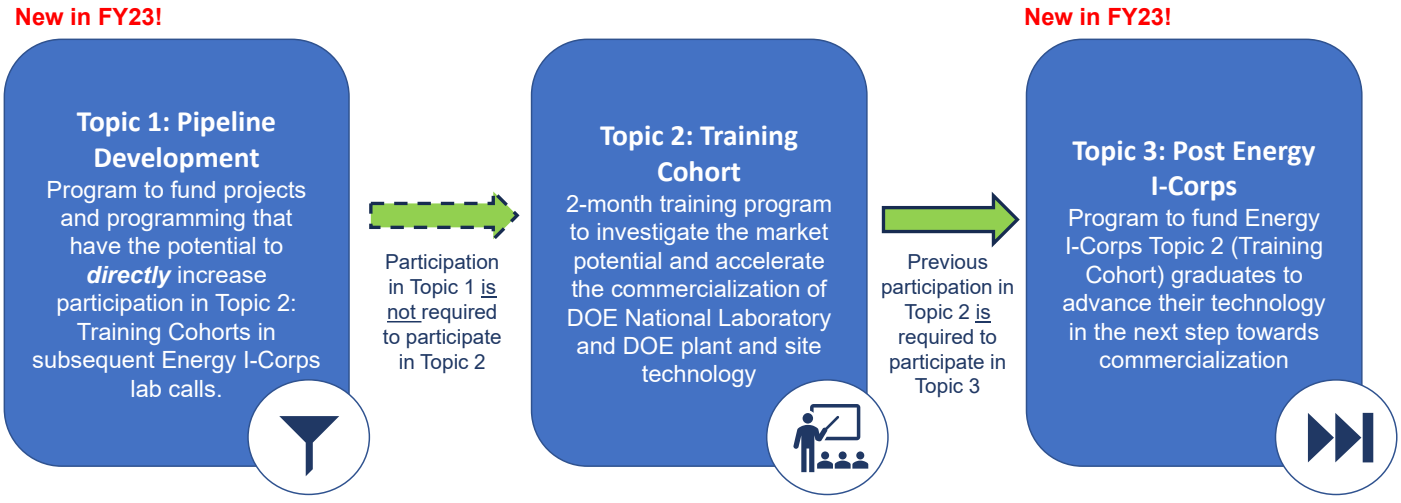


Figure 1: Energy I-Corps Program Structure

Program Overview

While the bulk of this report will focus on Topic 2: Training Cohorts, we are pleased to share updates on Topic 1: Pipeline Development and Topic 3: Post Energy I-Corps before diving in to Training Cohort metrics. Brief overviews of each of the three Energy I-Corps' topics follows:

Topic 1: Pipeline Development

In response to the evolution of the Energy I-Corps program within DOE and feedback from National Lab partners and DOE program office supporters, OTT developed the Energy I-Corps Pipeline Development (Energy I-Corps Topic 1) opportunity. Topic 1 is a refocused version of the previously offered Energy I-Corps "Satellite," "Site," or "Asynchronous" funding. Within this topic, DOE National Labs and DOE plants and sites are provided up to $100,000 to implement projects and programming that have the potential to directly increase participation in subsequent Energy I-Corps Training Cohorts. OTT provides each lab the latitude to develop a program to best serve their unique research community while seeding the idea of participation in Topic 2: Training Cohorts.

In fiscal year (FY) 2023, nine projects supporting eleven labs were selected. The selected projects include a range of tasks such as customer discovery, pitch competitions, intern support preparing Topic 2 applications, and networking with local startup businesses. The cumulative goals of the FY23 projects aim to provide lab-specific entrepreneurial training to over 80 researchers and increase the number of submissions to the 2024 Energy I-Corps training cohorts by more than 15 new submissions.

All projects were fully funded by OTT, unless otherwise indicated.

- Argonne National Laboratory
- Brookhaven National Laboratory
- Fermi National Accelerator Laboratory:
  - Co-funded by Office of Science's Accelerator R&D and Production Program, Office of Science's High Energy Physics Program, and OTT
- Lawrence Berkeley National Laboratory
- Multi-Lab Collaboration with Ames National Laboratory, Idaho National Laboratory, and Thomas Jefferson National Accelerator Facility
- National Renewable Energy Laboratory
- Pacific Northwest National Laboratory
- Savannah River National Laboratory
- SLAC National Accelerator Laboratory

For additional information on the Topic 1 projects, visit https://www.energy.gov/technologytransitions/energy-i-corps-topics-1-and-3-fy-2023.

Topic 2: Training Cohorts

The founding program in the Energy I-Corps portfolio is the Topic 2: Training Cohorts offering. Topic 2 invites teams of researchers to participate in an immersive 10-12 week training, during which the researchers define technology value propositions, conduct 75 stakeholder 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 DOE National Labs and DOE plants and sites and maintains and strengthens long-term U.S. competitiveness. Topic 2 is managed by DOE's National Renewable Energy Laboratory (NREL) in Golden, Colorado.

Topic 3: Post Energy I-Corps

Teams that complete Topic 2: Training Cohorts are excited about their newfound skills and strategies to commercialize their technologies, but may lack funding for next steps. The Topic 3: Post Energy I-Corps opportunity supports a subset of Training Cohort graduates with a high likelihood of commercializing their technology. Teams can receive up to $100,000 to cover costs of the next actionable step in their technology's commercialization and facilitate the teams in reaching their next source of more substantive support to continue their journey to market.

The cumulative goals of the FY23 projects aim to engage over 25 new external partners, produce five new National Laboratory Cooperative Research and Development Agreements or patent license agreements, create five new prototypes, and implement eight new technology tests or deployments. Each project also has specific diversity, equity, inclusion, and accessibility goals, including outreach to underrepresented customer segments and engagement with students from underrepresented groups.

The following five projects were selected as the inaugural set of awardees for this new topic. All projects are fully funded by OTT, unless otherwise indicated.

- Fermi National Laboratory: "High Power Electron Gun for Metal Additive Manufacturing" (Cohort 3)
  - Co-funded by the Office of Fossil Energy and Carbon Management (FECM) and OTT
- Lawrence Livermore National Laboratory: "Scale Up Production Of Advanced Sorbents for Direct Air Capture Application" (Cohort 4)
  - Co-funded by FECM and OTT
- Lawrence Livermore National Laboratory: "Solid State Bioreactor for The Conversion Of Gaseous Feedstocks to Value Added Products" (Cohort 14)
- Sandia National Laboratories: "Fostering Industry Engagement of SNL Membranes" (originally members of Energy I-Corps Cohort 2)
- SLAC National Accelerator Laboratory: "Grid Resilience and Intelligence Platform" (GRIP) (Cohort 14)

For additional information on the Topic 3 projects, visit https://www.energy.gov/technologytransitions/energy-i-corps-topics-1-and-3-fy-2023.

Energy I-Corps Portfolio FAQs

What is Energy I-Corps?

The goal of all efforts within the Energy I-Corps portfolio is to support and train DOE National Lab and DOE plant and site researchers to advance energy-related technologies toward commercialization.

How many teams have participated?

1. **Topic 1: Pipeline Development:** All 17 National Labs have participated in either the Pipeline Development program or its previous iterations, referred to as "Site" and "Satellite" funding.
2. **Topic 2: Training Cohorts:** As of November 2023, 215 teams from 12 National Labs have participated in Topic 2 over the course of 17 cohorts and the pilot.
3. **Topic 3: Post Energy I-Corps:** Five teams from four National Labs were awarded Post Energy I-Corps funding in its inaugural year.

What are the benefits?

1. **Topic 1: Pipeline Development:** Each selected DOE Lab, plant, or site awardee develops a Topic 2-promoting program that will most benefit their unique research community. This provides researchers with a taste of commercialization concepts and opportunities before deciding to commit to the full Topic 2 program. Taking examples from awarded FY23 programs, participants may benefit from a lab-hosted, lighter version of Topic 2, startup engagement, market research support, or other programming offerings.
2. **Topic 2: Training Cohorts:** Participants benefit from workshops taught by industry experts while gaining market insights gleaned from the more than 75 discovery interviews conducted during the duration of the program. The training equips DOE National Lab and DOE plant and site 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 DOE National Labs and DOE plants and sites.
3. **Topic 3: Post Energy I-Corps:** Selected teams receive funding to support their next step in commercialization, to help avoid a valley of death in the commercialization pathway.

Who can participate?

1. **Topic 1: Pipeline Development:** DOE National Labs and DOE plants and sites can apply. Applicants suggest projects and programming that have the potential to directly increase participation in future Energy I-Corps Training Cohorts
2. **Topic 2: Training Cohorts:** DOE National Lab and DOE plant and site researchers wanting to pursue commercialization with a DOE National Lab IP can apply. This is a technology-agnostic program, but participants should fall within the DOE investment portfolio including renewable energy, efficiency, advanced materials, nuclear energy, fossil energy, environmental management, national security, and others.
3. **Topic 3: Post Energy I-Corps:** Teams that successfully complete Topic 2: Training Cohorts are eligible to apply to Topic 3.

Who supports the participants?

1. **Topic 1: Pipeline Development:** Submitted applications are reviewed by OTT and shared with other DOE program offices and the National Nuclear Security Administration (NNSA) as funding opportunities. OTT is the primary funder of the Pipeline Development program. Programs from the Office of Science have also supported projects.
2. **Topic 2: Training Cohorts:** Submitted applications are reviewed by OTT and relevant DOE program offices. The offices of Energy Efficiency and Renewable Energy; Electricity; Environmental Management; FECM; Nuclear Energy; Cybersecurity, Energy Security, and Emergency Response; NNSA; and programs within the Office of Science have supported teams.
3. **Topic 3: Post Energy I-Corps:** Submitted applications are reviewed by OTT and relevant DOE program offices and NNSA. OTT is the primary supporter of this opportunity. FECM has also supported Topic 3 projects.

How can I get involved?

OTT solicits proposals for all three Energy I-Corps topics through a lab call. If you are interested in participating in Energy I-Corps, please contact your lab's Technology Transfer Office, or contact energyicorps@hq.doe.gov to learn more.

From this point onwards, this report will focus on Energy I-Corps Topic 2: Training Cohorts. The following words will be used interchangeably: Energy I-Corps, Topic 2, Training Cohorts, and cohorts.

Program Structure

For each Training Cohort of Energy I-Corps, 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 discovery interviews with industry stakeholders during the course of the program.

Once researchers complete the cohort 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.

Curriculum

The Energy I-Corps curriculum was initially developed in partnership with the National Science Foundation's Innovation Corps™ (I-Corps™) program. With the support of the National Labs and external industry advisors, NREL and OTT adapted the National Science Foundation's nationally recognized I-Corps training to meet the needs of the DOE Laboratory and DOE plant and site participants.

Adjustments made to the I-Corps curriculum address the specific challenges scientists working within the National Lab complex environment face when preparing their innovations for market, such as navigating the complexities of intellectual property, licensing opportunities, and startup development pathways. As more teams complete the training, OTT and NREL continue to improve and enhance the Energy I-Corps Topic 2 curriculum to best meet participant and industry needs.

Energy I-Corps comprises 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 manages both the opening and closing sessions, which involve in-person and virtual instruction and presentations.

Participating Labs: Participating DOE Labs and DOE plants and sites recruit, assemble, and submit applications for each cohort. The DOE Labs and DOE plants and sites play an integral role in supporting teams before, during, and after the program. Support might include assistance in identifying team members, 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 of the technology could lead to commercial value.

Training Program: Energy I-Corps Topic 2 spans 10 to 12 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 stakeholder discovery interviews.

To date, teams have participated from:

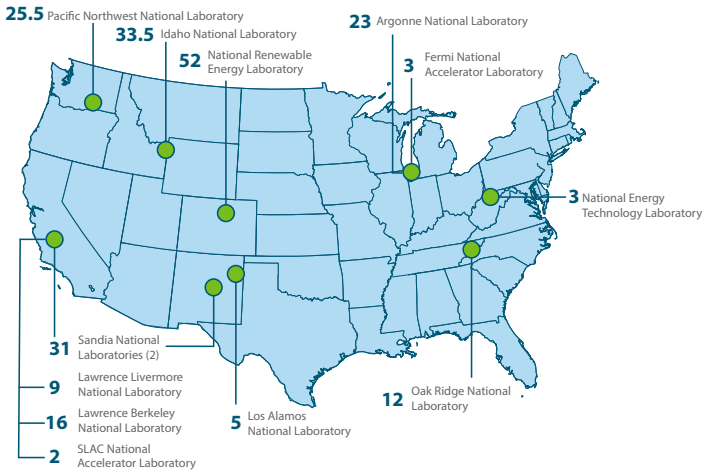
- Argonne National Laboratory
- Fermi National Accelerator Laboratory
- Idaho National Laboratory
- Lawrence Berkeley National Laboratory
- Lawrence Livermore National Laboratory
- Los Alamos National Laboratory
- National Energy Technology Laboratory
- National Renewable Energy Laboratory
- Oak Ridge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

Energy I-Corps Topic 2: Training Cohort technologies have collectively attracted more than $177 million in post-program funding. As of the end of the 17th training session in the fall of 2023, teams have worked with 215 industry mentors and conducted 15,500 discovery interviews to determine the commercial impact of their technologies.

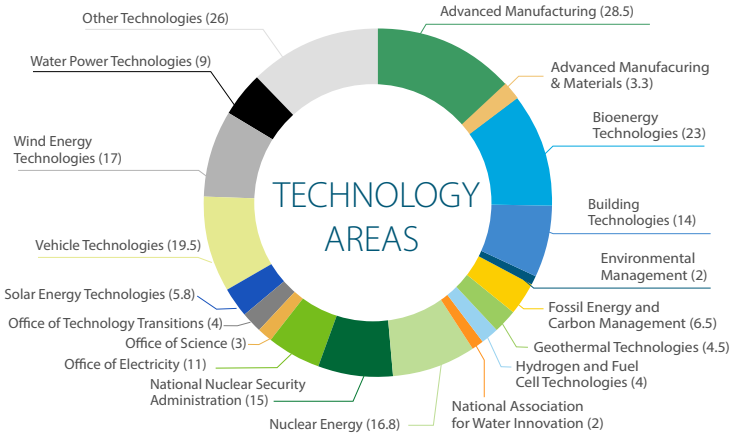
Quick Stats

17 COHORTS **of** ENERGY I-CORPS

215 TEAMS | **12** NATIONAL LABORATORIES



BRINGING **ENERGY INNOVATIONS** TO



LEARNING FROM

215 Industry Mentors **and** 15,500 Stakeholder Discovery Interviews With Companies Like:

EPRI, Shell, Ford, World Bank, Breakthrough Energy, John Deere, Siemens Gamesa, Chevron, Eaton, Samsung, Lowes, Johns Manville, LEGO, U.S. Army, Trane, Tesla, GM, Dow Chemical, 3M, Whirlpool, GE, Home Depot, Amazon

20+ New Businesses

More than 20 teams launched new businesses based on their Energy I-Corps Technology

$177M+ Post Program Funding

Post Energy I-Corps, technologies have attracted **over $177M in post-program funding**

15,500 Stakeholder Discovery Interviews

78 Licenses Executed

Energy I-Corps Team Profiles and Success Stories

Energy I-Corps Topic 2 aims to accelerate the deployment of energy technologies by delivering workforce development training and funding support to National Lab scientists and engineers. By empowering researchers to seek direct market feedback for their technology offerings, DOE-supported innovations have a broader impact on climate goals.

Since 2015, over 450 National Lab researchers have matriculated through Energy I-Corps. Participants graduate with a framework for industry engagement that guides future research and fosters a market-informed values back at the lab. The program's impact extends into the market itself, with more than 20 new businesses launched based on Energy I-Corps technology and 78 licenses executed.

The following pages showcase the success, both during and after the program, of just a few of the teams that have participated in Energy I-Corps.

Avian Solar

Lab: Argonne National Laboratory

DOE: Solar Energy Technologies Office

Cohort: 15

Bridging Artificial Intelligence and Ecology for Clean Energy

Advanced technology poses many opportunities in the commercial sector. But sometimes unexpected lessons are learned while trying to define that market.

What the Avian Solar team experienced was how to roll through the unexpected pivots.

Argonne National Laboratory Principal Software Engineer Adam Szymanski and Remote Sensing Scientist Yuki Hamada said their project, funded by the DOE Solar Energy Technologies Office, arose from a pressing concern: why are bird carcasses being reported at solar fields?

As solar energy gained momentum in 2014, Hamada said, stories of birds colliding with solar panels began to surface, casting a shadow on an otherwise eco-friendly technology. The true cause of these on-site carcasses, whether they were dropped by predators, died from collisions, or were stranded, remained a mystery.

The Avian Solar team devised an ingenious automated camera system equipped with artificial intelligence to find out. Unlike conventional monitoring, their tool distinguishes bird movements from other activities and, crucially, details collision events. The project aims to unveil the real impact of solar panels on avian populations.

Szymanski said their journey through the Energy I-Corps program—involving over 100 interviews with industry professionals—helped their mission evolve.

“As we interviewed and went through the whole process, it completely changed the picture,” he said.

Their tool, they discovered, addressed diverse needs beyond bird mortality. While they initially targeted large solar companies grappling with bird-monitoring regulations, they found that these regulations were geographically limited. As their interviews deepened, they identified a variety of scientists who saw the value of the raw data produced.

Yuki Hamada (left), entrepreneurial lead, and Adam Szymanski, principal investigator, working towards commercializing an automated camera system monitoring bird activity at solar facilities. *Photo by Kira Vos*

The team also encountered unexpected resistance. Field biologists, who manually monitor wildlife activity on-site, viewed the technology as a potential job threat.

“We never thought of [our technology] in that way, but Energy I-Corps gave us the opportunity to think differently,” Hamada said. “We’re not replacing jobs; we’re creating new ones.”

By refining the voluminous video footage, she said, researchers can focus on specific bird activities spotted by artificial intelligence, streamlining the research process.

In the face of economic practicalities, the Avian Solar team remains resolute in its objective. They intend to use their innovative technology not as a roadblock but as a new tool to bolster the solar industry. With current SETO funding, the Avian Solar prototype, which processes video streams in real time to detect and categorize bird ativities, could be operational at multiple U.S. solar facilities for testing within 6 months.

Szymanski said the project’s success lies not in capturing a single massive market but in addressing the myriad of smaller needs researchers have when studying the relationship between birds and solar fields—a testament to the adaptability and potential of their pioneering solution.

FeedForward K9

Lab: Idaho National Laboratory

DOE: Office of Nuclear Energy

Cohort: 14

Economics Versus Technology

Energy I-Corps projects can lead to diverse outcomes: a more impulsive technological advancement could lead to a large market, whereas a sound technological creation could without funding or market interest will require pivots.

The FeedForward K9 team, led by Ruixuan Li, a human factors research engineer in Idaho National Laboratory's Human Factors and Reliability Department, had the concept to provide "feedforward" human automation to assist nuclear reactor control room operators for DOE's Office of Nuclear Energy. The team included human factors scientists Zach Spielman and Tina Miyake.

Li said the experience in Energy I-Corps, which typically involves extensive direct interviews with industry stakeholders, taught them a hard lesson—sometimes the market is not receptive.

The technology behind FeedForward K9 is solid. Nuclear incidents in reactor control rooms are often due to human errors during data collection, response planning, and execution. Those random errors could be resolved by incorporating greater automation to help lead the way.

In the human body, a feedforward automated response might be shivering when we are cold to build up extra heat. In mechanical engineering, however, a feedforward control system provides sensors to detect disturbances affecting the machine. A built-in mathematical model then provides necessary predetermined responses to minimize the effect of the disturbance. The feedforward visualization technique leverages the capabilities of artificial intelligence technologies, including machine learning and control logic, to provide decision support and alert operators.

Ruixuan Li and Tina Miyake are working toward commercializing a visualization technique that leverages artificial-intelligence capabilities, including machine learning and control logic, to provide decision support for nuclear operators. *Photo from Idaho National Laboratory*

However, Li said, what the team heard repeatedly during industry interviews was, "That's not what we want."

"Companies are only interested in meeting existing regulations, and there is no market for our technology or plans to advance it yet," Li said. "It sounds like [companies] think [the technology] is feasible, but they don't want to put money into [it at this time.]."

The team's key takeaway from their experience in the Energy I-Corps program, is safety is important, but economics is the fundamental driver for technology commercialization. Examining what they learned, the team pivoted to look at what their technology was capable of to help other users, perhaps field operators. Embracing the pivot, the team has identified and plan to explore the possible market of those working towards creating remote monitoring and automation standards.

HighWind

Lab: National Renewable Energy Laboratory

DOE: Wind Energy Technologies Office

Cohort: 15

Disrupting the Wind Energy Industry

The reality of most technology is, if you want prime results, it costs extra money to get it. This theory applies to cars, mobile phones, health care, espresso makers, and, in this case, even wind turbines.

NREL Computational Scientist Ashesh Sharma and his team have the technology and funding in place from DOE's Wind Energy Technologies Office to excel. The team also included Marc Henry De Frahan from the Computational Science Center and Shreyas Ananthan, industry mentor and Chief Technology Officer at AscentOS.

Currently, their research results far surpass industry wind farm and turbine design standards and could advance green energy efforts into the future, but convincing and proving this to industry executives remains the true challenge.

The HighWind team uses physics and the most powerful supercomputers available to advance the wind energy industry. A previous project, ExaWind, was bolstered by a billion-dollar DOE initiative to resolve various applications on the fastest supercomputers ever. It resulted in the development of a suite of open-source high-fidelity modeling tools capable of simulating airflows across a range of turbine blade-length scales, spanning 10 orders of magnitude to atmospheric conditions. The team applied to Energy I-Corps to explore viable market pathways for ExaWind's commercialization.

"We created this software to simulate the highest ability of wind physics possible," Sharma said. "We didn't consider the design solutions needed for a simple workstation. Our tool is also much more expensive when it comes to computational cost. Energy I-Corps was our attempt to find where ExaWind could fill in the industry gaps and expand the user base of the software."

Despite their technical accomplishments and validation of their tools, Sharma said persuading the industry to embrace more precise, high-fidelity models at a higher cost remains the challenge. The team conducted extensive interviews with industry experts and executives.

Marc Henry de Frahan (left), entrepreneurial lead, and Ashesh Sharma, principal investigator, working towards commercializing of a suite of open-source high-fidelity modeling tools capable of enabling long-distance simulation of flows. *Photo by Kira Vos*

"Our takeaway was that people do aspire to access higher fidelity and accuracy," he said. "However, as things stand, only a handful of companies can realistically afford it. The cost remains a formidable barrier. The only way to sway the industry is through validation studies conducted on existing wind farms."

Sharma said acquiring experimental or field data from these wind farms is a monumental challenge, as the data is typically controlled by turbine suppliers. This is a classic chicken-and-egg dilemma. How can the team demonstrate the tool's accuracy to potential customers without access to their data, even when it is widely accepted that the physics and metrics being adopted are far more precise than industry standards?

Since their involvement in Energy I-Corps, most of the team's efforts have revolved around obtaining field data to formally establish the tool's accuracy. Although the project enjoys full funding and steady progress toward a robust product, the fundamental challenge persists—convincing companies to take the risk and invest in advancing their products.

"Our goal now is to redefine industry norms. If higher-fidelity models become the new benchmark, even smaller companies won't have an alternative but to adopt these models," Sharma said.

With this pivot, the HighWind team is responding to what the market actually needs, instead of pursuing a technology for which it might not be ready. As they continue to gather data and make strides, they are optimistic about the positive impact their innovation will have on the industry.

IrrigationViz

Lab: Idaho National Laboratory + Pacific Northwest National Laboratory

DOE: Water Power Technologies Office

Cohort: 12

The Realities and Joys of Taking Tech to Market

The Energy I-Corps team, funded by DOE's Water Power Technologies Office, ultimately learned that the market for technology is sometimes a gamble based on customer needs.

Their project, IrrigationViz, led by Idaho National Laboratory with Pacific Northwest National Laboratory and industry partners, addresses the inefficiencies and potential hazards of aging water delivery systems in the West. Assessing and planning for the modernization of these systems can be cost-prohibitive and out of reach for many smaller irrigation districts.

Team Entrepreneurial Lead James Kershaw, a Pacific Northwest National Lab software engineer with the Energy and Environment Directorate, said the tool is designed to aid irrigation district managers in pre-assessing projects and estimating water loss, groundwater impacts, and potential hydropower generation, before committing to costly engineering valuations. The team also included Idaho National Laboratory Principal Investigator and Data Scientist Shiloh Elliott and Industry Mentor Jeff Smyth of Sapere Consulting.

"The gap is that it takes money to get money," Kershaw said. "In order to qualify for federal grants, you need to provide a proposed design. If you have an engineer on staff, great. That person can assess the need, draw up a design, and assess the proposal. Some districts do not have the resources."

Kershaw said the goal was to create a visual, Sim City-style: IrrigationViz, a decision-support tool offering high-level estimates for irrigation modernization, integrating public and private data with geographic information systems. Developed in collaboration with the Farmer's Conservation Alliance and with input from several irrigation districts, IrrigationViz aimed to bridge the gap for districts struggling with limited resources to strategize and plan long term, despite the availability of federal funding for modernization.

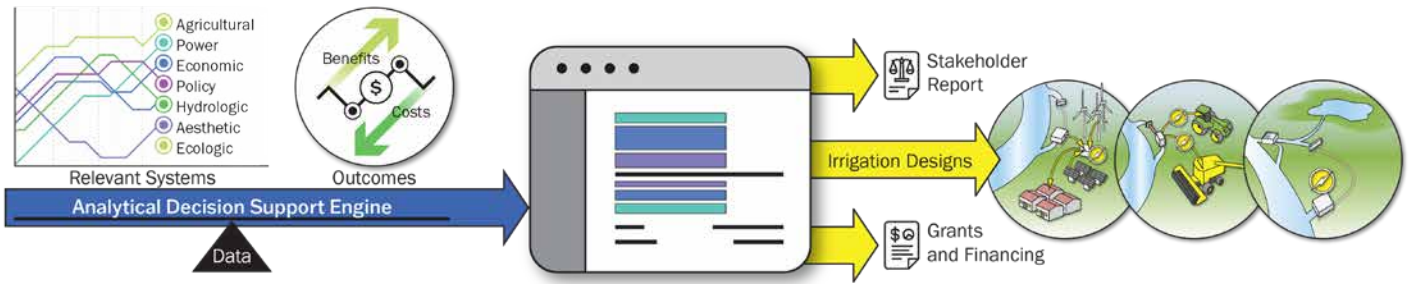
However, trust for and adoption of IrrigationViz remained challenging as the team navigated the balance between simplicity and accuracy. Through nearly 100 interviews and interactions with industry leaders and federal agencies during the Energy I-Corps program, the team grappled with finding a viable path to market.

"It's a very difficult problem, because for people to use the tool, they must be able to trust the tool. We're trying to take something that certified engineers do and turn it into a point-and-click automation thing. It's a tall order," Kershaw said.

The team explored various models, including supporting federal entities in grant evaluations and potential open-source avenues, only to realize the challenges posed by inconsistent evaluation methods and the districts' limited abilities and willingness to pay.

"The goal of Energy I-Corps is discovering the path to market. You must come up with a business model. What would it look like if we let this grow legs and run free out of the lab, right?" Kershaw said.

By going through the Energy I-Corps program and speaking with potential stakeholders, the team concluded that commercialization might not be feasible at this time without buy-in from the target market. The team nevertheless embraced the learnings and experiences gained through the program. Despite the challenges, Kershaw said he found joy in the process underscoring that sometimes the journey and the learnings it brings are just as valuable as the end goal. For the time being, while keeping one eye open for a commercialization window, the team continues incorporating their market-pull approach back at the lab to be better researchers.



To bring the irrigation industry into the modern century, the IrrigationViz team created a software system that serves as a master-planning tool modeling high-level costs and plans for a project. *Photo from IrrigationViz, PNNL*

MAC

Lab: National Energy Technology Laboratory

DOE: Office of Technology Transitions

Cohort: 12

A Deep Dive Into Oil Drilling and Enhanced Research

This Energy I-Corps team from the National Energy Technology Laboratory jumped headlong into the world of oil-drilling operations, creating not just a new market for their technology but invaluable lessons to guide their future work.

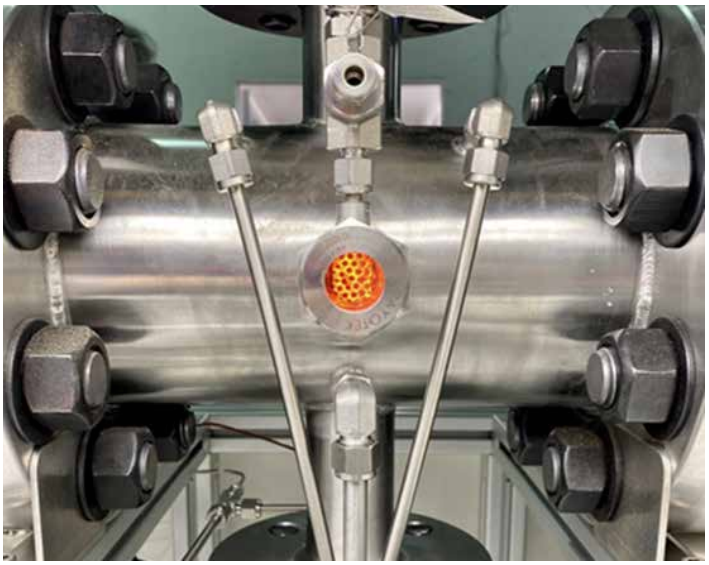
Led by National Energy Technology Laboratory Research Scientist Christina Wildfire and Chemical Engineer Daniel Haynes, who serves as portfolio lead for methane conversion, Team Microwave Assisted Catalysis developed a novel on-site microwave reactor on a skid system, which they then took through the Energy I-Corps program, funded by OTT.

Methane, predominantly found in natural gas, becomes a byproduct of oil drilling, leading to the process of flaring—burning off the gas on-site to reduce emissions. While converting methane to less-harmful compounds, flaring still contributes significantly to carbon dioxide emissions. It is also banned in several states, including Colorado for new drilling sites, and this trend is expected to continue.

Wildfire said their reactor offered a solution: converting the natural gas, typically flared off, into valuable chemicals directly at the drilling site. This business model, serving oil drillers, included complete installation and repurposing of chemicals.

Under the mentorship of industry veteran Terry Hanahan, the team dove into the complexities of oil drilling and the impacts of legislation on smaller drillers. What they discovered during the Energy I-Corps program was their initial target audience—major oil companies—was off-base. They shifted focus to service industry companies and smaller drilling operations, learning quickly that cold calling to set up surprise interviews would get them much further than relying on scheduling support.

“We learned so much about that industry, and how oil drillers do not consider flaring as a problem, but if you talk to legislators, they agree it’s a big issue and want to ban it. It got complicated fast,” Wildfire said. “It’s becoming more of an issue in certain states. The big drillers have the resources to bring in natural gas pipelines for oil sites to avoid flaring. The more independent drillers don’t have those resources and suffer more from the legislative changes.”



To capture natural gas instead of burning it, the MAC team uses a microwave reactor with an electric-based process to convert the methane into a higher-value chemical commonly used in plastics manufacturing. *Photo from MAC, NETL*

The oil-drilling companies told their group that if the methane conversion technology was economic, they would use it, but selling just a reactor was not a viable option.

“We quickly realized we couldn’t sell them a reactor. We would need a startup company to provide a service,” Wildfire said.

This led the team to learn more about other companies also taking natural gas and converting it into hydrocarbons. She said one company even took natural gas to power generators for supercomputer banks for companies like Disney’s animation computing groups.

Looking back at their time in Energy I-Corps, Wildfire said, the team will continue their research, finalizing catalysts and scaling the process, poised to contribute meaningfully to reducing emissions and transforming energy production.

“[Energy I-Corps] completely changed my mindset on research,” she said, “I want to do science because I think it makes a difference. I want to make sure my technology leaves the lab. I use the techniques we learned all the time, like customer discovery. I find out about the industry and now it’s a starting point for all my projects.”

Mixed Plastics Upcycling

Lab: Oak Ridge National Laboratory

DOE: Advanced Manufacturing Office*

Cohort: 15

Revolutionizing Plastic Recycling With Organocatalysts

More than 400 million metric tons of plastic is produced each year, and over 80% are not recycled. The different physical properties of material used in bottles, packaging, textiles, and other consumer goods turn recycling mixed plastics into a complex undertaking. At the same time, the demands of presorting makes plastic recycling inefficient and expensive. Even when a single type of plastic can be isolated, current recycling methods mostly deliver down-cycled plastics and chemicals only suitable for reuse in lower-quality products.

A new organocatalyst-based technology from Oak Ridge National Lab makes it possible to recycle mixed plastics in a single batch—eliminating costly sorting and increasing the plastic recycling rate. The efficient process transforms traditionally unrecyclable waste into widely used chemicals, while cutting energy use and greenhouse gas emissions, compared with petroleum-based chemical production. It can be used to selectively deconstruct diverse plastics including polyethylene terephthalate (PET), polycarbonate (PC), polyurethane (PU), and polyamide (PA), while keeping cellulose and commodity plastics such as polyethylene (PE), and polypropylene (PP) intact. The new organocatalyst also offers better stability when exposed to air and moisture, plus lower toxicity than metal-based catalysts.

Through Energy I-Corps, the Mixed Plastic Upcycling team gained a real-world understanding of industry needs throughout the plastics supply chain. Interviews and marketplace exploration gave the developers greater insight into the priorities and challenges faced by recycling processers, chemical producers, and polymer manufacturers. Input from industry stakeholders and mentors supplied critical direction in establishing a pathway to commercialization for this breakthrough mixed plastic recycling technology.

Tomonori Saito (left), principal investigator, and Md Arifuzzaman, entrepreneurial lead, working towards commericalizing of a new organocatalyst-based technology to recycle mixed plastics in a single batch. *Photo from Tomonori Saito, ORNL*

Following program completion, the Entrepreneurial Lead of the Mixed Plastics Upcycling team, Md Arifuzzaman, founded a startup named Re-Du and licensed the core technology. Re-Du was awarded a DOE Lab-Embedded Entrepreneurship Program fellowship through Oak Ridge's Innovation Crossroads to support entrepreneurial growth and technology validation. Additionally, the Energy I-Corps team submitted a nonprovisional international patent application for the mixed plastic deconstruction process and published a signature study, "Selective deconstruction of mixed plastics by a tailored organocatalyst," in the peer-reviewed journal Materials Horizons.

Beyond providing a powerful new method to combat plastic waste and climate change, ORNL's recycling technology could be a game changer for a number of other products, such as automotive and aerospace components. This will play a crucial role in creating the closed-loop economy that is needed to move the nation closer to net-zero emissions and a clean energy future.

*In 2023, the Advanced Manufacturing Office restructured to the Industrial Efficiency & Decarbonization Office and the Advanced Materials & Manufacturing Technologies Office

RECOVER

Lab: Pacific Northwest National Laboratory

DOE: Advanced Manufacturing Office* + Vehicle Technologies Office

Cohort: 12

From Athletics to Autos: Vitrimer Innovations in Sustainability

Most conventional epoxies, nylons, and polypropylenes used to manufacture automotive parts, electrical components, and construction materials are made from petroleum. These thermosets and thermoplastics are easy and cheap to produce but can be easily damaged by mechanical stress and exposure to extreme temperatures. While newer thermoset composites are strong, they are also expensive, extremely difficult to recycle, and produced using methods that emit hazardous toxins. At the same time, the recent push toward electrification demands even more lightweight vehicle and aeronautical components.

A new class of lightweight engineered plastics, called vitrimers, can deliver better performance, more impressive impact resistance, and a longer shelf life than typical thermoset composites. Vitrimers are also easier to manufacture, repair, and recycle, and the recovery of materials for second use helps recoup original production costs.

The Recyclable CarbOn-negative VitrimER (RECOVER) team's technology produces polycarbonate from carbon dioxide as a vitrimer precursor. Reuse of 20% of the carbon dioxide waste gas, combined with bio-based constituents, yields vitrimer materials with as much as 50% sustainable content and delivers significant environmental benefits at both ends of the supply chain. These novel vitrimers establish a beneficial use for the most significant source of greenhouse gas while simultaneously decreasing pollutants related to manufacturing, reducing production waste, and presenting greater potential for reuse and upcycling.

Suh-Jane Lee (pictured), principal investigator, with Wenbin Kuang and Leo Fifield, entrepreneurial leads, are working toward commercializing of a technology that reduces greenhouse gas emissions by converting CO_2 to a value-added material for various applications. *Photo by Senthil Subramaniam, PNNL*

Following an initial focus on applying vitrimer technology to athletic equipment as a market with relatively low barriers to entry, in the last year, the RECOVER team has expanded its efforts to begin targeting the automotive industry.

Taking lessons learned in dealing with manufacturers of expensive custom bicycles, researchers initiated dialogues with the automotive industry to determine the most likely pathways to market in that sector. Input from the team's industry mentor and extensive research have helped identify value propositions to more closely address the high throughput and budgetary dictates of auto manufacturing with this durable and lightweight material.

In the last year, the Energy I-Corps RECOVER team has partnered with the University of Akron and Raytheon Technologies Research Center. Together, they are moving forward with parallel development of recyclable carbon fiber composites using vitrimer resins that are more energy efficient to produce, stronger, longer-lasting, and contribute to a circular economy. This ancillary work is funded by a $1.9 million grant from DOE's Advanced Manufacturing and Bioenergy Technology Offices as part of the Bio-Optimized Technologies to keep Thermoplastics out of Landfills and the Environment (BOTTLE™) program.

*In 2023, the Advanced Manufacturing Office restructured to the Industrial Efficiency & Decarbonization Office and the Advanced Materials & Manufacturing Technologies Office

SuperChips

Lab: Lawrence Berkeley National Laboratory

DOE: Advanced Scientific Computing Research (ASCR) Program

Cohort: 11

Tackling Quantum Computing Control

Quantum computing has revolutionized society's ability to run complex programs much faster than classical computers. However, even state-of-the-art quantum computers struggle to meet the needs put upon them by today's increasingly sophisticated demands at the speed users expect. Quantum computers are currently limited in size, speed, memory, and scale-up, due to the need for a large amount of wiring.

The SuperChips team designs advanced microchips with decreased structural and functional complexity using superconducting devices that enhance complementary metal-oxide semiconductor transistors. This strategy reduces the number of wires necessary to control quantum computing architecture, which demands many readout and control signals for operation. The SuperChips Team builds virtual blueprints for these specialized chips, sends them to partners for manufacturing, and licenses them to customers.

Dilip Vasudevan, principal investigator for SuperChips, says companies wishing to sell quantum computers in the near future "need someone to help them build these efficient control chips. Without this missing piece of the puzzle, [quantum computers] cannot sell," he said.

These highly efficient designs are based on reconfigurable computing architectures that allow the team to customize performance to meet the needs of specific quantum system applications. Applications like machine learning, digital signal processing, financial algorithms, and scientific simulations can run much faster with this technology compared to current transistor-based electronic chips.

Dilip Vasudevan (pictured), principal investigator, with George Michelogiannakis and Shyam Dwaraknath, entrepreneurial leads, accelerated the commercialization of chip designs for high-performance computing architecture using superconducting devices. *Photo from SuperChips, LBNL*

The SuperChips team conducted customer interviews during Energy I-Corps to identify and define quantum system control problems. The team discovered two main priorities well suited for their custom microchip solution—quantum system control and heterogeneous hardware accelerator design for machine learning and neuromorphic systems.

During Energy I-Corps, SuperChips connected with two specific quantum system customers interested in their product. Customer interviews led to the team's incorporation of a business to design and prototype their chips.

The SuperChips technology has since been selected as an R&D 100 Awards Finalist and for DOE's Emerging Tech Studio, offered by OTT and NNSA, in partnership with FedTech. SuperChips was also among the top 10% of the 15,000 applications for Y Combinator.

In the last year, SuperChips pivoted to extend and apply their technology to the fintech and cybersecurity industries. Continuing to incorporate the market interviewing skills learned in the Energy I-Corps program, the team conducted interviews with bankers, trading companies, and other stakeholders to determine their specific needs. SuperChips is currently focused on building hardware accelerator chip designs to accelerate algorithms at trading companies and machine learning startups. This will enable faster trades, inference, and training when discovering more customers in the quantum control domain.

Tough Adhesive

Lab: Oak Ridge National Laboratory

DOE: National Nuclear Security Administration

Cohort: 15

Tough Adhesive Team Doubles Down on Tech

This research group from Oak Ridge National Laboratory came into the Energy I-Corps process well-established and fully supported. A patent on their recyclable and green tough adhesive was already filed and numerous media profiles already covered their concept story.

Essentially, their published technology takes used commodity plastics—something there is certainly no shortage of worldwide—and turns the material into a much stronger, more reliable, and entirely recyclable adhesive.

Researchers applied polymer chemistry to transform the plastics into a bonding agent with a rare combination of strength and elasticity, making it one of the toughest materials ever reported. The technology adapts to bear heavy loads, tolerate extreme stress and heat, and reversibly ties to various surfaces, including glass, aluminum, and steel, already turning heads in the scientific community.

Oak Ridge National Lab Team Lead and Synthetic Polymer Chemist, Anisur Rahman, said the Energy I-Corps experience brought an eye-opening discovery process to the table in business discovery.

“We are scientists, so we don’t know a lot about things on the marketing side. We know how to develop the product,” he said.

Their experience in Energy I-Corps ultimately expanded their horizons from the realms of engineering and chemistry to the much different world of marketing and economics. Interacting with over 75 industry contacts, the Tough Adhesive team refined their understanding of where their product could truly stick.

From left, Menisha Mahappu Koralalage, Bokyung Park, Sylas Rehbein, and Md Anisur Rahman are working toward the commercialization of an exceptionally strong and tough adhesive that could be used in a variety of applications. *Photo by Kira Vos*

“Industry adhesives are very strong, but most of them are very brittle. It gives you strength but can break very easily. There are other adhesives that are soft and give you the extension, but they do not give you the strength,” Rahman said. “There is a gap here and we feel our adhesive can give you both extension and strength.”

The team, comprising three entrepreneurial leads and an industry mentor, found strong support within the industry, thanks to the Energy I-Corps interview process. Ultimately, they found a potential licensee, and are, currently, discussing a licensing deal with an industry partner who produces different polymers for building applications. Rahman said the discussions point to the company integrating the Tough Adhesive team’s technology into its own adhesive-making process. The result would help fund the de-risking of the team’s product and fast-track it through further studies.

During their time spent during the Energy I-Corps program, the Tough Adhesive team ended up exploring customer discovery, connection, and transformation. The team not only developed a groundbreaking adhesive but also forged valuable industry relationships and gained a deeper understanding of the market, positioning their technology for success in the competitive world.

UBEM

Lab: Lawrence Berkeley National Laboratory

DOE: Building Technologies Office

Cohort: 12

CityBES Finds Collaboration Toward Real-World Impact

Team Urban Building Energy Modeling (UBEM) from Lawrence Berkeley National Laboratory not only found the Energy I-Corps program insightful, but also that it equipped them with the know-how to advance their goals through deeper collaboration.

Supported by DOE's Building Technologies Office, Lawrence Berkeley National Laboratory Senior Scientist Tianzhen Hong led the urban building energy modeling project with Research Scientist Kaiyu Sun, Post-Doctoral Researcher Jeetika Malik, and industry mentor Lowell Chu, an energy program manager at the City and County of San Francisco.

A cornerstone in the ambitious drive toward achieving carbon neutrality by 2050, CityBES (City Buildings, Energy & Sustainability) is more than just a modeling tool. The technology harnesses the international open data standard, CityGML, and employs the physics-based energy modeling tool EnergyPlus® to simulate building energy use and calculate savings from energy retrofits. It embodies urban retrofitting at scale, including electrification, energy efficiency, thermal resilience analysis, and cost-benefit analysis.

"It targets urban-scale, city-scale, or even neighborhood-scale—multiple, hundreds or even thousands of buildings can be evaluated," Sun said.

The team's goal of joining Energy I-Corps was to learn about potential CityBES customers and how it could be useful to them as a product or service. It was enlightening.

"It was like peeling an onion," Sun said. "We thought the cities were our customers, but after talking to them we learned most of the cities don't have the capabilities of doing their own modeling. They must hire consultants to do it for them. That's when we considered that consultants might be a better partner for CityBES, or both [cities and consultants]."

Tianzhen Hong, Kaiyu Sun, and Jeetika Malik are working towards the commercialization of a web-based data and computing platform providing energy modeling, benchmarking, and performance visualization of a city's building stock. *Photo from LBNL*

A testament to the program's impact, the team's interview with Portland General Electric materialized into a multi-million-dollar research collaboration to assess the impact of heat waves on utility operations, particularly during power outages in vulnerable communities.

Moving forward, Malik said, the true value of Energy I-Corps was they learned how to present their technology in a business setting, and those techniques opened doors to further collaboration.

"That was the best experience," Sun said. "We would never have done that without Energy I-Corps. The entire process led to new projects being funded and more support for other technical work."

The CityBES technology eventually went on to win a 2022 R&D 100 Award because of what the team learned in the program—refining their value proposition, framing more-effective interview questions, and exploring the unique facets of CityBES. It further led to multiple funded projects through DOE's Solar Energy Technologies Office and another for Los Angeles County.

In essence, the Lawrence Berkeley National Laboratory team's journey through Energy I-Corps showcases the synergy of innovation, collaboration, and real-world impact, with CityBES poised to be an instrumental force in the future of building decarbonization.

UltraSep

Lab: Los Alamos National Laboratory

DOE: Bioenergy Technologies Office

Cohort: 12

Advancing Particle Separation in Brewing and Beyond

Separating particles from liquids is a critical process in many established industries ranging from food and beverages to toxic chemicals. However, processes using conventional technologies like centrifugation and membrane filtration have considerable disadvantages.

Breweries currently prefer to use centrifuges to clarify beer, but few have them due to high purchase, maintenance, and energy costs. Centrifugation often removes more particles than intended, negatively affecting the quality and taste of the final product. Membrane filtration can also remove more particles than desired and impart unwanted tastes.

During the process, workers are exposed to hazardous radioactive doses while manually adjusting the pH, using strip tests to monitor pH changes, and performing lifting and pouring actions to transfer the suspensions into filter holders. The filtration process is slow, susceptible to delays due to clogging, and difficult to predict and control.

Ultrasonic filtration or separation (UltraSep) is an emerging technology that removes particles from liquids using a silent standing wave. The ultrasonic field traps microparticles with different densities than the liquid while allowing the liquid to flow through. The particles are moved laterally to nearby nodes, where they quickly clump together and settle to the bottom of the vessel for easy capture.

Compared to membrane filtration, UltraSep provides more selective particle removal and transforms slow, unpredictable filtration rates into a well-controlled, continuous process. The technology requires very little maintenance and does not generate the chemical wastes produced when membranes require cleaning or the solid wastes produced when membranes must be replaced.

From left, Jim Coons, Karla Erickson, Audrey Roman, and Jackie Dorhout applied a membrane-free filtration technology that removes particles from a range of liquids to actinide hydroxides. *Photo from UltraSep, LANL*

The UltraSep team conducted an in-depth analysis of the New Mexico craft beer market during Energy I-Corps. Through interviews with brewmasters, equipment manufacturers, grain suppliers, and other stakeholders, the team found that the market prioritizes quality and is open to new strategies for clarifying beer.

UltraSep can provide brewers with a more-selective clarification process, allowing them to remove large particles that decrease stability and shelf life while leaving in smaller molecules that may enhance flavor, taste experience, and quality. “We are encouraged by this technology’s ability to modify the chemical composition of beer compared to centrifugation,” said Technical Project Manager Jim Coons. “We are working to understand if UltraSep can create a cost-competitive path forward for brewers to produce beer with the same or superior consumer experience and stability.”

Since Energy I-Corps, the technology readiness level of UltraSep has increased from 4 to 6, meaning the team advanced their technology from being used only in a lab environment to prototype demonstration. The team has received additional funding totalling more than $1.5 million and partnered with local craft breweries to test the technology within the New Mexico Small Business Assistance program.

The UltraSep team has also found success in removing actinide hydroxide from wastewater, resulting in promising solutions for the water treatment industry. “The UltraSep process is automated and can be operated remotely with very little involvement from an operator,” Coons explained. “By not using a membrane, we have removed the clogging scenario, reduced the volume of secondary waste, and increased processing rates and predictability.”

Fermians

Lab: Fermi National Accelerator Laboratory

DOE: Advanced Manufacturing Office (+ Office of Fossil Energy and Carbon Management + Office of Technology Transitions)

Cohort: 3

From Fermians to Metal Zapper

When the Energy I-Corps organizers asked the team for a name for their project, the team from Fermilab was downright pragmatic. Because they were all from Fermi and did not know what their final product would look like, they called themselves the Fermians. Today, Senior Technology Development and Commercialization Manager Jayakar CHarles Thangaraj thought of a different name he feels fits better.

"Maybe I would call it metal zapper," he said, "because our electron beam technology melts metal powder to create parts."

The technology is a compact accelerator that fires electron beams (e-beams) to create metal parts—like what most 3D printers do with lasers. However, the e-beam can melt refractive metals, such as tungsten, molding those into items with much more durability than plastic. The compact accelerator already has many different uses, such as enabling durable road pavements and wastewater treatment, but Thangaraj and his team came in looking for another vertical to use.

"We wanted to look for something different, something that had not been tried before," he said. "We initially proposed this for use on the vulcanization of tires, but through dozens of interviews, we found there was not a big market, so we pivoted."

The interviews were part of the Energy I-Corps program, and it helped the team discover a niche market for e-beam molded metal for medical parts, machine parts, and more. Thangaraj felt the Energy I-Corps experience was so transformative that he became a huge advocate and now helps teach "mini-I-Corps" cohorts as part of the Topic 1 programming hosted at Fermilab.

Jayakar CHarles Thangaraj (pictured), principal investigator, with Daniel Bowring, entrepreneurial lead, are working toward the commercialization of a compact accelerator that fires electron beams to create metal parts
Photo by Tom Nicol, FNAL

"Energy I-Corps gives you a robust toolkit," he said. "It gives you an experimental approach to the discovery process. If you propose to build something and potential partners don't like it, that's great; you take that as data and then keep honing toward what people actually want. It crystallized an important question for me: 'Do you want to build something that actually solves a pain point for a reasonably large set of people, or do you just want to build something cool?'"

Since participation in Energy I-Corps, Fermilab's compact accelerator project received millions of dollars of funding for construction. Currently, Thangaraj and his IARC team at Fermilab are working on building the accelerator prototype through Energy I-Corps Topic 3. However, Thangaraj continually focuses on the lessons he learned from Energy I-Corps.

"When I see any research project at the lab, I just start thinking about who else could use it," Thangaraj said. "It's not only about technology; it's about solving a problem that's specific, measurable, and direct. There's a world that's bigger than science. We can all be better listeners."

To illuminate his newfound outlook on projects, Thangaraj related a story about a project in which his colleagues needed to solve a challenge that involved joining two metals to operate under cold temperatures. They believed gold would be a good option, because it is a good conductor. He suggested the team consider how expensive it would be to manufacture at scale using gold as the conductor material.

"Someone is going to be creative and replace the gold, so why don't we replace it right now?" he said. "It's important to think in scale and pay attention to manufacturing issues even at the R&D prototype stage. Fortunately, our team found a new solution, not a perfect one, but it works."

The Fermilab team is an awardee of OTT's Topic 3: Post Energy I-Corps funding opportunity. For this project, the team is working with a partner to build and test two cathodes to demonstrate that the cathodes can meet commercialization specifications.

Gamma Reality, Inc.

Lab: Lawrence Berkeley National Laboratory

DOE: Environmental Management

Cohort: 6

Gamma Reality, Inc.'s LAMP to Find Radiation

Radiation is an invisible hazard, and detectors, historically, were only geared toward expert users. Additionally, older detectors cannot pinpoint precisely where the hazard is. That is where Gamma Reality, Inc.'s (GRI) new Localization and Mapping Platform (LAMP) comes in.

"The technologies we developed at Lawrence Berkeley National Lab broke ground because we were able to visualize the radiation in a 3D map of the environment in real time," Erika Suzuki, co-founder of GRI and head of business development, said. "Now, anyone can look at a map and identify where a hazard is. We still provide important information, such as dose rate and isotope identification, but the real innovation is in the localization of radiation visualization. Because you're detecting in real time, you can map out a hotspot and immediately leave to reduce your exposure as needed."

GRI started when the team participated in Energy I-Corps' sixth cohort in 2017. After establishing the technology, the startup conducted research campaigns all over the world, and, wherever they went, people kept asking the same question.

"'Where can we get one?'" Suzuki said. "'It would help make my job safer and enable me to better understand and communicate where the radiation is.' Inspired by these experiences and our time in Energy I-Corps, we started thinking about how we could commercialize the technology."

Suzuki called the experience with Energy I-Corps a critical turning point in how the team built up the company.

"I realized that to truly make an impact, the technology would need to leave the lab so it could be used in the real world," she said. "I previously had no interest in launching a startup, but I was really fascinated by the commercialization process, especially after learning more about it during Energy I-Corps. Every day, the program taught us how to ask better questions and gain new perspectives into how our technology could be used by different people for different use cases. We were also able to test out various user engagement strategies and fail in a friendly environment. We're still using what we learned in Energy I-Corps today."

Andy Haefner, principal investigator, with Erika Suzuki, entrepreneurial lead, accelerated the commercialization of a technology that enables users to "visualize' gamma-ray emitting radioactive sources by producing 3D maps of an area of interest in real-time. *Photo from Erika Suzuki*

Participating in Energy I-Corps helped GRI explore potential target markets, and in 2019, GRI won both the Berkeley Lab and DOE National Laboratory Accelerator pitch competitions. After Energy I-Corps, GRI developed the use case for its first target market: nuclear power. In January 2020, GRI launched full-time operations.

GRI employs 11 people, and Suzuki says it can support the future of the current nuclear power fleet, as well as the development of next-generation nuclear reactors. LAMP helps plants more efficiently and safely plan work, which helps reduce radiation exposure for employees and operating costs.

One of GRI's partners, Dominion Energy, recently won a 2023 Nuclear Energy Institute Top Innovative Practice Award for their work with LAMP and deploying it remotely on Boston Dynamics' SPOT robot.

"We're excited to continue shipping LAMPs out the door," Suzuki said. "We're also continuing to expand LAMP's capabilities. LAMP provides a wealth of data, so there are huge opportunities."

She also has an important message for others considering participating in Energy I-Corps.

"Coming from a non-technical background myself," she said. "I want to tell others that you don't need to be a scientist or engineer or have a Ph.D. to commercialize technology."

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GRIP

Lab: SLAC National Accelerator Laboratory

DOE: Office of Electricity (+ Office of Technology Transitions)

Cohort: 14

Predicting Where Outages May Happen

It sounds like magic: knowing where a power outage may likely occur before it happens so a utility can take appropriate action either right before or soon after a grid disruption takes place.

“If you know there will be a wildfire in a certain area,” said Alyona Teyber, staff engineer at SLAC National Accelerator Laboratory and principal investigator for the Grid Resilience and Intelligence Platform (GRIP), “you can better prepare for it ahead of time. You can stage your crews, and you can reconfigure your systems so you can better ride out the event while maintaining safety and quality service to customers.”

The GRIP tool takes data sets and analyzes them to help predict what is most likely to happen during a disaster or weather event. For example, the GRIP team analyzed the vulnerability of wooden electric poles.

“We’re able to do a bulk analysis on which poles will fail at which part of the network,” Teyber said. “We do an analysis on the pole, considering the tilt, the wind, the framework, and we would predict when it would hit failure if there was a sustained wind in a certain direction.”

With this knowledge, GRIP users can deploy crews ahead of time, at the same time determining which outage would be the highest priority.

“There might be some poles that might be about to fall down, but they are supporting something that’s not crucial,” Teyber said. “The ones that are supporting a neighborhood that doesn’t have a backup system in place would be priorities.”

After going through the Energy I-Corps program, the GRIP team is now working with the U.S. Department of Homeland Security and other DOE offices to develop new use cases and find paths to commercialization. Southern California Edison is also testing the GRIP system. GRIP is also on the verge of working with additional utilities.

Alyona Teyber, principal investigator, with Gustavo Cezar, entrepreneurial lead, is working toward the commercialization of a technology-agnostic methodology to present analytics that can be deployed on any electrical utility platform.
Photo from SLAC

“As a person with an engineering background, I had very little understanding of the business side of things before Energy I-Corps,” Teyber said. “It gave me training and brought me up to speed to be able to give this thing legs. Learning how to approach people, how to communicate, learning to listen before communicating my project, learning to find commonalities, and learning to de-risk in a way that’s effective rather than what I think they want to see.”

The GRIP team continues to validate their tools with new potential users and pitch to funders to further their technology adoption.

“The next step is to get a full validation suite and a report from Southern California Edison,” Teyber said. “See if we can get a hook to continue forward [with the technology's commercialization.]"

The GRIP team is an awardee of OTT’s Topic 3: Post Energy I-Corps funding opportunity. With this award, the team is partnering with Post Road Foundation to expand GRIP’s market reach to include electric cooperatives.

nDETECT

Lab: Sandia National Laboratories

DOE: National Nuclear Security Administration

Cohort: 14

nDETECT Team Wins Prize to Advance Pollutant Monitoring Technology

When the nDETECT team went through Energy I-Corps, they were hoping to break ground with their technology. They did not expect to break ground in a different way.

The Energy I-Corps instructors, who voted each week during the 3-month program of nDETECT's Cohort 14, chose to award a $25,000 prize, the Energy I-Corps Commercialization Award, to Schindelholz and co-team member Wendy Rue for their efforts to move their technology toward commercialization. This was the first time instructors awarded a prize during any of the Energy I-Corps cohorts. The prize money, provided by DOE's OTT, aimed to help continue the team's commercialization journey.

"We were so excited," Mara Schindelholz, principal member of technical staff at Sandia and the principal investigator for the team, said. "We were a woman-led team, and we demonstrated that women are equally capable of excelling at technology innovation and commercialization."

nDETECT is a nitrogen dioxide sensor technology that is being developed at Sandia for real-time monitoring of pollutant gases. The sensors, composed of platinum interdigitated electrodes with a nanoporous absorbent layer, can be tuned to selectively absorb gases of interest through judicious material selection and the electrical response directly correlated to gas concentration. The award helped the team build the first stand-alone prototypes, with embedded electronics.

nDETECT now has two projects, one with the Kansas City National Security Campus, and the other at Sandia, to further optimize the design of their prototypes. The co-led Kansas City National Security Campus design is a greater fidelity sensor but requires more battery power, while the Sandia prototype is a lower-cost, more-qualitative alternative sensor solution. Schindelholz and the teams at Kansas City National Security Campus and Sandia submitted provisional patents for both types of sensors, in addition to receiving a patent for the original sensor in February 2023.

Mara Schindelholz, principal investigator, with Wendy Rue, entrepreneurial lead, is working toward the commercialization of a nitrogen dioxide sensor technology for real-time monitoring of pollutant gases. *Photo from Sandia National Lab*

"This sensor was originally developed for in-situ monitoring of off-gases within a nuclear weapon," Schindelholz said. "But we're also looking at how it could similarly be used in other applications, such as for the U.S. Department of Defense, for detection of off-gases from conventional munitions in a bunker, indicative of aging munitions."

She now has a chart of all the different possibilities for the sensor use, but nDETECT is focusing in on a few first. "If we could find one of those easier applications for adoption, that would help us to continue to mature the technology," Schindelholz said.

She credits the growth of the project to the insight she gained from Energy I-Corps."Energy I-Corps really helped us better align our product development to our first applications of interest, to ensure, in the future, a rapid transition of our technology." Schindelholz said.

In addition to continuing work with nDETECT, Schindelholz is on temporary assignment as a Small Business Innovation Research/ Small Business Technology Transfer program director at the National Science Foundation, funding technology startups.

"I credit that to Energy I-Corps as well," she said. "Although I have always had a passion for technology development, Energy I-Corps provided me with the necessary skills and knowledge to be able to actively participate in the area of technology commercialization."

RouteE

Lab: National Renewable Energy Laboratory

DOE: Vehicle Technologies Office

Cohort: 8

RouteE's Map to Google and Beyond

When developing the RouteE technology, creator Jake Holden, who works at NREL, was just trying to predict the amount of energy a vehicle would use to get from point A to point B. He never dreamed people around the world would end up using the technology when they opened Google Maps.

"There's a lot of it that doesn't feel real," Holden said. "The reach and the impact of this is unlike anything I could have pictured for it."

RouteE's secret is in the accurate prediction of energy usage for a variety of vehicle types, such as gasoline-powered cars, hybrids, or electric vehicles. Holden and others at the lab have now grown that capability so RouteE can optimize routes, using less fuel in a reasonable amount of time. Now, Google Maps uses it via the "green leaf," to recommend more eco-friendly routes for users.

Creation began in 2016–2017 while Holden and others worked on the Advanced Research Projects Agency—Energy TRANSNET project aiming to use smart phones to nudge travelers to make more-efficient decisions. This could be reminding them to leave work 15 minutes early or 15 minutes later to avoid traffic. To make that work, the team needed a way to model the energy outcomes, and that is where the groundwork for RouteE came together.

As Holden tried to determine the best use of the technology, he went through Energy I-Corps, which he says helped significantly.

"The most important thing that Energy I-Corps did, and this is the first thing I tell anyone when they ask," Holden said, "is that it made me a better researcher in thinking backwards from considering a good product market fit for technology I worked on. Stop focusing on just tinkering with this software and focus on what are the most pressing needs and how can we tailor RouteE to help. You can make a much better case for funding if you can say I've talked to X number of people, and here is the demand. This is the problem that needs to be solved in the world, and here's the solution we're proposing and the subsequent impact it can have."

From left, Clement Rames (entrepreneurial lead), Jacob Holden (principal investigator), and Joshua Foss (industry mentor), accelerated the commercialization of "green routing" to co-optimize travel time and energy use bringing both economic and environmental benefits. *Photo by Harrison Dreeves, NREL*

Google reached out to Holden and NREL in late 2019 and early 2020 to discuss efforts for sustainable mapping.

"It quickly became clear that RouteE was the right tool for the eco-friendly routes product they were trying to build," he said. "The thing that hit me the hardest was the potential impact. They estimated that simply defaulting Google Maps users to the less-fuel-consuming route stood to reduce on-road greenhouse gas emissions in the United States by 1%."

Google began working with the NREL team and the RouteE methodology and first released Eco-Friendly Routing in the United States in October 2020. Since then, large e-commerce and transportation network company fleet operators have worked with NREL to determine potential energy savings in their fleets through RouteE implementation.

The plan is now to open-source the RouteE tool and methodology so more organizations can take advantage of the potential energy savings. While this approach may not maximize revenue, Holden says he is prioritizing maximum real-world impact and believes this is the right path to doing so.

"It is a very tough path to go down to spin out a company, to go out and fight for funding," Holden said. "The risk was too high in many ways [, personally]. It would have been a tough road to get to the point of monetizing it. I'm happier with having taken the lower-risk option [of executing agreements with partners] with a higher likelihood that it gets out into the world."

Tereform

Lab: National Renewable Energy Laboratory

DOE: Bioenergy Technologies Office

Cohort: 13

Two Time's Terrific for Tereform

Most Energy I-Corps participants go through the program once, learn a great deal, and then continue to grow on their own. The Tereform team got to do it twice.

"Energy I-Corps was the galvanizing factor for launching this company," Kevin Sullivan, a researcher at the NREL and now Tereform's CEO, said. "Energy I-Corps gave us an understanding of how a business could feasibly work. We conducted more than 80 stakeholder discovery interviews, through which we developed our skills interviewing people and feeling comfortable asking the right questions."

Tereform takes waste textiles, such as carpet and clothing otherwise destined for a landfill, and uses a chemical process to break those textiles down into fundamental building blocks.

"We can remake the kind of polymers and plastics they were in the beginning," Mikhail Konev, former NREL researcher and now Tereform's Chief Technology Officer, said. "You can only mechanically recycle a water bottle so many times because plastics' physical properties degrade. Our process of chemical recycling allows us to do it over and over again."

The team was originally in Energy I-Corps Cohort 13, and then got to participate again in Cohort 15 when Tereform earned a spot in West Gate, NREL's new Lab-Embedded Entrepreneurship Program (LEEP). As a LEEP node, West Gate embeds innovators at NREL and pairs them with National Laboratory scientists and capabilities over a period of 2 years.

After its second time in Energy I-Corps, Tereform won the H&M Foundation's 2023 Global Change Award and is currently in discussions with several potential brand partners.

"We're hoping to co-develop some intellectual property and other sourcing materials around," Konev said. "Many brands are interested in being able to fully circularize a garment, whether it's with scrap materials during the production process or through a take-back program for unsellable garments."

Kevin Sullivan (left), entrepreneurial lead, and Mikhail Konev, principal investigator, are working toward the commercialization of a technology that breaks down waste textiles and other hard-to-recycle plastics with oxygen. *Photo from Kevin Sullivan, NREL*

Konev and Sullivan first connected at NREL while Konev was working on biomass and plastic depolymerization and Sullivan was studying how to use oxygen to break things down, such as chemical warfare agents and other toxic compounds. As they worked to use oxygen to break down biomass, they found it applied very well to plastics.

"So, Mikhail and I developed this project around breaking down hard-to-recycle plastics with oxygen, which led to a larger effort focusing on mixed plastics," Sullivan said.

Four years later, and with two rounds of Energy I-Corps under their belts, Tereform is an established company winning awards and looking at hiring additional employees. Both Sullivan and Konev are excited for what comes next.

"Our next product milestone is scaling up the amount of material processed in a single run," Konev said. "We're also thinking about future fundraising needs and bringing on more employees to help us establish an independent lab once Tereform completes the West Gate program."

By the Numbers

To support participation in an Energy I-Corps Training Cohort, teams are awarded funding from DOE program offices, NNSA, their National Lab, or industry partners. After the program concludes, teams often seek additional funding for continued commercialization activities. Post-program funding may take many forms, including Department of Energy funding, grants, laboratory research funding, cooperative research awards, industry support, private capital, etc. The information shown below highlights the initial funding investments as well as the post-program funding that teams have reported.

INVESTMENT TOTAL
$16,265,000

POST-PROGRAM FUNDING
$177,063,137

Funding Snapshot

	Teams Funded	Investment	Post-Program Funding
Technology Office Funded	190.5	$14,452,500	$163,164,278
Lab Funded	13.5	$987,500	$10,754,998
Pilot	10	$750,000	$2,897,000
Privately Funded	1	$75,000	$246,861
Grand Total	**215**	**$16,265,000**	**$177,063,137**

Technology Office Funding Detailed Breakdown

DOE Funding Office	Teams Funded	Investment	Post-Program Funding
AMO*	28.5	$2,147,500	$30,699,739
AMMTO	3.33	$266,667	$0
BETO	23	$1,740,000	$6,281,857
BTO	13	$985,000	$3,750,000
CESER	0.5	$40,000	$0
EM	2	$150,000	$7,572,500
FECM	6.5	$502,500	$2,325,000
GTO	4.5	$342,500	$4,020,000
HFTO	4	$302,500	$1,786,857
NAWI	2	$150,000	$4,600,000
NE	16.83	$1,269,167	$13,288,000
NNSA	15	$1,150,000	$8,426,002
OE	11	$832,500	$10,630,000
OS	4	$305,000	$6,630,000
OTT	4	$300,000	$2,985,000
SETO	5.83	$449,167	$38,243,000
VTO	20.5	$1,542,500	$7,160,323
WETO	14	$1,072,500	$4,670,000
WPTO	8	$605,000	$6,746,000
WWPTO	4	$300,000	$3,350,000
Total	**190.5**	**$14,452,500**	**$163,164,278**

*In 2023, the Advanced Manufacturing Office (AMO) restructured to the the Industrial Efficiency & Decarbonization Office (IEDO) and the Advanced Materials & Manufacturing Technologies Office (AMMTO)

By the Numbers

TEAMS FUNDED
215

STAKEHOLDER DISCOVERY INTERVIEWS
15,499

By Laboratory

Lab	Teams Funded	Post-Program Funding Received	Discovery Interviews
ANL	23	$14,862,224	1718
FNAL	3	$1,550,000	182
INL	33	$26,359,088	2396
LANL	5	$1,515,000	377
LBNL	16	$24,522,500	1171
LLNL	9	$16,430,500	484
NETL	3	$725,000	227
NREL	52	$59,625,859	3875
ORNL	12	$8,287,714	921
PNNL	26	$11,992,250	1808
SLAC	2	$345,000	83
SNL	31	$10,848,002	2207
Total	**215**	**$177,063,137**	**15,449**

By Cohort

Lab	Teams Funded	Post-Program Funding Received	Discovery Interviews
0	3	N/A	225
1	14	$3,851,000	767
2	14	$28,846,222	815
3	8	$4,150,000	475
4	15	$43,215,000	937
5	12	$1,728,000	916
6	8	$14,634,361	606
7	8	$15,170,714	669
8	10	$6,095,000	776
9	12	$9,720,000	910
10	10	$8,925,500	763
11	17	$15,201,088	1148
12	18	$8,395,250	1361
13	16	$7,063,002	1251
14	16	$7,360,000	1052
15	10	$1,294,000	837
16	13	$1,414,000	1104
17	11	N/A*	837
Total	**215**	**$177,063,137**	**15,449**

*Cohort completed during the writing of this report, so no post-program funding to report as of yet.

Participation by Technology Program Offices

Energy I-Corps teams are funded by individual technology program offices within DOE. Labs also have the opportunity to fund teams or find industry partners to fund teams. Information provided on the following pages incorporates reporting from the first cohort pilot through Cohort 17, ending in November 2023.

Teams can be co-funded by multiple program offices. Co-funded teams' interview numbers are divided by the number of funding program offices.

Advanced Manufacturing Office (AMO)

Team	Lab	Cohort	Discovery Interviews
Micro Miners (.5)	LLNL	2	30
NanoHeatBlock	ANL	2	83
Saline Solutions	LLNL	2	50
Fermians	FNAL	3	48
E-RECOV	INL	4	57
Re-Light	INL	5	75
Electroplate (.5)	INL	5	28
BaSiC	NREL	5	80
COMBA	LBNL	7	107
LaserSense (Iris Light Technologies	ANL	7	79
FLO.materials	LBNL	7	78
HyMag (.5)	ANL	8	39
CAN-Coatings	ANL	8	72
Shakti Power Systems	ANL	9	71
C-CHiRP	ANL	10	78
E-Ionsorb	LLNL	10	61
EMEE	INL	11	79
ARME	PNNL	11	77
Sustainability Innovators	INL	11	74
RE-Metal	INL	11	76
EC-Leach	INL	12	71
RECOVER (.5)	PNNL	12	39
WESAP	PNNL	12	93
CO2 converters (.5)	ANL	12	39
Wolfram Plating	SNL	13	68
Galileo	ANL	13	80
Phase Changers	NREL	14	78
FrozEn	PNNL	14	79
CAML	SNL	14	55
Regenerable Catalysts	SNL	15	65
Mixed Plastic Recycling	ORNL	15	88

TOTAL TEAMS FUNDED
28.5

INVESTMENT TOTAL
$2,147,500

POST-PROGRAM FUNDING
$30,699,739

DISCOVERY INTERVIEWS
2,097

Advanced Materials and Manufacturing Technologies Office (AMMTO)

Team	Lab	Cohort	Discovery Interviews
Diamond SemiConductors	SNL	16	77
Recyclobot	ANL	16	103
Litholution	INL	17	76
SSAM (.33)	PNNL	17	25

TOTAL TEAMS FUNDED
3.33

INVESTMENT TOTAL
$266,667

POST-PROGRAM FUNDING
$0

DISCOVERY INTERVIEWS
281

Participation by Technology Program Offices

Bioenergy Technologies Office (BETO)

Team	Lab	Cohort	Discovery Interviews
High-Moisture Pelleting Process	INL	2	86
FiberSAS	ANL	3	76
WasteNot	ANL	3	70
FUSS	LANL	4	71
Bio-Blend aka OptiBlend	INL	4	75
Nitrilica	NREL	5	77
Glycoplastics	NREL	5	77
CuB Fuels	NREL	5	98
Electro-Active (.5)	ORNL	7	40
Fermeley	LBNL	8	81
EcoPod	LBNL	8	77
Embodied Carbon	NREL	9	78
Grab-X	ANL	9	83
Cycle	NREL	10	86
Scum Ranchers	SNL	10	78
BETTER	NREL	11	73
UltraSep	LANL	12	76
Bio-NIPU (.5)	NREL	12	39
Biopack ML	LANL	12	76
Revamp	NREL	13	81
Bioreactor	LLNL	14	60
O2SAF	PNNL	15	77
Carbon Upcycled Bioproducts for Environmental Sustainability (CUBES)	SNL	16	82
3HP	PNNL	16	78

TOTAL TEAMS FUNDED
23

INVESTMENT TOTAL
$1,740,000

POST-PROGRAM FUNDING
$6,281,857

DISCOVERY INTERVIEWS
1,795

Building Technologies Office (BTO)

Team	Lab	Cohort	Discovery Interviews
VOLTTRON	PNNL	2	33
MAI for Buildings	ORNL	3	74
SwitchGlaze (.5)	NREL	3	27
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 (.5)	NREL	12	39
FreeSpace	NREL	12	77
UBEM	LBNL	12	77
Catch It	NREL	16	77
Retrofit Ready Decarb	LBNL	17	75

TOTAL TEAMS FUNDED
13

INVESTMENT TOTAL
$985,000

POST-PROGRAM FUNDING
$3,750,000

DISCOVERY INTERVIEWS
885

Participation by Technology Program Offices

Cybersecurity Energy Security and Emergency Response (CESER)

Team	Lab	Cohort	Discovery Interviews
FireMap (.5)	SNL	16	75

TOTAL TEAMS FUNDED
0.5

INVESTMENT TOTAL
$40,000

POST-PROGRAM FUNDING
$0

DISCOVERY INTERVIEWS
75

Office of Environmental Management (EM)

Team	Lab	Cohort	Discovery Interviews
Gamma Reality, Inc. (GRI)	LBNL	6	77
Purebeam	FNAL	7	78

TOTAL TEAMS FUNDED
2

INVESTMENT TOTAL
$150,000

POST-PROGRAM FUNDING
$7,572,500

DISCOVERY INTERVIEWS
155

Hydrogen and Fuel Cell Technologies Office (HFTO)

Team	Lab	Cohort	Discovery Interviews
Polymer Membranes	SNL	2	41
CryoH2	LLNL	4	56
Electro-Active (.5)	ORNL	7	40
High Flying Hydrides	NREL	13	78
GreenHEART (.5)	NREL	17	38

TOTAL TEAMS FUNDED
4

INVESTMENT TOTAL
$302,500

POST-PROGRAM FUNDING
$1,786,857

DISCOVERY INTERVIEWS
253

Participation by Technology Program Offices

Fossil Energy and Carbon Management (FECM)

Team	Lab	Cohort	Discovery Interviews
MECS	LLNL	4	64
CO2BOL-NG	PNNL	5	75
Memzyme	SNL	10	81
CO2 converters (.5)	ANL	12	39
ALFa-LDS for Methane	LANL	15	72
Pipeline Sensors	NETL	15	78
Lignocrete	NREL	17	76

TOTAL TEAMS FUNDED
6.5

INVESTMENT TOTAL
$502,500

POST-PROGRAM FUNDING
$2,325,000

DISCOVERY INTERVIEWS
485

Geothermal Technologies Office (GTO)

Team	Lab	Cohort	Discovery Interviews
Micro Miners (.5)	LLNL	2	30
TOUGH	LBNL	2	54
GeoCAES	NREL	4	51
Sandia Technology Systems	SNL	4	40
DUAL-SOURCE HEAT PUMP	ORNL	16	76

TOTAL TEAMS FUNDED
4.5

INVESTMENT TOTAL
$342,500

POST-PROGRAM FUNDING
$4,020,000

DISCOVERY INTERVIEWS
251

National Alliance for Water Innovation – LBNL (NAWI)

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

TOTAL TEAMS FUNDED
2

INVESTMENT TOTAL
$150,000

POST-PROGRAM FUNDING
$4,600,000

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
Dry Cask Vital Signs	INL	4	51
Change Detection Systems	INL	4	71
EMRALD	INL	5	76
Electroplate (.5)	INL	5	28
AMAFT	INL	5	76
4C's	INL	6	38
ELINA	INL	6	102
HOT	INL	7	75
AxiVis	INL	7	90
M2LD	INL	8	116
ROTORO, EH?	INL	9	77
Thermal Sound On	INL	10	73
Mesofluidics	PNNL	13	63
Feedforward K9	INL	14	60
MIA	ORNL	17	94
SSAM (.33)	PNNL	17	25

TOTAL TEAMS FUNDED
16.83

INVESTMENT TOTAL
$1,269,167

POST-PROGRAM FUNDING
$13,288,000

DISCOVERY INTERVIEWS
1,187

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	103
Fractured	SNL	13	76
Disease Precognition	LANL	14	82
nDETECT	SNL	14	75
Tough Adhesive	ORNL	15	74
Ridged Electrodes	SNL	16	77
Electro 3D	SNL	16	76
MagTag	SNL	17	75
PhotoSil	LLNL	17	77

TOTAL TEAMS FUNDED
15

INVESTMENT TOTAL
$1,150,000

POST-PROGRAM FUNDING
$8,426,002

DISCOVERY INTERVIEWS
1,157

Office of Electricity (OE)

Team	Lab	Cohort	Discovery Interviews
DCAT	PNNL	6	75
Glass paper	INL	8	75
EnergyBlox	SLAC	8	27
EcoBlock	LBNL	9	75
DER-CAM	LBNL	9	78
TRAST	PNNL	11	78
THERMS (.5)	SNL	12	34
C3D	INL	13	87
MASTERRI	INL	14	55
GRIP	SLAC	14	56
FireMap (.5)	SNL	16	75
GridSense	SNL	17	80

TOTAL TEAMS FUNDED
11

INVESTMENT TOTAL
$832,500

POST-PROGRAM FUNDING
$10,630,000

DISCOVERY INTERVIEWS
795

Participation by Technology Program Offices

Office of Science (SC)

Team	Lab	Cohort	Discovery Interviews
Superchips	LBNL	11	72
INN-Design	NREL	12	69
RoboDT	ANL	14	76
Efficient Isotopes	PNNL	15	76

TOTAL TEAMS FUNDED
4

INVESTMENT TOTAL
$305,000

POST-PROGRAM FUNDING
$6,630,000

DISCOVERY INTERVIEWS
293

Solar Energy Technologies Office (SETO)

Team	Lab	Cohort	Discovery Interviews
Solguard	NREL	2	51
Hydroscanner	LLNL	3	44
HALO	NREL	4	83
THERMS (.5)	SNL	12	34
Avian-Solar	ANL	15	123
NIO	NREL	16	79
SSAM (.33)	PNNL	17	25

TOTAL TEAMS FUNDED
5.83

INVESTMENT TOTAL
$449,167

POST-PROGRAM FUNDING
$38,243,000

DISCOVERY INTERVIEWS
439

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	PNNL	8	93
Resilicoat	ANL	9	82
HeadCount	NREL	10	74
SWaP Electronics	SNL	11	47
RECOVER (.5)	PNNL	12	39
e-mission	NREL	12	78
Athena	NREL	13	82
Ducted Fuel Injection: Cost-Effective Eco-friendly Diesel (DFI)	SNL	13	76
EnStore for BTMS	NREL	13	88
Lithium Battery	INL	13	75
Real-Twin	ORNL	14	78
ShAPE recycling	PNNL	14	63
ZAV	SNL	14	48
Track Analytics	SNL	16	75

TOTAL TEAMS FUNDED
20.5

INVESTMENT TOTAL
$1,542,500

POST-PROGRAM FUNDING
$7,160,323

DISCOVERY INTERVIEWS
1,516

Participation by Technology Program Offices

Wind and 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
$3,350,000

DISCOVERY INTERVIEWS
301

Water Power Technologies Office (WPTO)

Team	Lab	Cohort	Discovery Interviews
IHESS2020	INL	11	72
SLIC	PNNL	11	61
IrrigationViz	PNNL	12	96
Glides	ORNL	13	75
Lab-on-a-fish	PNNL	13	52
Under the C	NREL	14	71
Hydrogen Ships	SNL	14	40
SeaDragon	NREL	17	57

TOTAL TEAMS FUNDED
8

INVESTMENT TOTAL
$605,000

POST-PROGRAM FUNDING
$6,746,000

DISCOVERY INTERVIEWS
524

Wind Energy Technologies Office (WETO)

Team	Lab	Cohort	Discovery Interviews
HyMag (.5)	ANL	8	39
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
WindEZ	NREL	14	76
HighWind	NREL	15	107
NoVo Rotor	NREL	16	79
Distributed Wind Toolkit	NREL	16	75
Hercules	NREL	17	75
GreenHEART (.5)	NREL	17	38

TOTAL TEAMS FUNDED
14

INVESTMENT TOTAL
$1,072,500

POST-PROGRAM FUNDING
$4,670,000

DISCOVERY INTERVIEWS
998

Participation by Technology Program Offices

Lab-Funded Teams

Team	Lab	Cohort	Discovery Interviews
CI-ReClad	ORNL	1	75
Dynamic Aperture	ANL	1	23
EcoSnap	NREL	1	45
HYDRA	PNNL	1	40
SubLambda	PNNL	1	37
Tunation	ORNL	1	86
WISDEM	NREL	1	80
BioAlchemy	LBNL	2	51
Biolyst Renewables	NREL	2	81
Evodia	LBNL	2	45
Resin Wafer Deionization (RWEDI Solutions)	ANL	2	75
SwitchGlaze (.5)	NREL	3	27
OleoSponge	ANL	6	62
Apex Imaging	NREL	15	77

TOTAL TEAMS FUNDED
13.5

INVESTMENT TOTAL
$987,500

POST-PROGRAM FUNDING
$10,754,998

DISCOVERY INTERVIEWS
804

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	80

TOTAL TEAMS FUNDED
4

INVESTMENT TOTAL
$300,000

POST-PROGRAM FUNDING
$2,985,000

DISCOVERY INTERVIEWS
312

Participation by Technology Program Offices

Pilot Funded

Team	Lab	Cohort	Discovery Interviews
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
Frequency Sensing Load Controller	ANL	0	75
My Green Car	LBNL	0	75
TwistAct	SNL	0	75

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

Post-Program Funding

Team post-program funding reported through October 2023.

Team Name	Post-Program Funding Received	Funded through Energy I-Corps by:
4C's	$1,500,000	NE
AMAFT	$103,000	NE
Apex Imaging	$150,000	NREL
ARAI	$161,000	Pilot
ARME	$225,000	AMO
Athena	$375,000	VTO
Avian-Solar	$744,000	SETO
Biolyst Renewables	$6,449,998	NREL
Bioreactor	$100,000	BETO
BOND-NORTHWEST	$40,000	VTO
C3D	$570,000	OE
CAN-Coatings	$300,000	AMO
Change Detection Systems	$775,000	NE
CO2 converters	$250,000	AMO, FECM
CO2BOL-NG	$520,000	FECM
COMBA	$3,600,000	AMO
CuB Fuels	$360,000	BETO
DCAT	$10,000	OE
DFI	$2,072,000	VTO
Dual-Source Heat Pump	$1,270,000	GTO
Dynamic Line Rating	$1,850,000	WWPTO (wind)
EcoBlock	$8,000,000	OE
EcoSnap	$350,000	NREL
E-Ionsorb	$1,500,500	AMO
Electro-Active	$3,573,714	BETO, HFTO
ELINA	$6,505,000	NE
e-mission	$505,000	VTO
EMRALD	$745,000	NE
Enduring Advantage	$435,000	NNSA
EPDR	$50,000	NNSA
E-RECOV	$280,000	AMO
Fermeley	$500,000	BETO
FLO.materials	$4,800,000	AMO
Fractured	$16,000	NNSA
FrozEn	$300,000	AMO
Galileo	$250,000	AMO
Gamma Reality, Inc. (GRI)	$6,022,500	EM
GeoCAES	$300,000	GTO

Post-Program Funding

Team Post-Program Funding (continued)

Team Name	Post-Program Funding Received	Funded through Energy I-Corps by:
Glass Paper	$1,560,000	OE
GRIP	$345,000	OE
HALO	$37,080,000	SETO
High-Moisture Pelleting Process	$1,400,000	BETO
HOT	$840,000	NE
Hyper Team	$725,000	OTT
IHESS2020	$4,000,000	WPTO
LaserSense	$807,000	AMO
MAD3	$295,000	NNSA
MADe3D	$800,000	WETO
MASTERRI	$20,000	OE
MECS	$1,680,000	FECM
memQ	$970,000	OTT
Micro Miners	$4,900,000	AMO, GTO
Mixed Plastic Recycling	$400,000	AMO
NanoHeatBlock	$1,782,026	AMO
nDETECT	$565,000	NNSA
NIO	$144,000	SETO
OleoSponge	$350,000	ANL
OpenOA	$250,000	WETO
Opt-Grid	$246,861	IP Group (private)
Purebeam	$1,550,000	EM
QUAKE	$2,820,000	NE
RECOVER	$1,960,250	AMO, VTO
RE-Metal	$1,230,000	AMO
Resin Wafer Deionization	$1,701,000	ANL
Revamp	$620,000	BETO
RF Tag	$1,500,000	WWPTO (water)
RoboDT	$6,030,000	OS
RouteE	$1,795,000	VTO
Saline Solutions	$8,250,000	AMO
SLIC	$2,746,000	WPTO
Smart Charge Adapter	$1,393,198	VTO
Solguard	$150,000	SETO
SonicLQ	$285,000	Pilot
SpiderFloat	$1,900,000	WETO
STARS	$2,001,000	Pilot
Superchips	$600,000	OS

Post-Program Funding

Team Post-Program Funding (continued)

Team Name	Post-Program Funding Received	Funded through Energy I-Corps by:
Sustainability Innovators	$1,550,088	AMO
Switchable Polarity Solvents	$450,000	Pilot
SwitchGlaze	$2,300,000	BTO, NREL
TAP	$800,000	WETO
ThermalTracker-3D	$920,000	WETO
ThermaSET	$1,365,002	NNSA
Thermoelectric Dryer	$1,600,000	BTO
THERMS	$250,000	SETO, OE
Tunation	$154,000	ORNL
UBEM	$1,000,000	BTO
UltraSep	$1,515,000	BETO
UTS-Ultrasonic Technology Solutions	$1,290,000	OTT
UXI	$5,700,000	NNSA
WaterDAMS	$600,000	NAWI
Water-TAP3	$4,000,000	NAWI
WESAP	$1,770,000	AMO
WISDEM	$450,000	NREL
Wolfram Plating	$100,000	AMO
Total	**$177,063,137**	

17 cohorts* completed as of Fall 2023

Innovations have spanned 19 DOE program areas

including 215 teams from 12 National Labs

Teams have conducted 15,500 stakeholder discovery interviews with companies like: EPRI, Shell, Ford, World Bank, Breakthrough Energy, John Deere, Siemens Gamesa, Chevron, Eaton, Samsung, Lowes, Johns Manville, LEGO, U.S. Army, Trane, Tesla, GM, Dow Chemical, 3M, Whirlpool, GE, Home Depot, and Amazon

215 industry mentors and instructors involved

*Plus Pilot program cohort

Energy I-Corps Topic 2 Teaching Team

The Teaching Team brings the Energy I-Corps Training Cohort 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, stakeholder discovery review, team building, and network expansion.

Steve Albers
Co-Founder and Chief Technology Officer, Living Ink Technologies

Danielle France
Team Liaison, Innovation and Entrepreneurship Center, NREL

Max Green
Founder and Managing Member, Ratio Flux

Rebecca Kauffman
Principal, Sun Raven

Deepa Lounsbury
Managing Director, LabStart

Nakia Melecio
Senior Research Faculty, Georgia Institute of Technology

Jean Redfield
CFO and Co-Founder, JM Redfield LLC

Tom Teynor
CEO, Bell Plumbing and Heating

Program Team

The Program Team operates behind the scenes, ensuring the seamless execution of Energy I-Corps' mission to educate and empower National Lab researchers. These dedicated administrators play a pivotal role in shaping the program's success, providing invaluable support to participating teams, instructors, National Lab tech transfer offices, and DOE program offices. Leveraging their expertise in logistics, coordination, and execution, the Energy I-Corps Program Team contributes to the transformative journey of researchers as they navigate the realms of innovation and commercialization.

Carolina Villacis
Program Manager for full Energy I-Corps Portfolio, OTT

Matt O'Brien
Program Manager for full Energy I-Corps Portfolio, Contractor to OTT

Katherine Harsanyi
Program Advisor for full Energy I-Corps Portfolio, OTT

Shelly Curtiss
Program Manager for Topic 2: Training Cohorts, NREL

Katie Woslager
Program Manager for Topic 2: Training Cohorts, NREL

Technology Commercialization Internship Program

Another OTT program that integrates the Energy I-Corps curriculum is the Technology Commercialization Internship Program (TCIP). TCIP welcomed its third cohort of students in Summer 2023. The program was launched in 2021 and supports OTT's mission by training the next generation of entrepreneurs while simultaneously recruiting talent for DOE and the National Laboratories to advance commercialization within the United States.

TCIP is a unique paid opportunity for undergraduate STEM and business students to experience DOE's world-class National Laboratory system, boost their entrepreneurial thinking, and explore energy technology markets. Interns engage with National Laboratory mentors and learn about technologies at their partnered labs. Parallel to working with the National Laboratories, students also participate in intensive commercialization training through an asynchronous Energy I-Corps curriculum. Instructors provide interns with lectures, resources, and online workshops to tie lab work to the broader I-Corps framework. By providing interns access to the best-in-class Energy I-Corps program, they enhance their education and training in entrepreneurship and energy technology-related fields while increasing future marketability in these disciplines.

Outcomes from the first three years of TCIP include internship extensions, full-time offers from the National Lab, license leads and signed research agreements from the outstanding work of the interns. The 2023 program welcomed 15 students from various backgrounds, universities, geographical locations, and majors across the United States (Figure 2). 33% of the interns represented disadvantaged communities.* Accepted interns were paired with mentors and projects from eight DOE National Laboratories.

Figure 2: TCIP's third cohort of undergraduate student interns.

*As according to Justice40 guidelines and metrics.

Technology Commercialization Internship Program

All interns, mentors, laboratory staff and leadership, and OTT staff and leadership were invited to attend an end-of-summer event. Each year, the event is hosted by one of the program's participating laboratories. The 2023 event was held at Thomas Jefferson National Accelerator Facility in Newport News, Virginia. The interns were able to tour the facility, hear from lab and OTT staff, and present their final deliverables, including competing in two pitch competitions: individual pitch presentations and group presentations.

The top three winners for individual presentations included:

- **1st Place:** Zoryah Gray for the project "Market analysis and customer discovery for upcycling of single-use plastic waste" at Argonne National Laboratory
- **2nd Place:** Johnathan Russell for the project "Feasibility of wind interconnection standard platform" at Sandia National Laboratories
- **3rd Place:** Radeha Haque for the project "Commercial and Industrial Customer Discovery for Edge-Connect Hermetic Headers and Connectors" at Sandia National Laboratories.

The first-place winner and runner-up for group presentations included:

- **1st Place:** Team members Antonia Tahia Ginsberg-Klemmt, Arunabh Sarmah, and Alex Gutierrez Diaz for the project "GISMO Power"
- **Runner-Up:** Team members Nathan Mitchell, Obehi Ehigie, and Meghana Karthic for the project "Aeromine."

Intern Projects and Participating Labs

Argonne NATIONAL LABORATORY	• Market analysis and customer discovery for upcycling of single-use plastic waste
BERKELEY LAB	• Lawrence Berkeley National Laboratory Patent Portfolio Project
Brookhaven National Laboratory	• Mechanized Exfoliator and Automatic 2D Materials Transfer and Layering System
Fermilab	• Open-source embedded artificial intelligence at the edge
KANSAS CITY NSC National Security Campus	• Market Analysis and Partner Identification for National Security Technologies
Sandia National Laboratories	• Commercial and Industrial Customer Discovery for Edge-Connect Hermetic Headers and Connectors • Commercial and Industrial Customer Discovery on New Small, Low-Cost, Toxic Gas Sensor Platform • Community-Engaged Tech Transfer • Energy, Equity, and Environmental Justice Clean-Energy • Hydropower Landscape Analysis • Industry Production Partnerships for Defense System • Targeted Antibody Therapeutics • Transportation Sealing Monitor
Jefferson Lab	• Fine Wire Non-Destructive Evaluation

Thank You!

Thank you to the DOE, program offices, laboratories, instructors, and all who have made Energy I-Corps possible.

ENERGY I-CORPS

OTT Office of Technology Transitions

For more information, visit: energyicorps.energy.gov

Acronyms

AMO	Advanced Manufacturing Office
AMMTO	Advanced Materials and Manufacturing Technologies Office
ANL	Argonne National Laboratory
BETO	Bioenergy Technologies Office
BTO	Building Technologies Office
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
IEDO	Industrial Efficiency & Decarbonization 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
OTT	Office of Technology Transitions
PNNL	Pacific Northwest National Laboratory
SC	Office of Science
SETO	Solar Energy Technologies Office
SLAC	SLAC National Accelerator Laboratory
SNL	Sandia National Laboratories
TCIP	Technology Commercialization Internship Program
VTO	Vehicle Technologies Office
WETO	Wind Energy Technologies Office
WPTO	Water Power Technologies Office
WWPTO	Wind & Water Power Technologies Office

Prepared by NREL.
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