U.S. DEPARTMENT of ENERGY

CESER I-Corps Final Report

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List of Acronyms

CESER	Office of Cybersecurity, Energy Security, and Emergency Response
DER	Distributed energy resource
DOE	U.S. Department of Energy
EL	Entrepreneurial lead
IIJA	Infrastructure Investment and Jobs Act
IM	Industry mentor
NETL	National Energy Technology Laboratory
NLR	National Laboratory of the Rockies
OTC	Office of Technology Commercialization
PI	Principal investigator
RTO	Recovery time objective

Executive Summary

Energy I-Corps is a U.S. Department of Energy (DOE) sponsored entrepreneurial training program for laboratory researchers aimed at accelerating the commercialization of lab-developed technologies. The program, developed and managed by DOE's Office of Technology Commercialization (OTC) in partnership with the National Laboratory of the Rockies (NLR), uses a customized curriculum built on the Lean Launch Methodology and delivers a rigorous 10- to 12-week training program to selected laboratory-based teams.

The Energy I-Corps team at NLR worked with the DOE's OTC and Office of Cybersecurity, Energy Security, and Emergency Response (CESER) to develop and implement commercialization programming for awardees of the CESER Cybersecurity for Distributed Energy Resources Research, Development, and Demonstration Research Call, funded under Provision 40125(b) of the Infrastructure Investment and Jobs Act (IIJA). 40125(b) Projects were overseen by a technical monitor at the National Energy Technology Laboratory (NETL).

The CESER Energy I-Corps Program is considered an Energy I-Corps "lite" or "mini" program, with a lighter lift to accommodate scheduling and funding per participant.

This final report describes the CESER I-Corps program and provides recommendations on behalf of OTC to CESER to consider if CESER were to run an I-Corps program in future.

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1 Introduction

The Energy I-Corps team at the National Laboratory of the Rockies (NLR) worked with the U.S. Department of Energy's (DOE's) Office of Technology Commercialization (OTC) and Office of Cybersecurity, Energy Security, and Emergency Response (CESER) to develop and implement commercialization programming for awardees of the CESER Cybersecurity for Distributed Energy Resources Research, Development, and Demonstration Research Call, funded under Provision 40125(b) of the Infrastructure Investment and Jobs Act (IIJA). These 40125(b) projects were overseen by a technical monitor at the National Energy Technology Laboratory (NETL).

Energy I-Corps-based programming was provided to awardees throughout calendar year 2024. The goal of the program was, during the early stages of project performance, to ensure researchers are integrating effective commercialization efforts into their overall approach to help accelerate the commercial application of their technologies.

Energy I-Corps is a DOE-sponsored entrepreneurial training program for laboratory researchers aimed at accelerating the commercialization of lab-developed technologies. The program, developed and managed by OTC in partnership with NLR, uses a customized curriculum built on the Lean Launch Methodology and delivers a rigorous 10- to 12-week training program to selected laboratory-based teams. Initially launched as the Lab-Corps Pilot Program in 2015, the Energy I-Corps Program has completed training for 20 cohorts of teams across 14 national laboratories. It has expanded beyond its early emphasis on research sponsored by the Office of Energy Efficiency and Renewable Energy and is now open to all DOE technology areas. The program has trained 242 teams and has garnered interest across the laboratory system in increased opportunities for technology licensing and startup development.

CESER I-Corps is considered an Energy I-Corps "lite" or "mini" program with a lighter lift to accommodate scheduling and funding per participant. This is noted because there are key differences between the two programs, as summarized in Table 1.

Table 1. Key Differences Between Energy I-Corps and CESER I-Corps

Energy I-Corps	CESER I-Corps
2-month immersive training program	8-month curriculum delivery—Light touch
In-person, 3.5-day kickoff week/weekly curriculum delivery	All virtual programming
75 customer discovery interviews	20 customer discovery interviews
10 hours per week	10 hours per month
$100,000 per team—principal investigator (PI), entrepreneurial lead (EL), and industry mentor (IM)	$20,000 per participant—principal investigator (PI)
Competitive application process	40125(b) selected projects

Energy I-Corps	CESER I-Corps
Funded by Program Offices	Funded by Technology Commercialization Fund
Weekly office hours	1:1 coaching sessions every third week
Weekly presentation delivery	Presentation delivery based on specific I-Corps concepts
In-person graduation and final presentation	Virtual final presentation

The main Energy I-Corps program structure has a three-person team composed of a principal investigator (PI), entrepreneurial lead (EL), and industry mentor (IM). There are between 14 and 17 teams that participate in a formed cohort in the spring and fall that are selected through a competitive application process and funded by DOE Program Offices. For the CESER Mini-Energy I-Corps Program, eight 40125(b)-selected researchers participated in the CESER I-Corps commercialization training program from the following national laboratories:

- Argonne National Laboratory—Team GridEdgeGuardians (2 participants)
- Brookhaven National Laboratory—Team Dragonfly
- National Laboratory of the Rockies—Team SD4
- Oak Ridge National Laboratory—Team aiCyber
- Pacific Northwest National Laboratory—Team Protect
- Sandia National Laboratories—Team Goal Tender and Team sDERC.

The program design was led by NLR and Energy I-Corps Instructor Max Green. Teams participated in a program overview presentation led by OTC and a kickoff webinar in March 2024. All participants were expected to conduct 20 customer discovery interviews during their 8-month engagement. This training effort was created to accommodate and complement the existing awarded projects. Therefore, the training had a smaller targeted customer discovery goal than the 75 interviews required in the main Energy I-Corps program. Curriculum webinars were delivered weekly, followed by required office hours with the instructor, weekly homework assignments, guest speakers (including the Idaho National Laboratory CyberCore team and a researcher with more than a decade of cybersecurity experience), customer discovery interviews, and interview insights for presentation report-outs.

Customer discovery is a process that involves talking to potential customers to understand their needs and to test assumptions about a product or service. This can help reduce risk and avoid costly mistakes. Teams were taught methodology for the steps involved in customer discovery:

1. **Define a hypothesis**: Form a hypothesis that defines the problem and the proposed solution.

2. **Define assumptions**: Identify assumptions about the target market, customer segments, and business model.
3. **Ask questions**: Ask questions to understand customer needs, behaviors, and pain points.
4. **Evaluate and refine**: Analyze the data collected and refine the hypothesis and solution.

Each participant was required to formulate a list of questions to test their hypotheses. The purpose of the questions, and the interviews themselves, is developing solutions and keeping up with changes in the market. The training equips researchers at DOE national laboratories, plant, and sites 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 DOE national laboratories, plants, and sites.

The effort concluded with a final presentation from each participant, which was a culmination of their efforts. This included their business thesis, ecosystem model, customer discovery insights, and their final business model canvas design. The presentation was given to CESER, OTC, and the NETL technical monitor.

This final report describes the CESER I-Corps program and provides recommendations on behalf of OTC to CESER to consider if CESER were to run an I-Corps program in future.

2 Summary of Project Activities

This curriculum model was designed for the delivery of an Energy I-Corps “lite” program intended to provide hands-on experience with best practices in customer development and business model generation for CESER researchers. Participant teams gained a practical understanding of fundamental principles and processes that support the successful management and discovery of innovations across the technology life cycle. These included key elements of entrepreneurship designed to help craft a viable business model for their technology and illuminate commercialization opportunities and risks. Participants in the program were taught to leverage these skill sets to develop a more refined technology and milestone roadmap that aligns with their commercialization strategy while guiding their research agenda and resource utilization.

The strategy was to prioritize customer (stakeholder) engagement, paired with a strategically curated curriculum to help solidify principles and support retention of key concepts. These concepts were derived from the Energy I-Corps pedagogical structure, using a unique innovative framework to expose learnings and support participants to draw valuable insights from customer engagements.

The foundation for innovation management prioritized customer development, whereby techniques and skills were established to challenge assumptions about value creation. This foundation was used to expose stakeholder expectations, needs, and behaviors to guide the creation of a strong value proposition. The goal was to practice intellectual honesty and work to establish a formula tailored for each research team to design a clear commercialization strategy for their technology.

Max Green of RatioFlux, who taught the CESER I-Corps curriculum, has extensive expertise in the implementation of successful core processes for helping researchers, entrepreneurs, and businesses solve problems by helping leaders make more informed decisions Max encouraged participants to maintain rigor toward the assumptions customers naturally use to make decisions and work toward improving the participants abilities to challenge assumptions through the pursuit of knowledge and information gained via customer engagement. The goal was to challenge participants to think deeply, transfer knowledge and bring a passion for learning into the CESER I-Corps program.

3 Program Elements: Methodology and Program Design

The CESER I-Corps program elements included eight distinct lesson groups to help support a structured understanding of innovation management, from idea to product. Where applicable, program elements included workshops and participant presentations to support retention of key concepts and to provide the participant teams with the tools they need for ongoing development and continued growth after the program ends. Teams engaged directly with instructors and peers to ensure a developmental experience that will help further increase the quality of program outcomes.

Program workshops included the following elements—each delivered over several sessions. The proposed content was scaffolded so that content taught in the beginning of the program was re-emphasized throughout the program to ensure continuity and retention of fundamental concepts.

1. **Introduction to Customer Development**
    - Use of scientific inquiry to inform decisions, priorities, and change
    - Hypothesis development for customer development
    - Interview preparation and discovery planning effort
    - Methods to find potential customers, plan, and engage in customer discovery with stakeholders
    - Use of SMEs (subject matter experts) to outline key industry verticals that are specific segments or sectors of the economy that focus on a particular type of product, service, or customer need and early hypothesis development for unknown or misunderstood use cases.
2. **Stakeholder Ecosystems**
    - Ecosystems analysis: Understanding multiple stakeholder roles, relationships, flows of information, product, and capital flow through the value chain
    - Evaluating the customer workflow: Understanding how the job is currently performed and the resulting impacts, pain points, and inefficiencies experienced by the customer.
3. **Compelling Customer Problem Statements**
    - How does the customer view the problem? What language do they use, and does this align with how you speak about the problem?
    - What does the customer prioritize for change? (Where is their money going now, and what metrics do they use to guide these decisions?)
4. **Understanding Customer Impact**
    - Do customer behaviors (use of funds) align with assumed problem statements? How do we learn about this aspect of operation?
    - If the customer bought our solution, what difference would it make in their workflow, costs, or outcomes?
    - How well do our technical and product capabilities translate into tangible benefits that matter to the customer?
5. **Competitive Landscape Analysis**

- How do you evaluate alternative solutions to serve your customers? Define the full solution: How do you prioritize product features to customer needs? How can you explore partnerships or other necessary technology?
- Who are the stakeholders involved in decision-making? How does this change for different use cases?

6. **Value Proposition Design**
   - Draft a compelling value proposition, based on understanding of the customer, their problem, and the impact you create by displacing the status quo.
   - Adapt value propositions to align with market scale and opportunity.
7. **Partnerships**
   - When do we need to consider partnerships? Evaluate the give-and-take of partnering, its effect on resources (including community initiatives), and the ways it affects commercialization pathways.
   - Model partners into your business model: Outline the impact to revenue generation and the ability to serve prospective customers.
8. **Problem-Solution Fit**
   - Revisit customer decision-making criteria and illuminate lingering assumptions related to customer priorities, expectations, and needs.
   - Align the product development roadmap to support resources needed, timeline to adoption, and so on. Identify key milestones for development and support of integration into the market.
   - Final team presentations: Recommend a path forward.

For the duration of the project, there were no problems encountered or departure from the planned methodology. The program followed the proposed schedule and adjusted if there were scheduling conflicts. Feedback delivered in the program completion questionnaire indicated teams would have preferred more time in the program but appreciated the structure in light of the funding constraints. Future consideration will be given to design a program that delivers concentrated curriculum delivery for 1 month and then allows 1 month to conduct customer discovery and other required homework activities in preparation for the presentation. This could condense the program and keep up the momentum over a 4-month period. This would require both additional time and an increased funding commitment.

One suggested option was to host a 2-day in-person curriculum delivery in a “boot camp” style, in which participants would learn the fundamentals of the I-Corps Program and then reemphasize those concepts following the eight modules mentioned previously to reinforce learning. Additional program design could be considered as a possible future curriculum delivery solution.

Future consideration would be to design a program that established “discovery sprints,” focused on different commercialization topics and priorities. Curriculum delivery would prioritize asynchronous delivery, where teams could engage as they are available, followed by specific workshops dedicated to reviewing and critiquing deliverables established in the program.

- With discovery sprints established, more time could be dedicated per sprint, with breaks in between to focus on other work efforts and requirements. A recommended option is to deploy 4-week sprints, with a minimum of 30 hours dedicated to each sprint.
- It is highly recommended to allow the participants' fellow project team members to engage in the program or provide funds to engage with more in-depth coaching activities in support of the participants' discovery efforts.
- The following sprints are recommended (4 weeks on, 3 weeks off):
    - Sprint 1: Problem-Solution Fit
        - Understanding the customer problem and priorities
        - Customer benefit analysis (impact).
    - Sprint 2: Product-Market Fit
        - Mapping customer workflow and "jobs to be done"
        - Designing a compelling value proposition.
    - Sprint 3: Competitive Solutions
        - Understanding decision-making criteria
        - Changing the status quo.
    - Sprint 4: Partnership Development
        - Key activities, resources, and milestones
        - Expectations for engagement.

The major lesson learned was that although most participants appreciated the duration of the program to balance other work activities, this also resulted in slower progress and revisiting core curriculum competencies as a result of competing priorities. The long-term value to understand future programming would be follow-on check-ins to assess project maturation, additional partnerships formed, or technology deployments. Most of these teams identified and formed new partnerships. One of the values of completing customer discovery is that six pivots were made, which indicates that teams' initial assumptions about their technology solution shifted based on direct industry feedback. Ultimately, the process of customer discovery typically creates a mind shift to focus on industry concerns and needs. The value of I-Corps is that the curriculum learning tends to extend beyond the project duration.

4 Project Outputs

There were various project results from the participants. All participants except one determined they discovered and identified a viable path to commercialization for their technology.

The program also affected intellectual property generation efforts for one team. This resulted in a technical advance that was filed to start the process of patenting the SDN and IPv6 technology Sandia National Laboratories' Team sDERC is developing. In addition to the technical advance, the following partners were added to their Industry Advisory Board as a result of the CESER I-Corps effort:

- University of Arkansas
- Chevron
- Mitre
- U.S. Air Force
- U.S. Navy
- Public Service Company of New Mexico.

Team Dragonfly from Brookhaven National Laboratory entered a partnership with One, Ecolong LLC and determined that more can be requested in the future.

As for the next steps, many participants determined they need to further develop the technology to a stage where they can start identifying initial adopters for field tests, prioritizing the development and maturing of the proposed technologies. In addition, many will pursue the license/patent for the technologies. Some participants plan to continue reaching out to stakeholders in the distributed energy resource (DER) ecosystem to feed into their project as they continue to progress through the project. Now that participants have participated in outreach and have an understanding of need, teams plan on continuing customer discovery and marketing their technologies.

When asked for feedback, most participants felt the program met or exceeded their expectations. Overarching themes of participant feedback included (1) the program was useful and (2) the participants learned a lot about the general process of taking technology from the idea phase to potential commercialization.

Here are a few participant quotes that capture their experience:

"From the course point of view, I learned a lot of new business language that I am not exposed to as a researcher. Practical knowledge learned helped me understand new insights about the problem at hand. The program made a difference in our perspective. It has been an amazing journey, and I learned a lot. We will continue to do customer discovery even after the program ends."

–Team Protect, Pacific Northwest National Laboratory

“This program made us systematically think like an entrepreneur rather than think like a scientist.”

– Team GridEdgeGuardians, Argonne National Laboratory

“Very new and useful systematic approach on how to look at business models and the technology.”

–Team GridEdgeGuardians, Argonne National Laboratory

“The CESER I-Corps program provided a framework and focus to get more out of stakeholder engagement for the development of high impact research.”

–Team SD4, NLR

“This experience was helpful for customer discovery process and the sDERC project—will continue to do outreach so we are not in our own laboratory environment. Helped with perspective to fill a void that is out in the market and what we are doing is useful and necessary. We will continue to do interviews throughout the project. A utility company in NM was a company they contacted and are interested in collaborating and working with one of their test sites as an outcome of the interview process.”

–Team sDERC, Sandia National Laboratories

5 Other Project Accomplishments and Findings

Each team's learnings and outcomes from participating in the program were considerable. Here are a few key takeaways from each team:

GridEdgeGuardians: GridEdgeGuardians is working on a software tool that helps protect "grid edge" devices. The software tool will run on tiny computers and is designed to be easily integrated with existing systems. Their tool is like a shield, continuously checking for any unusual activities and making sure these devices work securely. This team made a great connection with problem-solution fit (identifying how the technology being developed serves a specific challenge in industry). They created some of the best customer segmentation, clearly articulating the difference between customers and why the customers matter to the implementation of the technology/solution.

Dragonfly: Their technology is Cybersecure and Data-Efficient Sharing Systems for Cloud-based DER Operation and Control. By the end of the program, this team discovered the lack of visibility to DERs is the biggest issue. (Owners/operators are not obligated to share information on control or cybersecurity systems, and the responsibilities are not well defined if a threat occurs.) This could lead to loss of revenue or intrusion into the network.

SD4: This team learned cybersecurity is not included in the early process of deployments, recognizing need to incorporate it earlier into other elements of the process (if commercialization is expected).

aiCyber: This team identified that the North American Electric Reliability Corporation (NERC) has strict requirements on the adoption of cloud-based solutions for critical operations over the utilities under its supervision. The team is really excited about delivering a cloud-based service to support ease of upgrades via over-the-air updates, which is not available for stand-alone systems currently. In certain regions, however, they do not follow NERC and are able to adopt a cloud-based system.

Team Protect: This team identified the workflow implications of adapting their capability. Stakeholders are very interested in placement of the value chain (but the team still needs to identify where their solution will be deployed).

Goal Tender: Goal Tender learned that Recovery Time Objectives (RTOs) are concerned about the potential impact of a mass cyberattack on widely deployed devices but currently lack jurisdiction to mandate secure communication protocols. This was a particularly interesting insight. Participants identified a new need (concern for the Distributed Energy Resources (DER)distributing bad data) and asked the question, "Can we trust the telemetry data?" The relationship between RTOs and aggregators may play a significant role in adoption opportunities, but this must be further explored.

sDERC: This team was trying to figure out the vendor process for changing over to IPv6. The biggest challenge identified from vendors was they are experiencing the exemptions for not having IPv6. This team feels the Information Technology sector is a

priority, not the Operational Technology sector. Vendors are concerned about modifying all of their devices. Other learnings included understanding how software-defined networking is a priority for NERC, indicating that IPv6 addressing could benefit from this.

SDERC learned from the customer discovery process that federally owned utilities and laboratories are exploring IPv6. They are expecting some mandates will accelerate adoption by the end of FY 2026. Non-federally owned organizations are dabbling in early testing but are not moving toward quick adoption.

6 Additional Project Scope Background

DERs are becoming an increasingly common and important component of the nation's power supply. These new clean energy technologies and systems can help make the energy grid more reliable in the face of extreme weather events. However, the security and stability of these critical systems develop and are implemented at a large scale and within highly interconnected systems. The CESER Mini Energy I-Corps Program ensured the researchers developing and demonstrating these technologies became knowledgeable of commercialization concepts and tools that could help promote end-user adoption and smooth integration into existing systems.

Appendix

Comparison of Accomplishments

Table A-1 outlines the goals of the CESER I-Corps program and the actual accomplishment metrics tracked during the program.

Table A-1. CESER I-Corps Performance Metrics

Participants	8
National laboratories represented	6
Total number of customer discovery interviews completed	133
Prior to participation with CESER I-Corps, did you have any commercialization training in the past? If yes, was this training complementary or duplicative?	Yes (2 participants)
Pivots made over the course of the program (market, customer segment, etc.)?	6 pivots were made based on customer discovery
New relationships that could potentially help with the commercialization of the technologies	7 participants formed new relationships
Number of total external stakeholders engaged with	133
List of the stakeholder organizations that participants engaged with	91
Development of program intellectual property generation efforts	Yes, one technical advance was filed to start the process of patenting for one of the projects
Partnerships entered in to with external stakeholders as a result of this effort	7
Participants planning to continue discovery/minimum viable product development efforts	6
Participants planning to license their technology	4

Additional Project Metrics

The below activity (A), output (O-1), and outcome (O-2) metrics were tracked for the project.

Technology Maturation Metrics

- **Prototype (A)**: Simplified version of a complete product, process or service that enables innovators to experiment, evaluate, iterate, learn, and adapt an innovation. Although Customer Discovery was valuable for each of the participating teams, six of the teams determined they needed to continue market

outreach. Those same teams also plan to continue their MVP development before the technology can be fully deployed; two prototypes were developed.

- **Demonstration (O-1)**: Testing and validation in relevant real-world environments to assess and prove the long-term operating goals of the technology and market ecosystem are achievable and repeatable. Team sDERC from Sandia formed considerable partnerships, specifically with the Public Utility of New Mexico, to test their technology.
- **Intellectual Property (O-1)**: Inventions resulting from project activities. One technical advance was created during the project for sDERC at Sandia National Laboratories.
- **Commercialized Technology (O-2):** Invention used in any capacity commercially and/or is a product on the market. To date, there were no participants that have produced a commercially viable product to introduce to the market.

Solution Adoption Metrics

- **Engagements (A)**: New interactions with stakeholders or program participants performed as part of project activities (e.g., meetings, interviews, workshops). There were 133 engagements during the project that included meetings and interviews.
- **Validated Documentation (O-1)**: Official documents created through project activities, vetted by third parties and/or consensus by project participant (e.g., approvals, independent assessments, letters of support or interest from potential partners and adopters). No third-party validated documentation was created during the project duration.
- **Partnerships (O-2)**: Collaborative ongoing relationships formalized through documentation. Seven partnerships were formed during the project.
- **Documentation Adoption (O-2)**: Number of official, validated documents created through project activities that are successfully adopted and operationalized. No official documentation was created during the project.

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