EnergyTech University Prize
2025 Official Rules Document

December 27, 2024

Office of Technology Transitions

AMERICAN MADE
U.S. DEPARTMENT OF ENERGY

Contents

1 Welcome to the EnergyTech University Prize

Welcome to the U.S. Department of Energy (DOE) Office of Technology Transitions (OTT) EnergyTech University Prize (EnergyTech UP)! EnergyTech UP offers two separate tracks—one for students and one for faculty members.

In the Student Track of EnergyTech UP, student teams will compete for a share of $485,000 in cash prizes for successfully identifying a promising energy technology, assessing its market potential, and creating a business plan for commercialization. Through the student portion of the competition, EnergyTech UP aims to cultivate the next generation of energy innovators while accelerating the transfer of energy technologies to market. In 2024 alone, the competition engaged more than 775 student participants within 225 teams from 113 collegiate institutions. By empowering a growing number of diverse students across the nation with knowledge and skills in energy technology commercialization, DOE seeks to stimulate the growth of the next generation of clean energy technology entrepreneurs.

This prize seeks to attract and support the talented students of today and help them grow into the engineers, policymakers, entrepreneurs, market analysts, and project developers of tomorrow. Multidisciplinary student teams will develop and present a business plan that leverages national laboratory-developed or other high-potential energy technologies, including university-developed technologies or other technologies of interest to student competitors.

The Faculty Track of EnergyTech UP seeks to expand the impact of the student EnergyTech UP program. In the Faculty Track, individual faculty members (or faculty teams) will compete for a share of $110,000 in cash prizes for the successful development and implementation of educational activities (e.g., coursework, accelerator, program) that engage an increasing number of students on energy technology commercialization and entrepreneurship topics at their institution. The goal of the EnergyTech UP Faculty Track is to increase the number and diversity of students who have access to educational activities that help them learn about energy technology commercialization and entrepreneurship.

This OTT program is seeking a diverse set of faculty (in terms of both background and institution type) who are passionate about the development and integration of educational activities centered on energy technology commercialization and entrepreneurship topics at their home institution. The content provided by faculty through their submissions is expected to inform a toolkit to be developed by OTT following the conclusion of this competition. The toolkit can potentially help other faculty members across the nation build entrepreneurship and commercialization activities at their institutions.

This prize is sponsored by DOE's OTT as well as several other DOE program offices, as noted in Section 8.10. EnergyTech UP, in partnership with American-Made Challenges, is designed to be approachable, equitable, and scalable nationwide. Winners will be chosen based on the strength of their proposal. Students interested in participating in the student prize will be provided with a curated list of national lab technologies that are ready for commercialization and can be used in their business plan.

DOE's EnergyTech UP will be governed by this official rules document. The prize administrator, the National Renewable Energy Laboratory (NREL), and DOE reserve the right to modify this official rules document if necessary and will publicly post any such modifications as well as notify prize competitors of the revised document.

2 About the Office of Technology Transitions

OTT serves as the steward of DOE’s research, development, demonstration, and deployment continuum and is sponsoring this prize to help technologies in their progression to commercialization.

DOE’s primary mission is to ensure our nation’s security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions. These solutions have given rise to a diverse range of technologies, from the superconducting magnets that enabled magnetic resonance imaging to the battery cathodes that are used in today’s plug-in electric vehicles.

World-changing innovations like these become possible only by transitioning technology out of the laboratory and into the commercial sphere. In 2015, the Secretary of Energy authorized the formation of OTT, and in 2020, Congress formalized its establishment.

3 Summary of Important Dates

For the exact times and latest information, visit the HeroX competition platform.

3.1 Student Track

- Monday, September 30, 2024: Rules published
- Thursday, October 24, 2024: Informational webinar introducing EnergyTech UP
- Friday, November 15, 2024: Office hours with prize administrators
- Tuesday, December 3, 2024: Updated Rules published
- Tuesday, December 10, 2024: Informational webinar focused on track details
- Monday, December 27, 2024: Updated Rules published
- Wednesday, January 8, 2025: Office hours with prize administrators for interested students and faculty
- Tuesday, January 14, 2025: Office hours with prize administrators for interested students and faculty
- Thursday, January 23, 2025: Recruiting webinar and team-building networking event
- Monday, February 3, 2025: Final student Explore Phase registration
- Monday, February 10, 2025: List of competing student teams announced
- Tuesday, February 18, 2025: Welcome and introductory webinar for all competing teams
- Tuesday, March 4, 2025: East regional events occur
- Wednesday, March 5, 2025: Central regional events occur
- Thursday, March 6, 2025: West regional events occur
- Friday, March 14, 2025: Regional finalists and bonus prize finalists announced
- Thursday, April 17, 2025: Business plans and recorded videos due from all finalists
- Friday, April 25, 2025: Final presentation files due from all finalists
- Date to be determined (targeted late April 2025): Final national competition event at partner to be determined.

3.2 Faculty Track

- Monday, September 30, 2024: Rules published
- Thursday, October 24, 2024: Informational webinar introducing EnergyTech UP
- Friday, November 15, 2024: Office hours with prize administrators
- Tuesday, December 3, 2024: Updated Rules published
- Tuesday, December 10, 2024: Informational webinar on track details
- Monday, December 27, 2024: Updated Rules published
- Wednesday, January 8, 2024: Office hours with prize administrators for interested students and faculty
- Monday, January 13, 2025: Faculty submission deadline for Faculty Explorer prize consideration
- Thursday, January 19, 2025: Faculty Explorer winners and Faculty Bonus Prize finalist announced
- Friday, April 25, 2025: Faculty implementation plan submission deadline
- Thursday, May 8, 2025: Faculty Implementation Phase winners and Faculty Bonus Prize Winner announced.

4 Technology Areas of Interest

Student submissions must focus on technologies that produce and/or store energy, improve the efficiency of energy consumption or energy transmission, or increase the security and reliability of energy systems.

DOE recognizes that primary energy sources take many forms, including nuclear energy; fossil energy like oil, coal, and natural gas; and renewable sources like wind, solar, geothermal, and hydropower. These primary sources are converted to electricity, a secondary energy source, which flows through power lines and other transmission infrastructure to homes and businesses.

Keeping power flowing to our nation's homes and businesses is a necessity for everyday life and economic vitality. DOE works to keep the grid secure from cyber and physical attacks, partners with states and other stakeholders to plan more weather-resilient infrastructure, and works to increase grid efficiency and energy storage capacity as more renewable energy sources come online.

Student teams may focus their submissions on technologies developed at a DOE national laboratory, technologies developed by the students themselves, or technologies developed at their institution. Teams are not required to have secured a license or rights to a technology to present a business plan that leverages that technology, but they should have confidence that the technology could hypothetically be licensed or otherwise be made available to a team for use as part of their business model.

Several DOE technology offices are offering bonus prizes for the best student entries in each technology office's respective field. Teams searching for a technology to build a business plan for are encouraged to engage with the OTT Lab Partnering Service described in 6.1 Lab Partnering Service below.

5 Diversity, Equity, and Inclusion

It is the policy of the Biden administration that:

> "The Federal Government should pursue a comprehensive approach to advancing equity for all people, including people of color, who have been historically underserved, marginalized, or adversely affected by persistent poverty or inequality.
>
> Affirmatively advancing equity, civil rights, racial justice, and equal opportunity is the responsibility of the whole of our government. Because advancing equity requires a systematic approach to embedding fairness in decision-making processes, executive departments and agencies (agencies) must recognize and work to redress inequities in their policies and programs that serve as barriers to equal opportunity.
>
> By advancing equity across the Federal Government, we can create opportunities for the improvement of communities that have been historically underserved, which benefits everyone."[1]

As part of this whole-of-government approach, this competition seeks submissions that will benefit members of disadvantaged communities and underrepresented groups. The formation of diverse student teams composed of individuals from groups historically underrepresented in science, technology, engineering, and mathematics (STEM) is highly encouraged. Student teams are also highly encouraged to develop business plans that would benefit disadvantaged communities and/or underrepresented groups.[2] Faculty teams are encouraged to submit work with high impact for teaching to underserved communities or underrepresented communities and/or teaching about how to ensure an equitable energy transition.

Further, to remove barriers to entry for all team members, the judging criteria have been established to determine success based on the strength of the proposal.

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[1] https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/20/executive-order-advancing-racial-equity-and-support-for-underserved-communities-through-the-federal-government/

[2] Pursuant to E.O. 14008, "Tackling the Climate Crisis at Home and Abroad," January 27, 2021, and the Office of Management and Budget's Interim Justice40 Implementation Guidance M-21-28, DOE recognizes disadvantaged communities as defined and identified by the White House Council of Environmental Quality's Climate and Economic Justice Screening Tool (CEJST).

6 Other Relevant Programs and Opportunities

In addition to EnergyTech UP, DOE funds several related programs that may provide additional value, context, or guidance to competitors. Participants are encouraged to learn more about each program as they develop their ideas and to consider additional opportunities.

6.1 Lab Partnering Service

OTT's Lab Partnering Service (LPS) is a suite of online applications that enables access to leading experts, innovations, and patents from across DOE and DOE's national laboratories. It delivers a myriad of information to provide access to a portfolio of investment opportunities. The LPS enables fast discovery of expertise and serves as a conduit between the investor and the innovator by providing multifaceted search capabilities across numerous technology areas and the DOE national laboratory complex. In support of EnergyTech UP, a custom "popular topic" tab has been created that highlights technology summaries, experts, facilities, and success stories from the national lab complex that may be of particular interest to competitors. Teams that are interested in participating in this contest but have yet to identify a technology to focus on should use this service to explore potential technologies.

LPS also has a search tool called the Visual Intellectual Property Search (VIPS). This tool enables a unique, visually facilitated search of the patent content in the LPS, which consists of published U.S. patent applications and issued U.S. patents resulting from research and development (R&D) funded by DOE as well as other organizations, namely NASA and the U.S. Department of Homeland Security. The patents are pulled from the U.S. Patent and Trademark Office patent database and show patents and patent applications from the last 20 years.

6.2 Energy I-Corps

Energy I-Corps, a key initiative of OTT, pairs teams of laboratory researchers with industry mentors for an intensive 2-month training in which the researchers define technology value propositions, conduct customer discovery interviews, and develop viable market pathways for their technologies. Researchers develop a framework for industry engagement to guide future research and inform a culture of market awareness within their labs. In this way, Energy I-Corps ensures investment in the national labs maintains and strengthens U.S. competitiveness over the long term.

All competing teams will receive access to the recorded Energy I-Corps curriculum and associated materials (typically available only to DOE national lab complex researchers).

6.3 Adoption Readiness Level Framework and the Commercial Adoption Readiness Assessment Tool

To achieve deployment, a technology must be sufficiently de-risked, and ecosystem economics must be established so that every player in the value chain has a viable economic model. This means that managing a technology portfolio solely through the well-understood and widely used technology readiness level (TRL) stage-gates is not enough. To describe market adoption risks, OTT has developed the adoption readiness level (ARL) framework to complement TRLs, in partnership with other DOE and industry stakeholders. The ARL framework assesses the market adoption risks of a technology and translates this risk assessment into a readiness score, representing the readiness of a technology to be adopted by the ecosystem. Seventeen dimensions are used to determine a technology's ARL, and the Commercial Adoption Readiness Assessment Tool (CARAT) integrates these dimensions into an assessment.

Teams are encouraged to consider their technology's ARL and leverage CARAT to inform their entry.

6.4 DOE's Pathways to Commercial Liftoff Reports

DOE plays a critical role in accelerating the commercialization of clean energy technologies and enabling the nation's broader industrial strategy—creating high-quality jobs, strengthening domestic supply chains and global competitiveness, and facilitating an equitable energy transition. DOE's Pathways to Commercial Liftoff reports provide public and private sector capital allocators with a perspective on how and when various technologies could reach full-scale commercial adoption, including a common analytical fact base and critical signposts for investment decisions. The reports are living documents that will be updated periodically and can be found at Pathways to Commercial Liftoff.

6.5 American-Made Network

The American-Made Network provides entrepreneurs with connections to help them succeed. The network is a collective made up of more than 475 technology incubators and accelerators, venture capital firms, angel investors, and industry representatives. Energy entrepreneurs can tap into the industry expertise and resources across the network to help accelerate the development and commercialization of their new ideas and products.

In the American-Made Network, members of the public and private sectors provide mentoring, tools, resources, and support to accelerate the transition of ideas into real-world solutions for environmental justice and economic renewal. Competitors are encouraged to visit the American-Made Network and explore the resources that are available to support their efforts in this prize and beyond.

6.6 Technology Commercialization Fund

A core responsibility of OTT is implementing the Technology Commercialization Fund (TCF), which was authorized in Section 1001 of the Energy Policy Act of 2005. Student competitors are encouraged to review previous TCF awards for inspiration and to consider TCF funding as a possibility in any business plan developed. The TCF is an annual funding opportunity that leverages R&D funding in the applied energy programs to mature promising energy technologies.

The goal of the TCF is twofold. First, it is designed to increase the number of energy technologies developed at DOE's national labs that graduate to commercial development and achieve commercial impact. Second, the TCF aims to enhance DOE's technology transfer system with a forward-looking and competitive approach to lab-industry partnerships.

7 How To Enter

EnergyTech UP will use the HeroX website as its competition platform.

Go to https://www.herox.com/EnergyTechUP and follow the instructions for registering and submitting all required materials before the deadlines identified in Section 3: Summary of Important Dates. Deadlines are also displayed on the HeroX website. In advance of registration, students and faculty can optionally express their interest in competing by completing an Interest Registry Form, which will ensure they receive notifications about program deadlines.

1. Go to the competition page at https://www.herox.com/EnergyTechUP.
2. Create a HeroX account if you do not already have one, including activating your account by clicking the verification link sent to your email. Then, sign in and choose “Solve This Challenge.” You will need to accept the competitor agreement to get started. This indicates your interest in competing; it is not a commitment to compete.
3. If you know the email addresses of your team members, or if you are joining an already established team, you can enter that information when prompted. If your team makeup is not yet known, you will have an opportunity to add other team members later. You can continue to adjust your team composition throughout the competition.
4. By the registration deadline, the team captain must click “Submit Final Entry” on HeroX to complete the team’s registration. To do so, the team captain must first click “Begin Entry,” fill out the required fields, and then choose “Save & Preview.” This step is when the team identifies their collegiate institution (accredited trade school, community college, college, university, or graduate school) and expected team makeup. There is no cost to submit a registration entry. Note that you can edit and resubmit your entry as many times as you would like up until the registration deadline.
5. Registration entries received by the deadline are deemed applicant teams.
6. Multiple student teams from a single school may compete, and multiple faculty teams from a single school may compete.
7. Teams may include students from multiple schools.
8. Only one person per team should submit a team registration. Other members can join the registered team via HeroX. Team members may be added or removed from a team at any time. Once you have registered a team, you can invite additional members using HeroX.
9. Following the close of registration for the Student Track Explore Phase, the prize administrators will review all registrations and may reallocate teams across regional conveners to ensure an appropriate and fair competition.
10. Email questions to the organizers at ott.energytechup@nrel.gov.

8 Student Track

The Student Track consists of three phases—the Explore Phase, the Refine Phase, and the Pitch Phase—as summarized in Figure 1.

Figure 1

8.1 Interest Registry (Optional)

Through the optional Interest Registry, students—or faculty advisors—who plan to apply can submit their information via the Interest Registry Form (accessible from the HeroX platform). Submissions will be accepted on a rolling basis and will consist of the individual's name, email, and name of their institution. This will allow DOE to provide communication and resources to interested individuals prior to the start of the competition (Explore Phase).

8.2 Explore Phase

Student teams will apply to become competitors by completing the registration entry form on the HeroX platform. Student applicants will submit a 200-word statement describing their proposed technology and associated business opportunity. Accepted teams will become competitor teams and will be given free access to OTT's Energy I-Corps curriculum to help them refine their ideas.

Student teams will then be invited to participate in a virtually held regional Explore Event. Teams will be matched to a regional convener by the prize administrator after the submission deadline to ensure equitable distribution of teams across each regional Explore Event. A maximum of 225 teams will be accepted, and a maximum of 18 competitor teams will present at each of up to 15 regional events. Each regional event will be held virtually by a regional convener located in the same geographic region as the team. Each team will have 8 minutes to explain their idea to a panel of judges (5 minutes for their initial pitch and 3 minutes for a Q&A period).

These virtual events aim to provide a rich experience for participants, allowing participants to engage in networking opportunities and attend other team and professional presentations. Each team is expected to have at least one student to present live at the virtual regional Explore Event. If a team has a faculty or industry advisor, the advisor is also encouraged to attend the Explore Event. However, faculty, nonstudent team members, and industry advisors may not participate in the team presentation.

Regional Finalists: Up to one student team will be selected as a regional finalist from each of the up to 15 regional events.

Bonus Prize Finalists: From among all presenting teams, up to one Bonus Prize finalist will be identified from each Bonus Prize offered.

National Lab Intellectual Property (IP) Licensing Bonus Prize Finalist: OTT may identify up to one National Lab IP Licensing Bonus Prize finalist from among the eligible presenting teams.

Undergraduate-Only Team Bonus Prize Semifinalists and Finalist: At the conclusion of each regional event, up to one student team will be selected as an Undergraduate-Only Team Bonus Prize semifinalist. These teams' entries will then be reviewed by OTT, who may identify up to one Undergraduate-Only Team Bonus Prize finalist. For the purposes of this competition, "undergraduate-only" includes those attending accredited trade schools, community colleges, and collegiate institutions.

8.3 Refine Phase

In the Refine Phase, all student finalist teams and faculty competitors will be given exclusive mentorship and continued free access to OTT's Energy I-Corps curriculum to help them refine their ideas.

All finalist teams will be paired with a mentor or mentors from industry, a DOE national lab, or DOE. Mentors will give competitors insights into technology development and feedback on their plan in preparation for their Pitch Phase activities. Competitors are also encouraged to explore the 6 Other Relevant Programs and Opportunities (described in Section 6) during this phase.

8.4 Pitch Phase

All finalist student teams will pitch their refined business plans at a national industry event expected to occur toward the end of April 2025. Student teams are expected to present in person at the event.

All student finalist teams will receive access to informative sessions designed to engage thought leadership on critically important topics for our nation's energy and innovation future. No registration or conference fee will be charged to any students or faculty associated with a finalist team to attend, though attendees are required to coordinate and pay for their own travel and lodging expenses.

National Prize Winners: First-, second-, and third-place winners will be identified.

Bonus Prize Winners: The program offices sponsoring each of the Bonus Prizes may identify and award up to one winner for each bonus prize offered.

National Lab IP Licensing Bonus Prize Winner: Up to one winner of the National Lab IP Licensing Bonus Prize may be identified and awarded by OTT.

Undergraduate-Only Team Bonus Prize Winner: Up to one winner of the Undergraduate-Only Team Bonus Prize may be identified and awarded by OTT.

Additional program information is available at www.energy.gov/energytechup. Questions should be submitted to ott.energytechup@nrel.gov.

8.5 Student Eligibility

- All participating students must be enrolled in an accredited collegiate institution. Students must be enrolled in at least one class and must be pursuing a degree throughout the duration of the competition.
- For the purposes of this competition, "collegiate institution" refers to a school of postsecondary or higher education, including but not limited to accredited trade schools, community colleges, colleges, universities, and graduate schools.
- Postsecondary students of any level (associate, bachelor's, master's, Ph.D., certificate, etc.) are eligible to compete.
  - Students will self-certify their eligibility as part of registration for the competition.
  - Current collegiate level will be considered when determining eligibility for the Undergraduate-Only Team Bonus Prize.
  - Teams with students from multiple collegiate institutions are allowed, and multiple teams from the same collegiate institution are allowed.
  - Individual students may be members of only one team.
- Teams must consist of at least two collegiate students, with a single student identified as team captain. There is no limit to team size.
- The team captain must be a U.S. citizen or permanent resident.
- The final submission must come from the team captain's HeroX account.
- Teams must declare, and keep consistent, their team's name throughout the competition.
- The team may have nonstudent team members or advisors who provide input and guidance and support the development of the idea, but only students may present to judges. Students must be a majority of the team makeup.
- Expert reviewers, competition administrator staff, DOE national lab employees, and DOE employees are ineligible to compete.
- Immediate family members of DOE employees and NREL prize administrators are ineligible to compete.
- To be eligible to compete for the national prizes, the team must be selected as a finalist.
- By uploading a submission package, the team self-certifies that it is compliant with the eligibility requirements. If the competition administrator becomes aware that a team or individual is not eligible, that team may be disqualified from competition.
- This prize competition is expected to positively impact U.S. economic competitiveness. Participation in a foreign government talent recruitment program[3] could conflict with this objective by resulting in unauthorized transfer of scientific and technical information to foreign government entities. Therefore, individuals participating in foreign government talent

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[3] A foreign government talent recruitment program is defined as an effort directly or indirectly organized, managed, or funded by a foreign government to recruit science and technology professionals or students (regardless of citizenship or national origin, and whether having a full-time or part-time position). Some foreign government-sponsored talent recruitment programs operate with the intent to import or otherwise acquire from abroad, sometimes through illicit means, proprietary technology or software, unpublished data and methods, and intellectual property to further the military modernization goals and/or economic goals of a foreign government. Many, but not all, programs aim to incentivize the targeted individual to physically relocate to the foreign state for the above purpose. Some programs allow for or encourage continued employment at U.S. research facilities or receipt of federal research funds while concurrently working at and/or receiving compensation from a foreign institution, and some direct participants not to disclose their participation to U.S. entities. Compensation could take many forms, including cash, research funding, complimentary foreign travel, honorific titles, career advancement opportunities, promised future compensation, or other types of remuneration or consideration, including in-kind compensation.

recruitment programs of foreign countries of risk are not eligible to compete. Further, teams that include individuals participating in foreign government talent recruitment programs of foreign countries of risk[4] are not eligible to compete.

- Entities and individuals publicly banned from doing business with the U.S. government, such as entities and individuals debarred, suspended, or otherwise excluded from or ineligible for participating in federal programs, are not eligible to compete.
- To be eligible, an individual authorized to represent the competitor must agree to and sign the following statement upon registration with HeroX:

  I am providing this submission package as part of my participation in this prize. I understand that the information contained in this submission will be relied on by the federal government to determine whether to issue a prize to the named competitor. I certify under penalty of perjury that the named competitor meets the eligibility requirements for this prize competition and complies with all other rules contained in the official rules document. I further represent that the information contained in the submission is true and contains no misrepresentations. I understand false statements or misrepresentations to the federal government may result in civil and/or criminal penalties under 18 U.S.C. § 1001 and § 287, and 31 U.S.C. §§ 3729-3733 and 3801-3812.

8.6 Prizes To Win

In addition to the outlined prizes below, an introductory email *may* be sent—at the discretion of DOE—to one or more relevant accelerators or incubators to introduce the student team members, providing the possibility of future collaboration. This can occur for student teams in any phase.

Explore Phase

Regional Finalists: These teams will be awarded $5,000 and invited to the Refine and Pitch phases. Up to $75,000 total will be awarded to regional finalists.

Bonus Prize Finalists: These teams will be awarded $5,000 each and invited to the Refine and Pitch phases.

National Lab IP Licensing Bonus Prize Finalist: This team will be awarded $5,000 and invited to the Refine and Pitch phases.

Undergraduate-Only Team Bonus Prize Semifinalists and Finalist: This team will be awarded $5,000 and invited to the Refine and Pitch phases.

Refine Phase

There will not be prizes awarded as part of this phase.

[4] Currently, the list of countries of risk includes Russia, Iran, North Korea, and China. This list is subject to change.

Pitch Phase

At the conclusion of the Pitch Phase, DOE will award three national prizes and several bonus prizes to student teams.

National Prizes: The national first-place winner will be awarded $50,000, the national second-place winner will be awarded $35,000, and the national third-place winner will be awarded $25,000. A total of $110,000 in national prizes will be awarded.

Bonus Prizes: Each program office's Bonus Prize winner will be awarded $20,000. The focus areas of each Bonus Prize are provided in Table 6.

National Lab IP Licensing Bonus Prize: One National Lab IP Licensing Bonus Prize winner may be selected and awarded $20,000 by OTT. The focus area of the National Lab IP Licensing Bonus Prize is provided in Table 6.

Undergraduate-Only Team Bonus Prize: One winner of the Undergraduate-Only Team Bonus Prize may be identified and awarded by OTT. The winning team will be awarded $20,000. The focus area of the Undergraduate-Only Team Bonus Prize is provided in Table 6.

A single competing student team may win a national prize and one or more bonus prizes, a single prize in either category, or no prize at all.

8.7 What Students Submit

Registration

- A 200-word written summary addressing the energy technology to be leveraged and the business opportunity
- (Optional) A preliminary slide deck that summarizes the team's business plan, including the suggested content identified in Table 2
- A team name that will remain consistent throughout the competition
- A completed registration entry form on HeroX, including answers to all required questions.

Explore Phase

- A 200-word written summary addressing the energy technology to be leveraged and the business opportunity
- A slide deck that summarizes the team's business plan, including the suggested content identified in Table 4 and optionally in Table 6
- A live (not recorded), virtual pitch to judges, 5 minutes in length, and participation in a 3-minute Q&A session with judges
- A completed Explore Phase entry form on HeroX that includes answers to all required questions.

Refine Phase

There will be nothing to submit as part of this phase.

Pitch Phase

- A written business plan addressing the suggested content identified in Table 8, up to 10 pages in length
- A recorded video explaining the technology to be leveraged and the business opportunity, up to 7 minutes in length
- A slide deck that summarizes the team's business plan, including the suggested content identified in Table 8
- A live (in-person) pitch to judges, approximately 5–10 minutes in length, to be determined in collaboration with the national event host and defined in a future rules update.

8.8 How Explore Phase Student Teams Are Determined

Eligibility Review

The prize administrator screens all completed registrations for eligibility. The prize administrator will review eligible submissions according to the evaluation criteria described in this document and will make the final selection of competing teams. Competing teams will then be assigned to a regional convener Explore Event as deemed appropriate by the prize administrator.

How We Score Team Registrations

The prize administrator will individually evaluate all eligible registration submissions and written statements given in Table 2 for each submission's region using the scoring scale shown in Table 1.

Table 1. Scoring Scale

1	2	3	4	5	6
Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree

Registration Submission Criteria

The prize administrator will evaluate the eligible teams using the criteria provided in Table 2. Teams will be evaluated based on the extent to which the registration submission aligns with the criteria statements.

Table 2. Registration Submission Criteria

Registration Submission Criteria	
Suggested questions to address in content: • What is the energy technology to be leveraged? • Who will buy the product or service, and why do they need the product or service? • Who will benefit should this business succeed? • What role will this business play in the energy transition?	**Criteria:** • The team understands their technology of choice and has evaluated the relevant market, outlined a vision for the role the business could play in an equitable energy transition, and considered what would be necessary to achieve success.

Based on these review criteria, the prize administrator will invite selected teams to compete in each regional convener's Explore Event. As indicated in the Additional Terms and Conditions (Appendix A), geographic diversity may be considered as a selection criterion for invitation to compete in the Explore Phase events. These teams will then be asked to provide the submission materials required for the Explore Phase. During the Explore Phase, teams will present their business plans to regional judges as part of a live event held virtually.

8.9 How Explore Phase Student Finalists Are Determined

Each regional convener will identify and secure a panel of judges to evaluate the Explore Phase presentations. Winners will be announced as part of each Explore Event, and within 30 days following the announcement, the prize administrator will work with winners to collect the necessary information to distribute cash prizes.

How Regional Judges Score the Explore Phase

A panel of judges, chosen independently by regional conveners, will evaluate the teams using the statements given in Table 4 and Table 6, based on the presentation given by each team as part of a live event held virtually. Immediately following the conclusion of the Explore Phase presentations, judges will meet to determine which teams will be selected as regional finalists. Scores will not be shared with any of the teams. Only the regional finalists and semifinalists will be announced. Semifinalists will be identified by combining the eligibility criteria with the same evaluation criteria and process used for identifying regional finalists. Each bullet listed in the Explore Phase criteria will receive a score from 1–6. Teams will be judged based on the extent to which the judging panel agrees with the criteria according to the scale shown in Table 3.

Table 3. Scoring Scale

1	2	3	4	5	6
Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree

Explore Phase Content and Criteria

For the Explore Phase, teams will present an initial business idea that leverages one or more national lab-developed or other emerging energy technologies. The business idea should be developed independently by students. As mentioned previously, teams will be given 5 minutes to present their technology and business plan, followed by 3 minutes of Q&A with the judges. The team should have a clear understanding of the technology and its commercialization potential, the existing market, and a plan for commercializing their chosen technology. The judging panel will evaluate the teams using the criteria in Table 4 and Table 6.

A panel of expert judges will evaluate, score, and comment on each submission. The criteria have equal weight, and the final score from an individual judge for a submission package equals the sum of the scores for all the statements. All the judges' scores are then averaged for a final score for the submission package. The regional judging panel will consider individual scores when selecting the finalist from their region's Explore Event. In addition to the finalist from each Explore Event, a semifinalist for the Undergraduate-Only Team Bonus Prize may be identified from each Explore Event.

This prize seeks to encourage inclusivity and diversity,[5] commercialization of national lab technology, and the pursuit of a broad mix of technologies. Before making the final awards, judges will assess the portfolio against these dimensions. The final determination of winners by the prize administrator will consider reviewer scores, team presentation performance, reviewer deliberation, and the program policy factors listed in Appendix A – Additional Terms and Conditions. Winners are not determined based on the likelihood that the presenting team will implement the business plan or on the underlying technology, but rather on the quality and innovativeness of the plan itself, should a qualified team of individuals attempt to execute the business plan.

[5] Executive Order 14035 defines the term ''diversity'' as the practice of including the many communities, identities, races, ethnicities, backgrounds, abilities, cultures, and beliefs of the American people, including underserved communities.

Table 4. Explore Phase Content and Criteria

Suggested questions to address in content:	Criteria:
1. Technology Identification	
Suggested questions to address in content: • What is the energy technology to be leveraged?	**Criteria:** • The team deeply understands their technology of choice and has explained it clearly.
2. Market Assessment	
Suggested question(s) to address in content: • Who will buy the product or service, and why do they need it? • Who is currently serving this market and how? • What unmet market need will this technology help to fill?	**Criteria:** • The team understands the relevant market, potential competitors, and customers for their identified technology, including what pain points this technology might solve for the customer.
3. Economic Feasibility Analysis	
Suggested questions to address in content: • What might customers be willing to pay for this product or service? • How much might it cost the business to produce this product or service?	**Criteria:** • The team's analysis is credible and has identified what the customer is willing to pay for the product, thoroughly justifying their product/service's cost of production and understanding its implication on their profit margins.
4. Potential Impact	
Suggested questions to address in content: • Who will benefit should this business succeed? • What role will this business play in the energy transition?	**Criteria:** • The proposed business includes thoughtful and specific activities that advance energy and environmental justice and equity and inclusion, including for members of disadvantaged communities[6] (e.g., those that are affected by persistent poverty or job loss due to the energy transition), and the team

[6] Disadvantaged communities are those experiencing one or more of the following: low income, high and/or persistent poverty, high unemployment and underemployment, racial and ethnic residential segregation (particularly where the segregation stems from discrimination by government entities), linguistic isolation, high housing cost burden and substandard housing, distressed neighborhoods, high transportation cost burden and/or low transportation access, disproportionate environmental stressor burden and high cumulative impacts, limited water and sanitation access and affordability, disproportionate impacts from climate change, high energy cost burden and low energy access, jobs lost through the energy transition, and lack of access to healthcare.

	has outlined a realistic vision for the role they see this business playing in the energy transition.
5. Overall Business Plan	
Suggested questions to address in content: • How is success defined? • What people and resources are needed to put this plan into action?	**Criteria:** • The team's definition of success is reasonable, and the business, if implemented as proposed, would be likely to achieve the specified metrics of success, including personnel, equipment or other assets, and partnerships necessary.

8.10 How Bonus Prize Finalists and Winners Are Determined

Finalists: The prize administrator screens all completed Explore Phase submissions and, in consultation with DOE, assigns eligibility for each bonus prize to each entry. The prize administrator will then assign expert reviewers to independently score the content of each submission, including a recording of the presentation provided by the team as part of an Explore Event. Expert reviewers will review submissions according to the criteria described in this document. A representative of OTT will make the final selection of finalists for the bonus prizes based on the expert reviewers' scores and comments as well as the program policy factors described in these rules.

Winners: The prize administrator will assign expert reviewers to independently score the content of each submission, including the pitch given by the team as part of the National Pitch Event. Expert reviewers will review submissions according to the evaluation criteria described in this document. A representative of OTT will make the final selection of winners for the bonus prizes based on the reviewers' scores and comments as well as the program policy factors described in these rules.

How Bonus Prizes Are Scored

Expert reviewers selected by the prize administrator and OTT will individually evaluate all team pitches based on the pitch content and the written submission given in Table 6. Judges will meet after the Pitch Phase presentations to discuss the teams with high average scores, update their scores to reflect all the information available, and determine the winner(s).

Table 5. Scoring Scale

1	2	3	4	5	6
Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree

Bonus Prize Challenge and Criteria

For the bonus prizes, teams present a comprehensive business plan that leverages a national lab-developed or other promising energy technology. The judging panel will evaluate the teams using the evaluation criteria provided in Table 6 and scoring scale in Table 5. Teams will be judged based on the extent to which the judging panel agrees with the criteria.

Teams are encouraged to review the content and references provided by each program office offering a bonus prize in Appendix B of these rules[7]. The rules will be updated with Appendix B as additional prizes are confirmed. These summaries of the program office's area of interest and the related industry landscape may provide valuable insights to teams as they identify potential technologies to leverage and possible business opportunities.

Table 6. Bonus Prize Challenge and Criteria

OTT National Lab IP Licensing Bonus Prize	
Prize description: Leverage the OTT's LPS to identify a national lab-developed technology available for licensing, and propose an innovative business model to commercialize the technology.	**Criteria:** The entry demonstrates a clear understanding of the technology listed on OTT's LPS as well as its market potential and presents an innovative business model to significantly increase its adoption.
OTT Undergraduate-Only Team Bonus Prize	
Prize description: As a team made up of only undergraduate students, including those pursuing an associate degree or a bachelor's degree, demonstrates and proposes an innovative business model for an emerging energy technology.	**Criteria:** The eligible team presents an entry that demonstrates a clear understanding of the technology and its market potential and presents an innovative business model to significantly increase its adoption.
Arctic Energy Office Bonus Prize	
Prize description: As a team made up of Alaska-based students, demonstrate and propose an innovative business model for an emerging energy technology that helps meet the energy,	**Criteria:** The eligible team presents an entry that demonstrates a clear understanding of the technology and its market potential for the Arctic region and presents an innovative business model to significantly increase the Arctic's clean energy transition and reduce

[7] Appendix B will be added to this Rules document at a later time.

science, and security needs of the U.S. and its Arctic allies.	reliance on diesel and/or lower emissions and energy burden for Alaskans/Arctic people.
Geothermal Technologies Office Bonus Prize	
Prize description: Develop innovative business models to increase the adoption of geothermal technologies that address key exploration and operational challenges.	**Criteria:** The entry demonstrates a clear understanding of the technology and market potential for geothermal technologies and presents an innovative business model to significantly address key exploration and operational challenges while engaging a diverse and inclusive cohort.
Office of Nuclear Energy Bonus Prize	
Prize description: Develop innovative business models to accelerate the development and deployment of advanced technologies supporting advanced reactors and fuel cycle technologies.	**Criteria:** The entry demonstrates an understanding of the chosen technology and its market potential, and the path to improved technology and/or enhanced adoption is well-articulated and reasonable.
Office of Electricity Grid-Enhancing Technologies (GETs) Bonus Prize	
Prize description: Develop innovative business models to increase the adoption of GETs to benefit the U.S. power grid.	**Criteria:** The presentation emphasizes a clear understanding of GETs and the market potential for GETs to be implemented by various utility entities in a way that decreases congestion and reduces electricity costs.
Office of Electricity Grid-Scale Power Electronics (PE) Bonus Prize	
Prize description: Develop innovative business models to stimulate the adoption of advanced power electronics in the U.S power grid.	**Criteria:** The presentation emphasizes a clear understanding of the technology and market potential for advanced power electronics and presents an innovative business model to significantly increase their adoption.
Office of Electricity Long-Duration Energy Storage (LDES) Bonus Prize	
Prize description: Develop innovative business models to propose an LDES technology solution, explain the technology's use case, and address	**Criteria:** The presentation outlines a clear understanding of LDES technologies and the LDES market space, explores barriers to greater LDES adoption, and

market challenges to enable greater adoption of LDES in the U.S. power system. Innovative energy storage use cases are encouraged.	proposes an innovative business plan to accelerate LDES deployment for a defined, innovative use case.
Solar Energy Technologies Office Bonus Prize	
Prize description: Develop innovative business models to improve the performance, affordability, reliability, and value of solar technologies in the U.S. grid and to tackle emerging challenges in the solar industry.	**Criteria:** The entry demonstrates a clear understanding of the technology and the market potential for optimizing the performance and/or reducing the costs associated with components, installation, and operation of solar energy systems and presents an innovative business model to significantly increase the technology's adoption.
Hydrogen and Fuel Cell Technologies Office Bonus Prize	
Prize description: Develop innovative business models to identify mechanisms for commercially viable hydrogen technologies to achieve market liftoff, supporting domestic competitiveness, job creation, and achievement of climate goals.	**Criteria:** The entry demonstrates a clear understanding of the technology and the market potential for hydrogen technologies and presents an innovative business model to significantly increase the technology's adoption.
Office of Manufacturing and Energy Supply Chains Bonus Prize	
Prize description: Develop an innovative business model or commercialization plan to increase the adoption of industrial decarbonization improvements at small- and medium-sized manufacturers.	**Criteria:** The entry effectively demonstrates a new approach that showcases and solves a key barrier to the implementation of industrial decarbonization improvements for small- and medium-sized manufacturers.
Water Power Technologies Office Bonus Prize	
Prize description: Develop innovative business models for a novel hydropower or marine technology of your choice that tackles emerging challenges in the water power industry and aims to improve the performance, affordability, reliability, and value of hydropower or marine energy in the United States.	**Criteria:** The entry demonstrates an understanding of the chosen technology and its market potential, and the path to improving the technology and/or increasing its adoption is well-articulated and reasonable. The team demonstrates a commitment to diversity, equity, inclusion, and justice.

8.11 How Pitch Phase Student Winners Are Determined

The prize administrator screens all completed submissions and ensures compliance with all requirements in these rules and, in consultation with DOE, identifies and tasks expert reviewers with independently scoring the content of each submission. Reviewers will review submissions according to the evaluation criteria described in this document. DOE, at its sole discretion, may decide to hold short interviews with a subset of the competitors. These interviews will be held prior to the announcement of the winners. Interview attendance is not required, and interviews are not an indication of winning. The Pitch Phase final judge, a representative of OTT, will make the final selection of winners based on the Pitch Phase judges' scores and comments as well as the program policy factors described in these rules. Winners will be announced as part of the Pitch Event.

How the Pitch Phase Is Scored

A panel of expert reviewers will watch each team's pitch and will read, score, and comment on each submission. Each bullet listed in the Pitch Phase criteria (Table 8) receives a score from 1–6, as indicated in Table 7. The bullets have equal weight, so categories that have more review criteria have a greater influence on the final score. The score from an individual reviewer for a submission package equals the sum of the scores for all the bullets. All reviewers' scores are then averaged for a final reviewer score for the submission package. The Pitch Phase final judge will consider reviewer scores when deciding the winners.

This prize seeks to encourage inclusivity and diversity, commercialization of national laboratory technology, and the pursuit of a broad mix of technologies. Before making the final selections/awards, reviewers will assess the portfolio against these dimensions. The final determination of winners will consider reviewer scores, team presentation performance, reviewer deliberation, and the program policy factors listed in Appendix A – Additional Terms and Conditions.

Table 7. Scoring Scale

1	2	3	4	5	6
Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree

Pitch Phase Content and Criteria

For the Pitch Phase, teams submit a comprehensive business plan that leverages a national lab-developed or other promising energy technology and a prerecorded pitch. Successful teams will demonstrate a clear understanding of the technology and its commercialization potential, the existing relevant market, and a convincing plan for commercialization. Pitch Phase judges will review the business plan and prerecorded pitch and provide up to three statements of concern or questions to each team at least 48 hours prior to the deadline to submit the presentation file. Teams can then choose to address those statements in their live pitch. The judging panel will evaluate the teams using the criteria in Table 8. Teams will be judged based on the extent to which the judging panel agrees with the evaluation criteria. Winners are not determined based on the likelihood that the presenting team will implement the business plan or on the underlying technology, but rather on the quality and innovativeness of the plan itself, should a qualified team of individuals attempt to execute the business plan.

Table 8. Pitch Phase Content and Criteria

1. Technology Identification	
Suggested question(s) to address in content: • What is the emerging energy technology to be leveraged in the proposed business?	**Criteria:** • The team deeply understands their technology of choice and has explained it clearly.
2. Market Assessment	
Suggested question(s) to address in content: • Who will buy the product or service, and why do they need the product or service? • Who is currently serving this market? • How can this technology help a business better serve the market? • How will the business find and secure customers?	**Criteria:** • The team deeply understands the range of potential customers for their identified technology, including what pain points this technology might solve for the customer. • The team has evaluated the entire relevant market of potential competitors. • The team has clearly identified a strategy to serve a sizable unmet market need. • The team has developed a comprehensive strategy for finding and securing customers.
3. Economic Feasibility Analysis	
Suggested question(s) to address in content: • What are customers willing to pay for this product or service? • How much will it cost the business to produce this product or service? • How will the business become financially sustainable?	**Criteria:** • The team has thoroughly justified what the customer is willing to pay (e.g., via a detailed analysis of competitor offerings and what people pay for them today). • The team deeply understands the steps necessary to produce and deploy the product/service and has thoroughly justified its cost of production. • The team has a well-justified estimate of how much money they need to raise to get the project off the ground and has presented a realistic projection of when and how the

	company will attain positive cash flow and a sufficient return on investment.
4. Potential Impact	
Suggested question(s) to address in content: • Who will benefit should this business succeed? • What role will this business play in the energy transition?	**Criteria:** • The proposed business includes thoughtful and specific provisions for advancing equity and inclusion, including for members of disadvantaged communities (e.g., those that are affected by persistent poverty or job loss due to the energy transition). (See footnote 3 on page 16.) • The team has clearly outlined a realistic vision for the role—however large or small—they see this business playing in the energy transition.
5. Overall Business Plan	
Suggested question(s) to address in content: • How is success defined? • What people and resources are needed to put this plan into action?	**Criteria:** • The team's definition of success is reasonable, and the business, if implemented as proposed, would be likely to meet the specified metrics of success. • The team has comprehensively identified what personnel, equipment or other assets, and partnerships are necessary to achieve success, as they have defined it.

9 Faculty Track

The Faculty Track seeks applications from faculty members interested in incorporating or expanding energy technology commercialization and entrepreneurship topics into their institution's educational activities. The Faculty Track consists of three phases—the Explore Phase, the Develop Phase, and the Implementation Phase. Additionally, a bonus prize is offered.

DOE recognizes that some faculty may already have significant experience and therefore sufficient support to successfully implement their plan for the 2025/2026 academic year, whereas others may require more time to develop and implement their educational activities. Both approaches are welcome. DOE seeks thoughtful educational activities with a high likelihood of effective and impactful implementation that expand technology commercialization and entrepreneurship education across a diverse[8] student population.

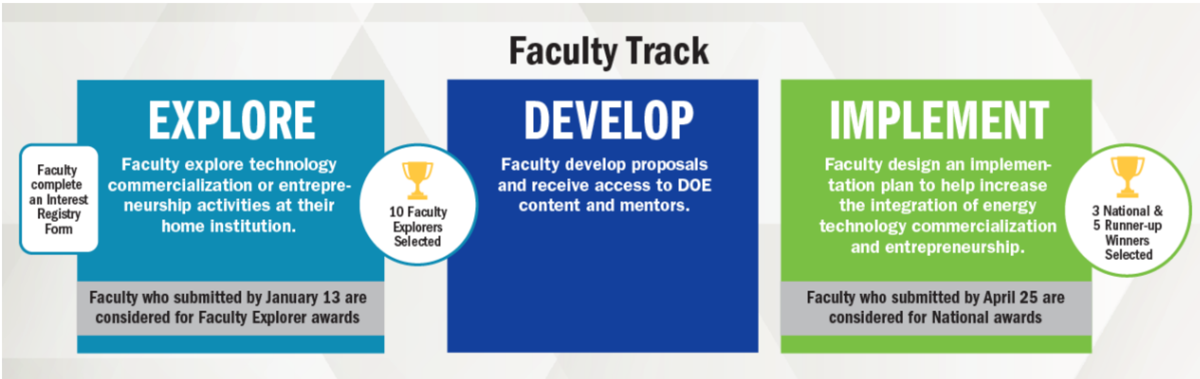
Examples of incorporation and expansion of proposed educational activities include (but are not limited to):

- The integration of new key educational modules into an existing course(s)/program(s)
- The development of a new course(s)/program(s)
- The creation of an accelerator or incubator program
- Creative co-teaching situations involving faculty from different disciplines
- Creative distance learning modules/course(s)
- The creation of new student-centered materials that actively engage learners in the classroom
- The development of new content presentation materials (for in-person or online learning) or any other approach determined to be impactful by the faculty and supported by their department/administration.

The content provided by faculty through their submissions is expected to inform a toolkit to be developed by OTT following the conclusion of this competition. The toolkit can potentially help other faculty across the nation build entrepreneurship and commercialization activities at their institutions.

[8] Executive Order 14035 defines the term ''diversity'' as the practice of including the many communities, identities, races, ethnicities, backgrounds, abilities, cultures, and beliefs of the American people, including underserved communities.

Figure 2



9.1 Interest Registry (Optional)

Through the optional Interest Registry, faculty who plan to apply to be a competitor for the Implementation Phase will submit their information via the Interest Registry Form (accessible from the HeroX platform). Submissions will be accepted on a rolling basis and will consist of the faculty's name, email, and name of their institution. This will allow DOE to communicate with faculty during the Develop and Implementation phases and provide resources to interested faculty. As an example, a webinar will be hosted to share DOE resources that are available; those who have completed the Interest Registry form will be invited to such events.

9.2 Explore Phase

Faculty who submit an Explore Phase entry on HeroX and meet eligibility requirements become faculty competitors and are given free access to several resources to help them refine their ideas and learning materials.

The Explore Phase is intended to support participants who are excited to implement entrepreneurship and/or commercialization activities but may not have deep integration of energy technology commercialization or entrepreneurship activities in their home institution. As such, these participants may need the resources provided by the Explore Phase to create an implementation plan.

Faculty (or faculty teams) apply to the Explore Phase by completing the registration entry form on the HeroX platform. The focus of the Explore Phase is identifying faculty with promising interests, ideas, and/or materials who are likely to effectively develop, refine, and implement high-quality and impactful activities for a student population that does not currently have access to these kinds of opportunities.

Participants must also demonstrate that they have preliminary interest in and support for their proposal from institutional leadership (e.g., a department chair, associate dean, or dean). For the Explore Phase, competitors do not need to have any current integration of energy technology commercialization or entrepreneurship in their institution's activities.

Faculty Explorers: Up to 10 faculty (or faculty teams) will be identified as Faculty Explorers from among the Explore Phase submissions received by the deadline. All faculty competitors, including Faculty Explorers, are eligible to compete in the Implementation Phase.

9.3 Develop Phase

In the Develop Phase, all faculty who submitted their information to the Interest Registry and all faculty competitors identified as part of the Explore Phase, including those identified as Faculty Explorers, will be provided with mentorship and continued free access to DOE resources.

All faculty competitors will be given access to a mentor from DOE. Mentors will give competitors insights and feedback on their plan in preparation for their implementation plan submission.

Faculty competitors are encouraged to explore all DOE OTT resources, including the ARL framework, the LPS, Pathways to Commercial Liftoff reports, and other materials. By the end of the Develop Phase, all competitors are highly encouraged to incorporate the ARL concepts and framework into their proposals in a logical and intentional manner for the educational benefit of the students engaged with the activities. However, proposals can be submitted with alternative frameworks or approaches.

9.4 Implementation Phase

Any eligible faculty member may submit an implementation plan on or before April 5, 2024. Selected winners will be announced by the deadline indicated in the rules. Faculty are not expected to present in person at the student EnergyTech UP National Event, but may attend if interested.

Proposals should include how this topic could be integrated into student activities along with a letter of support signed by the relevant department chair or administrator, such as an associate dean, dean, provost, or vice provost.

The implementation plan submitted as part of this phase should include a timeline for implementation at the competitor's home institution. Competitors should indicate whether implementation is possible in the 2024/2025 academic year.

Faculty Winner: Up to eight faculty competitor teams will be identified as winners. While Explore Phase Faculty Explorers will be encouraged to advance to the Develop and Implementation phases, any eligible faculty member who submits a complete package by the Implementation Phase deadline is eligible to be identified as a faculty winner.

Additional program information is available at www.energy.gov/energytechup. Questions should be submitted to ott.energytechup@nrel.gov.

9.5 Faculty Eligibility

- All participating faculty must be employed by an accredited collegiate institution.
- For the purposes of this competition, "collegiate institution" refers to a school of postsecondary or higher education, including but not limited to accredited trade schools, community colleges, colleges, universities, and graduate schools.
    - Faculty will self-certify their eligibility as part of the registration for the competition.

- Faculty may compete as a single-individual team or as a member of a team with multiple faculty members.
    - Teams with faculty from multiple collegiate institutions are allowed, and multiple faculty teams from the same collegiate institution are allowed.
    - Faculty may be full-time or part-time employees of their institution.
- All faculty teams must identify a single team captain.
- All faculty competing as individuals, and all faculty team captains, must be U.S. citizens or permanent residents. There is no limit to team size.
- The final submission must come from the faculty competing as an individual, or in the case of a team, from the team captain's HeroX account.
- A team may have nonfaculty team members or advisors who provide input and guidance and support the development of the idea.
- Expert reviewers, competition administrator staff, national laboratory employees, and DOE employees are ineligible to compete.
- Immediate family members of DOE employees and NREL prize administrators are ineligible to compete.
- The faculty member (or faculty team) does not need to have been selected as a Faculty Explorer to be eligible to compete for the Implementation Phase faculty prizes.
- By uploading a submission package, the faculty member (or faculty team) self-certifies that they are compliant with the eligibility requirements. If the prize administrator becomes aware that a team or individual is not eligible, that team may be disqualified from competition.
- This prize competition is expected to positively impact U.S. economic competitiveness. Participation in a foreign government talent recruitment program[9] could conflict with this objective by resulting in unauthorized transfer of scientific and technical information to foreign government entities. Therefore, individuals participating in foreign government talent recruitment programs of foreign countries of risk are not eligible to compete. Further, teams that include individuals participating in foreign government talent recruitment programs of foreign countries of risk[10] are not eligible to compete.
- Entities and individuals publicly banned from doing business with the U.S. government, such as entities and individuals debarred, suspended, or otherwise excluded from or ineligible for participating in federal programs, are not eligible to compete.
- To be eligible, an individual authorized to represent the competitor must agree to and sign the following statement upon registration with HeroX:

  I am providing this submission package as part of my participation in this prize. I understand that the information contained in this submission will be relied on by the federal government

[9] A foreign government talent recruitment program is defined as an effort directly or indirectly organized, managed, or funded by a foreign government to recruit science and technology professionals or students (regardless of citizenship or national origin, and whether having a full-time or part-time position). Some foreign government-sponsored talent recruitment programs operate with the intent to import or otherwise acquire from abroad, sometimes through illicit means, proprietary technology or software, unpublished data and methods, and intellectual property to further the military modernization goals and/or economic goals of a foreign government. Many, but not all, programs aim to incentivize the targeted individual to physically relocate to the foreign state for the above purpose. Some programs allow for or encourage continued employment at U.S. research facilities or receipt of federal research funds while concurrently working at and/or receiving compensation from a foreign institution, and some direct participants not to disclose their participation to U.S. entities. Compensation could take many forms, including cash, research funding, complimentary foreign travel, honorific titles, career advancement opportunities, promised future compensation, or other types of remuneration or consideration, including in-kind compensation.

[10] Currently, the list of countries of risk includes Russia, Iran, North Korea, and China. This list is subject to change.

to determine whether to issue a prize to the named competitor. I certify under penalty of perjury that the named competitor meets the eligibility requirements for this prize competition and complies with all other rules contained in the official rules document. I further represent that the information contained in the submission is true and contains no misrepresentations. I understand false statements or misrepresentations to the federal government may result in civil and/or criminal penalties under 18 U.S.C. § 1001 and § 287, and 31 U.S.C. §§ 3729-3733 and 3801-3812.

9.6 Prizes To Win

Explore Phase

Faculty Explorer Prize: From the eligible entries submitted by the deadline, up to 10 faculty members or faculty teams will be selected as Faculty Explorers. These selected Faculty Explorer teams will be awarded $5,000 each and will be encouraged to continue to the Develop and Implementation phases. A maximum of $50,000 total will be awarded to Faculty Explorers. A letter will also be sent to their institution on behalf of DOE announcing the prize award. At the conclusion of the Implementation Phase, DOE will award eight prizes.

Faculty Implementation Prize: The top three proposals will be awarded $25,000 for first place, $15,000 for second place, and $10,000 for third place. Five additional entries will be awarded $2,000 each as runners-up. A letter will also be sent to each winner's institution on behalf of DOE announcing the prize award.

9.7 What Faculty Submit

Interest Registry Form

- Name(s) of faculty
- Name of institution(s)
- Email(s) of faculty.

Explore Phase

- **A project title and short summary** of the proposal (no more than 250 words)
- **A single slide that summarizes the proposal** for integrating or expanding the topics of energy technology commercialization and entrepreneurship into the faculty's institution and the potential impact, should it succeed
- **A three-page written document** addressing the suggested content shown in Table 10
- **A completed entry form** on HeroX with answers to all required questions, including institutional demographics
- **Resume or CV** for faculty or faculty teams that includes a summary of experience with teaching entrepreneurship, business, energy, technology commercialization, technology transfer, licensing, or similar topics. Comprehensive prior experience is not required. This information is used to ensure that a diversity of perspectives are included in the program.

Implementation Phase

- **A project title and short description** of the proposal (no more than 350 words)
- **An implementation plan** (up to 10 pages) addressing the suggested content shown in

Table 12. Submissions may include figures as appropriate.
- **Letter or letters of support** from department and/or institutional leadership supporting the proposal and the implementation plan
- **Resume or CV** that includes a summary of experience with teaching entrepreneurship, business, energy, technology commercialization, technology transfer, licensing, or similar topics. Comprehensive prior experience is not required. This information is used to ensure that a diversity of perspectives are included in the program.
- **A completed entry form** on HeroX including answers to all required questions, including institutional demographics.

9.8 How Faculty Explorers Are Determined

As part of their registration, faculty provide information about their current teaching activities and submit an initial proposal for how they will create opportunities for students to be exposed to energy technology commercialization and energy entrepreneurship activities. Proposals should articulate the realistic anticipated positive impact that incorporating the proposed activities is likely to have on the student population.

The prize administrator screens all completed Explore Phase submissions received by the deadline and, in consultation with DOE, assigns eligibility. The prize administrator will then assign expert reviewers to independently score the content of each submission.

Faculty Explorers will be announced by the deadline indicated in Section 3.2, and within 30 days following the announcement, the prize administrator will work with winners to collect the necessary information to distribute cash prizes.

How Judges Score the Faculty Explore Phase

A panel of judges will evaluate the faculty teams using the statements given in Table 10 based on the submissions received by the deadline. Following review of the submission packages, judges will meet to determine which teams will be selected as Faculty Explorers. Scores will not be shared with any of the teams. Each bullet listed in the Explore Phase evaluation criteria will receive a score from 1–6. Teams will be judged based on the extent to which the judging panel agrees with the criteria according to the scale shown in Table 9.

Table 9. Scoring Scale

1	2	3	4	5	6
Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree

Faculty Explore Phase Content and Criteria

For the Explore Phase, teams will indicate their interest, existing activities, and an initial proposal for the development and implementation of new educational activities related to energy technology commercialization and entrepreneurship. The judging panel will evaluate the teams using the criteria in Table 10.

A panel of expert judges will evaluate, score, and comment on each submission. The evaluation criteria have equal weight; the final score from an individual judge for a submission package equals the sum of the scores for all the statements. All judges' scores are then averaged for a final score for the submission package.

This prize seeks to encourage inclusivity and diversity, commercialization of DOE national lab technology, and the pursuit of a broad mix of approaches. Before making the final awards, judges will assess the proposals against these dimensions. The final determination of winners by the prize administrator will consider reviewer scores, reviewer deliberation, and program policy factors listed in Appendix A – Additional Terms and Conditions.

Table 10. Registration Submission Content and Criteria

Faculty Registration Submission Criteria for Explore Phase	
Suggested question(s) to address in content:	**Criteria:**
• Why are you applying to this program, and why do you believe that your proposed educational activities will benefit students and your home institution? • How do you see your proposed activities fitting into and complementing current program(s) and student pathways at your accredited institution? • What are the foreseen challenges of implementing your proposed activities into existing program(s) and student pathways within the department/division, and what is your plan for risk mitigation? • Describe the level of commitment from your department and leadership for developing and implementing your proposed educational activities.	• The faculty clearly articulated a credible interest, identified an unmet opportunity at their home institution for the proposed materials, and provided a convincing understanding of the likely benefit to students at their home institution. A vision for the role their plan could play in an equitable energy transition was evident. • The faculty articulated a clear understanding of the current program structure as well as the constraints and flexibility of student pathways leading to program/degree completion requirements. The response considered what would be necessary to achieve success, understood the learning objectives, and summarized the potential impact. • The faculty did not shy away from citing realistic challenges for the implementation of the proposed learning materials within the boundaries of existing course(s) and the department/division/program and described an appropriate risk mitigation plan. • The faculty secured and provided clear and convincing evidence of support from department and/or relevant academic leadership for the development and implementation of the proposed educational activities.

9.9 How Implementation Phase Faculty Winners Are Determined

The prize administrator screens all completed submissions and ensures compliance with all requirements in these rules and, in consultation with DOE, tasks expert reviewers with independently scoring the content of each submission. Expert reviewers will review submissions according to the evaluation criteria described in this document. DOE, at its sole discretion, may decide to hold short interviews with a subset of the competitors. These interviews will be held prior to the announcement of the winners. Interview attendance is not required, and interviews are not an indication of winning.

designed to help other faculty across the nation who are interested in building entrepreneurship and commercialization activities at their institutions.

The Implementation Phase final judge, a representative of OTT, will make the final selection of winners based on the Implementation Phase expert reviewers' scores and comments as well as the program policy factors described in these rules. Winners will be announced as part of the National Pitch Event.

How the Implementation Phase Is Scored

A panel of expert reviewers will read, score, and comment on each submission. Each bullet listed in the Implementation Phase criteria receives a score from 1–6. The bullets have equal weight, so categories that have more review criteria have a greater influence on the final score. The score from an individual reviewer for a submission package equals the sum of the scores for all the bullets. All reviewers' scores are then averaged to determine the final score for the submission package. The Implementation Phase final judge will consider reviewer scores when deciding the winners.

This prize seeks to encourage inclusivity and diversity, commercialization of national laboratory technology, and the pursuit of a broad mix of approaches. Before making the final selections/awards, reviewers will assess the proposals against these dimensions. The final determination of winners will consider reviewer scores, reviewer deliberation, and program policy factors listed in Appendix A – Additional Terms and Conditions.

Table 11. Scoring Scale

1	2	3	4	5	6
Strongly disagree	Disagree	Slightly disagree	Slightly agree	Agree	Strongly agree

Implementation Phase Content and Criteria

DOE is interested in learning how faculty can implement educational activities focused on energy technology commercialization and entrepreneurship at their institutions. For the Implementation Phase, faculty members (or faculty teams) submit a comprehensive implementation plan that leverages DOE resources provided in the Develop Phase. The evaluation criteria for the implementation plan are outlined in **Table *12***. Successful faculty or faculty teams will demonstrate a clear understanding of this opportunity, challenges, the extent of the institution's current learning opportunities, and a convincing plan for implementation. Submissions will be judged based on the extent to which the judging panel agrees with the criteria. Winners are determined based on the quality and innovativeness of the plan itself as well as the potential impact of implementation.

The content provided by faculty in the Implementation Phase is expected to inform a toolkit. The toolkit will be developed by DOE following the conclusion of this competition. The toolkit will be designed to help other faculty across the nation who are interested in building entrepreneurship and commercialization activities at their institutions.

Table 12. Faculty Implementation Phase Content and Criteria

1. Analysis of Need	
Suggested question(s) to address in content:	**Criteria:**
• What are the current demographics of your institution? • What are the existing relevant activities, programs, and/or coursework related to commercialization and entrepreneurship? • What is the scope of the student body that you plan to include in these activities (e.g., graduate, undergraduate, departments or schools within your home institution)?	• The response provides basic demographic information for the home institution. The response conveys an understanding of the academic landscape within and across the institution and demonstrates a clear understanding of current activities around commercialization and entrepreneurship.
2. Actionability	
Suggested question(s) to address in content:	**Criteria:**
• What are the educational activities that you are proposing, and how will they support the learnings of students in commercialization and entrepreneurship? • What resources do you need to implement this proposed activity, and do you have them? • How could DOE tools like ARLs, Pathways to Commercial Liftoff, or LPS be implemented in your proposal?	• The response provided high-quality and complete content that is likely to be implementable, impactful, and sustainable at the faculty's own institution. The submitted material was aligned with expected learning objectives and could also be valuable to other U.S. collegiate institutions considering similar efforts. • The materials clearly and meaningfully incorporated ARLs into the content. They also indicated relevant connections to the Pathways to Commercial Liftoff reports and/or other DOE resources.
3. Support	
Suggested question(s) to address in content:	**Criteria:**
• What hurdles need to be cleared for the idea to be implemented (e.g., for a new course, is	

there an internal committee that needs to approve the course before it is part of the official school course offerings)? • What support has been established for the proposal as presented, including letters of support to help overcome any hurdles?	• The submission has provided clarity on the potential institutional hurdles that need to be overcome for implementation. • There is clear and credible support from institutional leadership for this proposal and where applicable, support to overcome any hurdles. The submitted materials have provided evidence that their proposals are in alignment with institutional priorities.
4. Potential Impact	
Suggested question(s) to address in content: • How is success defined? • How will success be measured? • How will students benefit if this proposal were to succeed? • Could other institutions leverage what you have developed and if so, how?	**Criteria:** • The proposed plan clearly addresses the learning opportunities and needs of its intended student population. • The project provided high-quality and complete content that is likely to be incorporated and valuable for sustained use at the faculty's own institution. • Additional degrees of success could be deemed likely through broader impacts if the project materials could be disseminated and implemented at other institutions considering similar efforts.
5. Overall Implementation Plan	
Suggested question(s) to address in content: • What is the timeline, and what are the rough stages of implementation? • How will this be implemented? What resources do you need for implementation? Do you have them? If not, what is your plan for obtaining the resources that you need? • How can DOE best support the program in future years (e.g., guest speakers, judges for prizes)?	**Criteria:** • There is sufficient information to enable successful implementation, a clear timeline for implementation, and clarity on the resources needed to successfully implement the proposal at the institution. Resources exist or there are ideas on how to get those resources and ideas on how DOE can be involved are included.

Appendix A – Additional Terms and Conditions

Universal Contest Requirements

Your submission for EnergyTech UP is subject to the following terms and conditions:

- Faculty competitors agree to release their submission package under a Creative Commons Attribution 4.0 International License (see https://creativecommons.org/licenses/by/4.0/).
- You must include all the required submission elements. The prize administrator may disqualify your submission after an initial screening if you fail to provide all required submission elements. Competitors may be given an opportunity to rectify submission errors due to technical challenges.
- Your submission must be in English and in a format readable by Adobe Acrobat Reader. Scanned handwritten submissions will be disqualified.
- Submissions and competitors will be disqualified if any engagement with EnergyTech UP—including but not limited to the submission, the HeroX forum, or e-mails to the competition administrator—contains any matter that, at the sole discretion of DOE or the prize administrators, is indecent, obscene, defamatory, libelous, lacking in professionalism, or demonstrates a lack of respect for people or life on this planet.
- If you click "Accept" on the HeroX platform and proceed to register for the competition described in this document, these rules will form a valid and binding agreement between you and the U.S. Department of Energy. This agreement is in addition to the existing HeroX Terms of Use for all purposes relating to these contests. You should print and keep a copy of these rules. These provisions only apply to the contests described here and no other contests on the HeroX platform or anywhere else. To the extent that these rules conflict with the HeroX Terms of Use, these rules shall govern.
- The competition administrator, when feasible, may give competitors an opportunity to fix nonsubstantive mistakes or errors in their submission packages.
- Reviewers will review submissions according to the evaluation criteria described in this document. Expert reviewers may not (a) have personal or financial interests in, or be an employee, officer, director, or agent of any entity that is a registered competitor in the prize; or (b) have a familial or financial relationship with an individual who is a registered competitor. These judge requirements apply to all reviews across all regions.
- As part of your submission to this prize, you will be required to sign the following statement:

  I am providing this submission package as part of my participation in this prize. I understand that the information contained in this submission will be relied on by the federal government to determine whether to issue a prize to the named competitor. I certify under penalty of perjury that the named competitor meets the eligibility requirements for this prize competition and complies with all other rules contained in the official rules document. I further represent that the information contained in the submission is true and contains no misrepresentations. I understand false statements or misrepresentations to the federal government may result in civil and/or criminal penalties under 18 U.S.C. § 1001 and § 287, and 31 U.S.C. §§ 3729-3733 and 3801-3812.

Program Policy Factors

While the scores of the expert reviewers will be carefully considered, it is the role of the prize administrator to maximize the impact of contest funds. Some factors outside the control of competitors and beyond the independent expert reviewer scope of review may need to be considered to accomplish this goal. The following is a list of such factors. In addition to the reviewers' scores, the below program policy factors may be considered in determining winners.

- Geographic diversity and potential economic impact of projects in a variety of markets.
- Whether the proposed business plan ideas have received an investment of $200,000 or more and/or have won a pitch competition in the amount of $20,000 or more. The purpose of this contest is to foster the development of new ideas.
- Whether the use of additional DOE funds and provided resources continue to be nonduplicative and compatible with the stated goals of this program and DOE's mission generally.
- The degree to which the submission exhibits technological or programmatic diversity when compared to the existing DOE project portfolio and other competitors.
- The level of industry involvement and demonstrated ability to accelerate commercialization and overcome key market barriers.
- The degree to which the submission is likely to lead to increased employment and manufacturing in the United States or provide other economic benefit to U.S. taxpayers.
- The degree to which the submission will accelerate transformational technological, financial, or workforce advances in areas that industry by itself is not likely to undertake because of technical or financial uncertainty.
- The degree to which the submission supports complementary DOE efforts or projects, which, when taken together, will best achieve the research goals and objectives.
- The degree to which the submission expands DOE's funding to new competitors and recipients that have not been supported by DOE in the past.
- The degree to which the submission exhibits team member diversity and the inclusion of underrepresented groups, including but not limited to graduates and students of historically black colleges and universities (HBCUs) and other minority-serving institutions (MSIs) or members operating within Qualified Opportunity Zones or other underserved communities.
- The degree to which the submission addresses one or some of the Justice40 priorities.
- The degree to which the submission enables new and expanding market segments.
- Whether the project promotes increased coordination with nongovernmental entities for the demonstration of technologies and research applications to facilitate technology transfer.

Verification for Payments

The prize administrator will verify the identity and the role of the participants potentially qualified to receive the prizes. Receiving a prize payment is contingent upon fulfilling all requirements contained herein. The prize administrator will notify winning competitors using their provided email contact information after the date that results are announced. Within 30 days of the date the notice is sent, each competitor (or parent/guardian if under 18 years of age) will be required to sign and return to the prize administrator a completed NREL Request for ACH Banking Information form and a completed W-9 form (https://www.irs.gov/pub/irs-pdf/fw9.pdf). At the sole discretion of the prize administrator, a winning competitor will be disqualified from the competition and receive no prize funds if: (i) the person/entity cannot be contacted, (ii) the person/entity fails to sign and return the required documentation within the required time period, (iii) the notification is returned as undeliverable, or (iv) the submission or person/entity is disqualified for any other reason.

Teams and Single-Entity Awards

The prize administrator will award a single dollar amount to the designated primary submitter, whether the submitter represents a single entity or multiple entities. The primary submitter is solely responsible for allocating any prize funds among its member competitors as they deem appropriate. The prize administrator will not arbitrate, intervene, advise on, or resolve any matters between team members or between teams.

Submission Rights

By making a submission, and thereby consenting to the rules of the contest as described in this document, a competitor is granting to DOE, the prize administrator, and any other third parties supporting DOE in the contest a license to display publicly and use all parts of any submission for any other government purpose. This license includes posting or linking to any portion of the submission made via the competition administrator or HeroX applications, including the contest website, DOE websites, and partner websites, and the inclusion of the submission in any other media worldwide. The submission may be viewed by DOE, the competition administrator, and the reviewers for purposes of the contests, including but not limited to screening and evaluation purposes. The competition administrator and any third parties acting on their behalf will also indefinitely retain the right to publicize competitors' names and, as applicable, the names of competitors' team members and organizations that participated in the submission process on the contest website.

By entering, the competitor represents and warrants that:

1. The competitor's entire submission is an original work by the competitor, and the competitor has not included third-party content (such as writing, text, graphics, artwork, logos, photographs, dialogue from plays, likenesses of any third party, musical recordings, clips of videos, television programs, or motion pictures) in or in connection with the submission, unless (i) otherwise requested by the competition administrator and/or disclosed by the competitor in the submission, and (ii) the competitor has either obtained the rights to use such third-party content or the content of the submission is considered to be in the public domain without any limitations on use;
2. Unless otherwise disclosed in the submission, the use thereof by the competition administrator, or the exercise by the competition administrator of any of the rights granted by the competitor under these rules, does not and will not infringe or violate any rights of any third party or entity, including, without limitation, patent, copyright, trademark, trade secret, defamation, privacy, publicity, false light, misappropriation, intentional or negligent infliction of emotional distress, confidentiality, or any contractual or other rights;
3. All persons who were engaged by the competitor to work on the submission or who appear in the submission in any manner have:
    a. Given the competitor their express written consent to submit the submission for exhibition and other exploitation in any manner and in any and all media, whether now existing or hereafter discovered, throughout the world;

b. Provided written permission to include their name, image, or pictures in or with the submission (or if a minor who is not the competitor's child, the competitor must have the permission of their parent or legal guardian), and the competitor may be asked by the competition administrator to provide permission in writing;
c. Not been and are not currently under any union or guild agreement that results in any ongoing obligations resulting from the use, exhibition, or other exploitation of the submission.

Copyright

Each competitor represents and warrants that the competitor is the sole author and copyright owner of the submission; that the submission is an original work of the applicant or that the applicant has acquired sufficient rights to use and to authorize others, including DOE, to use the submission, as specified throughout the rules; that the submission does not infringe upon any copyright or upon any other third party rights of which the applicant is aware; and that the submission is free of malware.

Teams are not required to have secured a license or rights to a technology to present a business plan that leverages a specific technology, but they should have confidence that the technology could hypothetically be licensed or otherwise be made available to a team for use as part of their business model.

Contest Subject to Applicable Law

All contests are subject to all applicable federal laws and regulations. Participation constitutes each participant's full and unconditional agreement to these contest rules and administrative decisions, which are final and binding in all matters related to the contest. This notice is not an obligation of funds; the final awards are contingent upon the availability of appropriations.

Resolution of Disputes

DOE is solely responsible for administrative decisions, which are final and binding in all matters related to the contest.

Neither DOE nor the prize administrator will arbitrate, intervene, advise on, or resolve any matters between team members or among competitors.

Publicity

The winners of these prizes (collectively, "winners") will be featured on the DOE and NREL websites.

Except where prohibited, participation in the contest constitutes each winner's consent to DOE's and its agents' use of each winner's name, likeness, photograph, voice, opinions, and/or hometown and state information for promotional purposes through any form of media worldwide, without further permission, payment, or consideration.

Liability

Upon registration, all participants agree to assume, and thereby have assumed, any and all risks of injury or loss in connection with or in any way arising from participation in this contest and/or development of any submission. Upon registration, except in the case of willful misconduct, all participants agree to and thereby do waive and release any and all claims or causes of action against the federal government and its officers, employees, and agents for any and all injury and damage of any nature whatsoever (whether existing or thereafter arising; whether direct, indirect, or consequential; and whether foreseeable or not) arising from their participation in the contest, whether the claim or cause of action arises under contract or tort.

Records Retention and the Freedom of Information Act

All materials submitted to DOE as part of a submission become DOE records and are subject to the Freedom of Information Act. The following applies only to portions of the submission not designated as public information in the instructions for submission. If a submission includes trade secrets or information that is commercial or financial, or information that is confidential or privileged, it is furnished to the government in confidence, with the understanding that the information shall be used or disclosed only for evaluation of the application. Such information will be withheld from public disclosure to the extent permitted by law, including the Freedom of Information Act. Without assuming any liability for inadvertent disclosure, DOE will seek to limit disclosure of such information to its employees and to outside reviewers when necessary for review of the application or as otherwise authorized by law. This restriction does not limit the government's right to use the information if it is obtained from another source.

Submissions containing confidential, proprietary, or privileged information must be marked as described below. Failure to comply with these marking requirements may result in the disclosure of the unmarked information under the Freedom of Information Act or otherwise. The U.S. government is not liable for the disclosure or use of unmarked information and may use or disclose such information for any purpose.

The submission must be marked as follows, and the specific pages containing trade secrets, confidential, proprietary, or privileged information must be identified:

Notice of Restriction on Disclosure and Use of Data:

Pages [list applicable pages] of this document may contain trade secrets or confidential, proprietary, or privileged information that is exempt from public disclosure. Such information shall be used or disclosed only for evaluation purposes. [End of Notice]

The header and footer of every page that contains confidential, proprietary, or privileged information must be marked as follows: "Contains Trade Secrets or Confidential, Proprietary, or Privileged Information Exempt from Public Disclosure." In addition, each line or paragraph containing proprietary, privileged, or trade secret information must be clearly marked with double brackets.

Competitors will be notified of any Freedom of Information Act requests for their submissions in accordance with 29 C.F.R. § 70.26. Competitors may then have the opportunity to review materials and work with a Freedom of Information Act representative prior to the release of materials.

Privacy

If you choose to provide HeroX with personal information by registering or completing the submission package through the contest website, you understand that such information will be transmitted to DOE and may be kept in a system of records. Such information will be used only to respond to you in matters regarding your submission and/or the contest, unless you choose to receive updates or notifications about other contests or programs from DOE on an opt-in basis. DOE and NREL are not collecting any information for commercial marketing.

General Conditions

DOE reserves the right to cancel, suspend, and/or modify the contest, or any part of it, at any time. If any fraud, technical failures, or any other factor beyond DOE's reasonable control impairs the integrity or proper functioning of the contests, as determined by DOE at its sole discretion, DOE may cancel the contest.

Although DOE indicates that it will select up to several winners for each contest, DOE reserves the right to only select competitors that are likely to achieve the goals of the program. If, in DOE's determination, no competitors are likely to achieve the goals of the program, DOE will select no competitors to be winners and will award no prize money.

ALL DECISIONS BY DOE ARE FINAL AND BINDING IN ALL MATTERS RELATED TO THE CONTEST.

DOE may conduct a risk review, using government resources, of the competitor and project personnel for potential risks of foreign interference. The outcomes of the risk review may result in the submission being eliminated from the prize competition. This risk review, and potential elimination, can occur at any time during the prize competition. An elimination based on a risk review is not appealable.

Competition Authority and Administration

EnergyTech UP is organized by DOE and NREL, which is managed and operated by the Alliance for Sustainable Energy, LLC, for DOE. Funding is provided by DOE OTT. The views expressed herein do not necessarily represent the views of DOE or the U.S. government.

EnergyTech UP is governed and adjudicated by this rules document, which is intended to establish fair contest rules and requirements. The competition is designed and administered by a team consisting primarily of DOE and NREL staff. In the case of a discrepancy with other competition materials or communication, this document takes precedence. The latest release of these rules takes precedence over any prior release. The prize administrator reserves the right to change contest criteria, rules, and outcomes as needed. Additionally, competitors are encouraged to bring to the organizers' attention to rules that are unclear, misguided, or in need of improvement. For the purposes of competition evaluation, a violation of the intent of a rule will be considered a violation of the rule itself. Questions on these rules or the program overall can be directed to ott.energytechup@nrel.gov.

Expert reviewers may not (a) have personal or financial interests in, or be an employee, officer, coordinator, or agent of any entity that is a registered participant in the contest; or (b) have a familial or financial relationship with an individual who is a registered competitor in this contest.

By making a submission and consenting to the rules of this competition, each team member grants to the government permission to use and make publicly available any entry provided or disclosed to DOE in connection with the competition. In addition, each team grants to the government, and others acting on its behalf, a paid-up nonexclusive, irrevocable, worldwide license to reproduce, prepare derivative works, distribute copies to the public, and perform publicly and display publicly, by or on behalf of the U.S. government, any and all copyrighted works that are or make up any submission.

EnergyTech UP and any associated nicknames and logos ("Competition Marks") are trademarks owned by DOE. The trademark license granted to contestants is below. Non-contestants can request individualized trademark licenses (for the purpose of engaging with contestants and/or expressing interest in the competition); the decision to grant such licenses is under the sole discretion of DOE.

1. Contestants are granted, for the duration of the competition, a revocable, nonexclusive, royalty-free license to use the Competition Marks for the purposes of producing materials for the competition and other approved competition-related activities, as long as the use does not suggest or imply endorsement of the contestant by DOE, and the use of the Competition Marks by a contestant does not imply the endorsement, recommendation, or favoring of the contestant by DOE.
2. Contestants may not use the Competition Marks for any other purpose. Contestants may not sublicense the Competition Marks.
3. All contestants can request individualized trademark licenses; the decision to grant such requests is under the sole discretion of DOE.

Further, from the Competes Act:

> (j) Intellectual property
>
> > (1) Prohibition on the government acquiring intellectual property rights
> >
> > The Federal Government may not gain an interest in intellectual property developed by a participant in a prize competition without the written consent of the participant.
> >
> > (2) Licenses
> >
> > As appropriate, and to further the goals of a prize competition, the Federal Government may negotiate a license for the use of intellectual property developed by a registered participant in a prize competition.

National Environmental Policy Act Compliance

DOE's administration of this prize is subject to the National Environmental Policy Act (NEPA) (42 USC 4321, et seq.). NEPA requires federal agencies to integrate environmental values into their decision-making processes by considering the potential environmental impacts of their proposed actions. For additional background on NEPA, please see DOE's NEPA website at http://nepa.energy.gov/.

While NEPA compliance is a federal agency responsibility and the ultimate decisions remain with the federal agency, all participants in this prize will be required to assist in the timely and effective completion of the NEPA process in the manner most pertinent to their participation in the prize competition. Participants may be asked to provide DOE with information on their planned activities such that DOE can conduct a meaningful evaluation of the potential environmental impacts.

Return of Funds

As a condition of receiving a prize, competitors agree that if the prize was awarded based on fraudulent or inaccurate information provided by the competitor to DOE, DOE has the right to demand that any prize funds or the value of other noncash prizes be returned to the government.

Appendix B – Office of Nuclear Energy

Statement of Interest

The Office of Nuclear Energy's (NE's) mission is to advance nuclear energy science and technology to meet U.S. energy, environmental, and economic needs. NE has identified the following goals to address challenges in the nuclear energy sector, help realize the potential of advanced technology, and leverage the unique role of the government in spurring innovation:

1. Enable continued operation of existing U.S. nuclear reactors
2. Enable deployment of advanced nuclear reactors
3. Secure and sustain the global nuclear fuel cycle
4. Expand international nuclear energy cooperation.

There is enormous potential to expanding nuclear energy into new markets and applications beyond the grid, including preserving the existing fleet, advancing reactors and fuel cycle technologies, and decarbonizing industrial sectors.

Bonus Challenge

NE is challenging you to develop innovative business models to accelerate the development and deployment of advanced technologies supporting advanced nuclear reactors and the existing fleet capabilities in the United States.

Evaluation Statement

The entry demonstrates an understanding of the technology and market potential of the chosen technology, and the path to improved technology and/or enhanced adoption is well-articulated and reasonable.

Content

Introduction

NE conducts crosscutting nuclear energy research and development (R&D), and associated infrastructure support activities, to develop innovative technologies that offer the promise of dramatically improved performance for its mission needs as stated above, while maximizing the impact of U.S. Department of Energy (DOE) resources.

NE strives to promote integrated and collaborative research among national laboratory, university, industry, and international partners in conjunction with NE's programs to deploy innovative nuclear energy technologies to the market to meet strategic goals and optimize the benefits of nuclear energy.

NE funds research activities, through both competitive and direct mechanisms, as required to best meet those goals. This approach ensures a balanced R&D portfolio and encourages new nuclear power deployment with creative solutions to address industry challenges.

Technology Overview

NE supports R&D in the following key NE program-related areas:

Reactor Concepts Research, Development, and Demonstration (RC RD&D) Program

The Reactor Concepts Research, Development, and Demonstration program supports conducting research on existing and advanced reactor designs to enable the industry to address technical and regulatory challenges associated with maintaining the existing fleet of commercial nuclear reactors, promoting the development of a robust pipeline of advanced reactor designs and technologies and associated supply chains, and progressing these advanced reactor designs and technologies toward demonstration, when ready. Program activities are focused on addressing technical, economic, safety, and security enhancement challenges associated with the existing commercial light water reactor fleet and advanced reactor technologies, covering large, small, and micro-sized designs and an array of reactor types, including fast reactors using liquid metal coolants and high-temperature reactors using gas or molten salt coolants.

The key challenges addressed by this program include improving the affordability of nuclear energy technologies, enhancing safety and reducing technical and regulatory risks, and improving the economic outlook for the U.S nuclear industry.

Fuel Cycle Research and Development (FC R&D) Program

The Fuel Cycle Research and Development (FC R&D) program conducts applied R&D on advanced fuel cycle technologies that have the potential to accelerate progress on managing the nation's spent fuel, improve resource utilization and energy generation, reduce waste generation, and limit proliferation risk. Advancements in fuel cycle technologies support the enhanced availability, economics, and security of nuclear-generated electricity in the United States, further enhancing U.S. energy independence and economic competitiveness. The FC R&D program also contributes to the department's policies and programs for ensuring a secure reliable and economic nuclear fuel supply for both existing and future reactors.

The key challenges being tackled by this program are both the front and back ends of nuclear fuel cycle technologies and reducing technical risk and financial uncertainties, improving resource utilization and energy generation, reducing waste generation, and limiting proliferation risk.

Spent Fuel and High-Level Waste Disposition (SFWD) R&D Program

The Spent Fuel and High-Level Waste Disposition (SFWD) R&D program conducts scientific research and technology development to enable long-term storage, transportation, and disposal of spent nuclear fuel (SNF) and high-level wastes (HLW). The primary focus of this subprogram supports the development of disposition-path-neutral waste management systems and options in the context of the current inventory of SNF and HLW.

The key challenges identified by this program include consent-based siting, long-term storage, transportation, and ultimate disposal.

Nuclear Energy Enabling Technologies (NEET) Program

The Nuclear Energy Enabling Technologies (NEET) program conducts R&D and makes strategic investments in research capabilities to develop innovative and crosscutting nuclear energy technologies to resolve nuclear technology challenges. The crosscutting research focuses on innovative research that directly supports the existing fleet of nuclear reactors and enables the development of advanced reactors and fuel cycle technologies, including topical areas such as advanced sensors and instrumentation, advanced materials and manufacturing technologies, and others. Also, NEET invests in modeling and simulation tools for existing and advanced reactor and fuel system technologies. Further, the program provides U.S. industry, universities, and national laboratories with access to unique nuclear energy research capabilities through the Nuclear Science User Facilities. In addition, NEET-sponsored activities support the goals, objectives, and activities of the Gateway for Accelerated Innovation in Nuclear initiative to make these technology advancements accessible to U.S. industry through private-public partnerships.

The key challenges highlighted by this program include the development of advanced sensors and instrumentation, advanced materials and manufacturing technologies, and modeling and simulation tools.

Advanced Reactor Demonstration Program (ARDP)

The Advanced Reactor Demonstration Program (ARDP) focuses on supporting the development of commercially promising advanced reactors that have the potential for near- and mid-term demonstration and commercial deployment.

ARDP includes these four major elements:

- National Reactor Innovation Center (NRIC) – Supports testing, demonstration, and performance assessment to accelerate deployment of advanced reactors through development of advanced nuclear energy technologies by utilizing the unique DOE national laboratory facilities and capabilities;
  - Risk Reduction for Future Demonstrations – Supports cost-shared (up to 80% government, not less than 20% industry) partnerships with U.S.-based teams to address technical, operational, and regulatory challenges to enable development of a diverse set of advanced nuclear reactor designs for future demonstration;
  - Regulatory Development – Coordinates activities with the Nuclear Regulatory Commission (NRC) and U.S. industry to address and resolve key regulatory framework and licensing technical issues that directly impact the “critical path” to advanced reactor demonstration and deployment; and
  - Advanced Reactor Safeguards and Security – Evaluates safeguards and security issues that are unique to advanced reactors to help reduce roadblocks by solving regulatory challenges, reducing safeguards and security costs, and utilizing the latest technologies and approaches for plant monitoring and protection.

The key challenges being addressed by this program include resolving technical, regulatory, and operational uncertainties hindering the wide-scale deployment of advanced reactors.

Market Opportunity

Many market opportunities exist that broadly fall within the categories of (1) enabling continued operation of existing U.S. nuclear reactors, which includes activities designed to address technical, cost, safety, and security issues associated with the existing commercial light water reactor, (2) enabling deployment of advanced nuclear reactors, and (3) developing advanced nuclear fuel cycles and spent nuclear fuel management options.

Additional Resources

- DOE Office of Nuclear Energy

  https://www.energy.gov/ne/office-nuclear-energy

- History of Nuclear Energy

  https://www.energy.gov/ne/about-us/history

- Fuel Cycle Technologies

  https://www.energy.gov/ne/initiatives/fuel-cycle-technologies

- HALEU Availability Program

  https://www.energy.gov/ne/haleu-availability-program

- Consent-Based Siting

  https://www.energy.gov/ne/consent-based-siting

- Advanced Sensors and Instrumentation (ASI)

  https://asi.inl.gov/#/

- Advanced Materials and Manufacturing Technologies (AMMT)

  https://ammt.anl.gov/

- Nuclear Energy Advanced Modeling and Simulation (NEAMS)

  https://neams.inl.gov/

- Nuclear Science User Facilities (NSUF)

  https://nsuf.inl.gov/

- Nuclear Facility Operations

  https://www.energy.gov/ne/nuclear-facility-operations/

- Nuclear Energy University Program

  https://www.energy.gov/ne/nuclear-energy-university-program

- Gateway for Accelerated Innovation in Nuclear (GAIN)

  https://www.energy.gov/ne/initiatives/gateway-accelerated-innovation-nuclear-gain

- Office of Nuclear Energy Funding Opportunities

  https://www.energy.gov/ne/funding-opportunities

- Nuclear Energy Institute

  https://www.nei.org/home

- Nuclear Innovation: Clean Energy Future

  https://www.energy.gov/ne/nuclear-innovation-clean-energy-future

- STEM Resources

  https://www.energy.gov/ne/stem-resources

- Document Library

  https://www.energy.gov/ne/listings/document-library

- Small Modular Reactor Technologies

  https://www.energy.gov/ne/advanced-small-modular-reactors-smrs

- Light Water Reactor Technologies

  https://www.energy.gov/ne/nuclear-reactor-technologies/light-water-reactor-sustainability-lwrs-program

- Advanced Reactor Technologies

  https://www.energy.gov/ne/advanced-reactor-technologies

- Space Power Systems
- https://www.energy.gov/ne/space-nuclear-mission-historyCoal-to-Nuclear Transitions

  https://www.energy.gov/ne/coal-nuclear-transitions

Appendix C – Office of Manufacturing and Energy Supply Chains (MESC): Decarbonization Solutions for Small and Medium-Sized Manufacturers

Statement of Interest

Established in 2022 as a new office under the Office of the Under Secretary for Infrastructure, MESC serves as the frontline of clean energy deployment, accelerating America's transition to a resilient, equitable energy future through billions of dollars in direct investments in manufacturing capacity and workforce development. The mission of MESC is to strengthen and scale America's clean energy supply chains, particularly through engagement with small and medium-sized manufacturers (SMMs), through:

- Transformative manufacturing capacity investments,
- Targeted workforce investments in the energy workforce of the future, and
- Cutting-edge energy supply chain vulnerability and innovation analysis.

MESC intends to eliminate vulnerabilities in U.S. clean energy supply chains while driving social, economic, and environmental impact through our programs and awards.

Bonus Challenge

MESC is challenging you to develop an innovative and practical business model for deployment of decarbonization solutions at SMMs—recognizing the inherent obstacles associated with the difficult-to-decarbonize industrial sector of the energy economy, combined with the implementation challenges confronting SMMs due to uncertain payback periods and financing obstacles.

Evaluation Statement

The entry emphasizes a clear understanding of and plans to address the opportunities and challenges associated with decarbonization at SMMs.

Content

Introduction

The U.S. industrial sector is considered a difficult-to-decarbonize sector of the energy economy, in part because of the diversity of energy inputs that feed industrial processes and operations. In other words, there is no single strategy for reducing industrial carbon dioxide (CO_2) emissions—rather, a more "all-of-the-above" approach is required.

Underscoring the importance of the industrial decarbonization challenge is the sheer magnitude of it the sector's emissions. The industrial sector accounts for roughly one-third of the nation's primary energy use and energy-related CO_2, including:

- Fuel-Related Emissions: Emissions associated with the combustion and use of fuels (from fossil or non-fossil sources) at industrial facilities for needs other than electricity (e.g., for process heat)
- Electricity Generation Emissions: Emissions attributed to the generation of electricity used at industrial facilities, whether that electricity is generated on-site or off-site
- Industrial Process Emissions: Non-energy-related process emissions from industrial activities (e.g., direct CO_2 emissions from chemical transformations in materials being processed)
- Manufactured Product Life Cycle Emissions: Emissions generated from cradle to grave (or cradle to cradle) that include emissions generated both upstream of the manufacturing processes (supply chain) and downstream (during product use and end of life).

In response, DOE has identified the following four key approaches to industrial decarbonization:

- **Energy efficiency** offers the greatest opportunities for near-term decarbonization solutions, including improvements in system efficiencies, process yield, and recovery of thermal energy; expansion of energy management practices; and increased implementation of smart manufacturing strategies designed to reduce energy consumption. Transitioning process-heat-related technologies and applications to low-carbon energy sources (electricity, hydrogen, biomass, etc.) is needed at scale. It is important that near-term energy efficiency improvements be done with longer-term decarbonization pathways in mind, to avoid lock-in to technologies that are harder to decarbonize.
- **Electrification** is a promising opportunity because over 50% of all manufacturing energy is used for thermal processing, yet less than 5% of these operations are electrified. Electrification, particularly of thermal processes, provides an opportunity to leverage decarbonized and inexpensive electricity sources and reduce industrial emissions from on-site combustion of fossil fuels. Industrial electrification technology includes electrification of process heat (e.g., heat pumps) or electrification of hydrogen production for industrial process use. Heat pumps can satisfy a range of thermal demands in low to medium temperatures across a range of industries.
- **Low-carbon fuels, feedstocks, and energy sources (LCFFES)** represent clean energy technologies that do not release greenhouse gases (GHGs) to the atmosphere from their production or use, and these energy sources will be an important tool in the development of potential decarbonization solutions. Examples of LCFFES in a manufacturing context include renewably sourced electricity and/or heat, photovoltaic (PV) systems, geothermal energy, and clean hydrogen as a synthetic fuel—especially those industries typically reliant on fossil fuels.
- **Carbon capture, utilization, and storage (CCUS)** is less likely to be deployed in a manufacturing context, particularly in the near term, when compared to energy efficiency, LCFFES, and electrification solutions. However, these three approaches are not sufficient to reach net-zero emissions. DOE anticipates that CCUS solutions will provide the largest single source of long-term emission reductions. Both carbon utilization and carbon storage will be critical to achieving the final carbon reductions.

Technology Overview

An essential element of potential decarbonization projects—especially within the context of SMMs—is finding a way to make them work that presents minimal risk to plant operations and/or profitability. SMMs generally don't have the flexibility or the resources to cease operations for days or weeks at a time to implement major product or process changes simply because "it's good for the environment."

Therefore, projects/technical solutions submitted in response to this solicitation are more likely to address the building envelope or the most immediate ancillary systems as opposed to the primary manufacturing line. However, there will be instances in which a focus on the main product line is feasible—but DOE is looking for nondisruptive, relatively simple, and repeatable solutions.

As these ideas are developed, it is necessary to assess them in several ways, including their decarbonization impacts, their duration and certainty, the complexity and cost of implementation, and the degree to which the impacts can be quantified and communicated within the firm, as well as to external stakeholders.

Implicit in the presentation and evaluation of decarbonization solutions is the need to define the CO_2 emissions baseline from which any measure of decarbonization impact at a particular facility will be quantified. There are a wide variety of publicly available tools (some of which are included in the reference section of this document) that can be used to estimate industrial CO_2, including Scopes 1, 2, and 3 emissions. For this reason, DOE is not particularly interested in CO_2 footprint tools as a technical solution; however, when proposing decarbonization projects, potential applicants should clearly define at what level(s) their technical solution applies.

Technical Solution

The choice of proposed technical solution(s), as well as the specific format of the accompanying description, is entirely up to the applicant; however, DOE expects the description to contain the following elements:

- Context – The specific process, industry, or product within which the proposed technical solution can be applied;
- Description – What aspect of the manufacturing process or environment is being changed/impacted and how;
- Quantification – The estimated numerical impact(s) of the implemented technical solution—i.e., energy saved, input reduced, emission/waste eliminated (including cost);
- Applicability/Replicability – A discussion of the potential cumulative impacts of replicated adoption of the technical solution; and
- Considerations – Other factors, caveats, and evolving circumstances that could influence the impacts of the proposed technical solution.

Market Opportunity

Current operations among SMMs present numerous opportunities in decarbonization. The path forward will change over time as the number of successful projects grows and a more robust, classification system can be developed.

Additional Resources

References and Guidance Documents

1. U.S. Department of Energy. "Pathways to Commercial Liftoff: Industrial Decarbonization." September 2023. https://liftoff.energy.gov/wp-content/uploads/2023/09/20230918-Pathways-to-Commercial-Liftoff-Industrial-Decarb.pdf.
2. U.S. Department of Energy. "Industrial Decarbonization Roadmap." DOE/EE-2635. September 2022. https://www.energy.gov/sites/default/files/2022-09/Industrial%20Decarbonization%20Roadmap.pdf.
3. Lawrence Berkeley National Laboratory. "Decarbonization Assessment Guidance." https://industrialapplications.lbl.gov/industrial-decarb.

Industrial Decarbonization Tools

"Simplified GHG Emissions Calculator" – U.S. EPA

This resource is a Microsoft Excel sheet-based model for calculating an organization's GHG emissions. The tool is very thorough and includes emissions quantification for all three scopes. It's relevant for facilities aiming to quantify emissions within the identified boundary.

The tool can be found at: https://www.epa.gov/climateleadership/simplified-ghg-emissions-calculator.

"eGRID Power Profiler" – U.S. EPA

The online tool helps calculate the fuel mix of sources (and emissions factor) used to generate electricity for a specific eGRID subregion. The input required by the tool is the facility's zip code. The results are expressed in the form of standalone CO_2/CO_2 equivalents emissions per MWh of electricity consumed at the site. Its database also includes emissions factors back to the vintage year 1996. Currently, the tool has an emissions factor up to the year 2020.

The tool can be found at: https://www.epa.gov/egrid/power-profiler#/.

"GHG Inventory Management Plan Checklist" – U.S. EPA

This resource is a Microsoft Word-based checklist that outlines requirements in a thorough inventory management plan. Its application is relevant for facilities in identifying steps toward developing a successful GHG reporting plan.

The resource can be found at: https://www.epa.gov/climateleadership/ghg-inventory-development-process-and-guidance.

"MEASUR Tool Suite" – U.S. DOE

This tool suite includes various manufacturing energy calculators, including a "CO_2 Savings Calculator." The calculator (under general calculators in the tool) is a quick and easy way to calculate carbon-equivalent emissions and reductions for a variety of stationary fuels and electricity sources. It can be downloaded and installed on a computer by facilities and Information Analysis Centers for analysis.

The tool can be found at: https://www.energy.gov/eere/amo/measur.

"Electrification for Decarbonization Tool" – Oak Ridge National Laboratory

This is a MEASUR-based tool, which is currently available in a beta version that calculates the energy, cost, and carbon reductions for electrifying fuel-fired equipment. The tool has high relevance for quickly showcasing the potential savings (or lack thereof) from electrification, and the carbon impacts it represents.

The tool can be found at: https://electrification.ornl.gov/.

"Low Carbon Action Plan Tool" – U.S. DOE's Better Buildings Program

The Action Plan Template helps develop low-carbon pathways for a facility. It is a very in-depth template for setting up a facility to produce an action plan for reaching low/no carbon emissions. Relevant parts of this tool could be utilized on an ad-hoc basis.

The tool can be found at: https://betterbuildingssolutioncenter.energy.gov/better-plants/software-tools.

"Estimating GHG Emissions From Pulp and Paper Mills" by National Council for Air and Stream Improvement (NCASI)

This Microsoft Excel-based tool facilitates the calculation of GHG emissions from the pulp and paper manufacturing subsector to conform to the requirements of the U.S. DOE's Voluntary Reporting of Greenhouse Gases (1605b program). It consists of a Visual Basic-based graphical user interface that guides a user through the GHG inventory process. It can be utilized by facilities and IACs to establish baseline and future emissions data for this subsector.

The tool can be found at: https://www.ncasi.org/wp-content/uploads/2020/05/GHG_Calc_Tools_PandP_spreadsheet_Version2.1b.xlsm.

Appendix D – SETO Bonus Focus: Performance, Affordability, Reliability, and Value of Solar Technologies

Statement of Interest

Develop innovative business models to improve the performance, affordability, reliability, and value of solar technologies on the U.S. grid and to tackle emerging challenges in the solar industry.

Evaluation Statement

The entry demonstrates a clear understanding of the technology and market potential for optimizing performance and/or reducing the costs associated with components, installation, and operation of solar energy systems and presents an innovative business model to significantly increase its adoption.

Content

Introduction

Solar energy, being the fastest-growing electricity source,[11] is expected to be key part of the U.S. strategy to achieve such goals. Solar generation satisfied about 5.6% of the total U.S. electricity demand in 2023 and it is projected to serve 37%–42% of electricity demand by 2035.[12,13] Such substantial growth needs to be supported by innovation that ensures seamless integration of solar generation into the electric grid, enhances capital efficiency in manufacturing and deployment, and leads to advances in the performance, reliability, and affordability of solar systems.

Solar Technologies Overview

Solar radiation is light—also known as electromagnetic radiation—that is emitted by the sun. The amount of sunlight that strikes the Earth's surface in an hour and a half is enough to handle the entire world's energy consumption for a full year. Solar technologies capture this radiation and convert sunlight into other forms of energy more readily compatible to our economy. For example, photovoltaic (PV) technologies convert sunlight into electricity that can be used directly or stored in batteries. Alternatively, mirrors can concentrate solar radiation to produce heat, which can generate electricity or be stored thermally.[14]

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[11] https://www.c2es.org/content/renewable-energy/

[12] https://www.energy.gov/sites/default/files/2021-09/Solar%20Futures%20Study.pdf

[13] https://www.eia.gov/todayinenergy/detail.php?id=61203

[14] https://www.energy.gov/eere/solar/how-does-solar-work

PV technologies—more commonly known as solar panels—generate power using devices that absorb energy from sunlight and convert it into electrical energy through semiconducting materials. These devices, known as solar cells, are then connected to form larger power-generating units known as modules or panels. The most common solar cells used in commercially available solar panels are made of crystalline silicon and have efficiencies typically ranging from 18%–22%.[15], and newer monocrystalline solar cell have reached efficiencies over 26%. PV installations exist as either large-scale electric utility plants or are more commonly found as residential, commercial, or industrial distributed energy resources (DERs) on building rooftops. Often, they are combined with energy storage (currently mostly batteries), which are charged with solar energy and supply energy at nighttime or when sunlight is not available. Concentrating solar-thermal power (CSP) systems use mirrors to reflect and concentrate sunlight onto receivers that collect solar energy and convert it to heat in a high-temperature medium, which can then be used to produce electricity, drive a variety of industrial applications requiring process heat, or be stored for later use. It is used primarily in very large power plants.

Costs

Solar system costs comprise of the hardware costs of the various system components (e.g., solar panels, racking systems, solar inverters and other converters, electrical panels, electrical wiring, and potentially battery storage) as well as a number of non-hardware costs, known as soft costs, such as permitting, financing, and installation costs. The levelized cost of energy (LCOE)[16]

Over the past decade, solar energy has achieved significant cost reductions, resulting in very competitive LCOE.[17], while the commercial or utility-scale solar power cost is about $0.06 to $0.08 per kWh. DOE is targeting a LCOE for solar of $0.02 to $0.05 per kWh by 2030.

Focus Areas

This section lists several areas of interest where innovative technologies can advance the state of the art and, if they become commercially competitive, improve the performance, affordability, reliability, and value of solar systems. The list is not exhaustive, but it identifies several high-interest and high-potential areas.

Distributed Generation PV Systems

PV systems are typically found as rooftop installations operating as distributed energy resources. Residential rooftop PV installations are generally 3–10kW_{DC} in size, while commercial and industrial rooftop PV installations are more commonly >30 kW_{DC} and ≤1 MW_{DC}. Such systems can be grid-connected or isolated, stand-alone systems and are often coupled with energy storage systems (ESS) or also combined with electric vehicle (EV) charging systems. SETO is interested in technologies that can reduce installation costs of such PV, PV+ESS, or PV/ESS/EV systems (leading to increased DER penetration), optimize performance and control of such distributed generation systems, and allow such DER systems to provide support and services to the main grid, if needed. This also includes the

[15] https://www.energy.gov/eere/solar/crystalline-silicon-photovoltaics-research

[16] https://www.energy.gov/sites/prod/files/2015/08/f25/LCOE.pdf

[17] https://www.energy.gov/eere/solar/goals-solar-energy-technologies-office

development and operation of virtual power plants (VPPs), which are a connected aggregation of DER technologies operated in a coordinated way. VPPs offer deeper integration of renewables and demand flexibility, which in turn offers cleaner and more affordable power[18] and methodologies, algorithms, and software solutions for the control, operation, and grid integration of DERs and VPPs are an area of great interest.

Photovoltaic Cell Technologies and Materials

About 95% of solar panels on the market today use either monocrystalline silicon or polycrystalline silicon as the semiconductor.[19]:

- Multijunction solar cells
- Thin-film solar cells (CdTe)
- Perovskite solar cells
- Organic photovoltaics (OPV).

Building-Integrated Photovoltaics (BIPV) and Photovoltaic Building Materials (PVBM)

BIPV electric power systems are multifunctional construction materials. They are an integral component of the building envelope as well as a solar electric energy system that generates electricity for the building.[20], integrating solar panels on roofing products, building facades, curtain walls, fences, canopies, shade structures, or balcony balustrades.

Vehicle-Integrated Photovoltaics (VIPV)

The field of vehicle-integrated photovoltaics (VIPV) designates the mechanical, electrical, and design-technical integration of PV modules into vehicles.[21]PV modules integrate seamlessly into the vehicle exterior and electric system architecture to supply power to on-board electric loads or batteries. VIPV modules serve dual functionality by generating electric energy while replacing other structural parts of the vehicle, like the roof, the hood, the doors, or the sunroof. In simpler cases, referred to as vehicle-added or attached PV (VAPV), more traditional individual PV modules are attached to the existing vehicle structure serving only the energy generation role.

Agrivoltaics

Dual-use solar refers to the concurrent use of land for both electricity and agricultural production. PV panels are installed on farmlands in a way that agricultural activities can continue, with agricultural production taking place underneath solar panels, in adjacent zones around the solar panels, or both. Agrivoltaic systems enable farmers, ranchers, and other agricultural enterprises to gain value from solar technologies while keeping land available for agricultural purposes.[22] between them where

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[18] https://www.energy.gov/lpo/virtual-power-plants

[19] https://www.energy.gov/eere/solar/articles/pv-cells-101-primer-solar-photovoltaic-cell

[20] https://www.nrel.gov/docs/fy00osti/25272.pdf

[21] https://www.ise.fraunhofer.de/en/key-topics/integrated-photovoltaics/vehicle-integrated-photovoltaics-vipv.html

[22] https://www.energy.gov/eere/solar/seto-2020-solar-and-agriculture

crops can grow or livestock can live, as well as in controlled-climate agriculture, at greenhouses that use sunlight (not indoor farming with artificial light).

Floatovoltaics

A floating solar photovoltaic (FPV) system is an emerging technology in which a PV system is placed directly on top of a body of water, as opposed to on land or on building rooftops.[23] Floatovoltaics, can provide additional co-benefits to generating electricity, such as elimination of competition for land use, which could be used for other purposes, and mitigation of evaporation losses. FPV systems can be installed over natural (e.g., oceans or lakes) or human-made water bodies, like freshwater reservoirs, wastewater ponds, or hydropower reservoirs.

Photovoltaic-Thermal

Photovoltaic-thermal (PVT) systems convert incoming solar radiation into both thermal and electrical energy. By producing two usable types of energy within the same collector, PVT can be more efficient than either PV or solar-thermal alone. The electricity produced can be pushed onto the grid, while the heat can be used for conditioning of building space, hot water, or industrial processes.[24] This area focuses on integrated PVT systems and components for PVT systems, including solar modules, collectors, and control systems.

Power Electronics

Power electronic (PE) devices are used to extract electric energy from the solar panels and make it available for use by other devices. Inverters are used to convert the direct current (DC) electricity generated by solar PV modules into alternating current (AC) electricity, which is used for local transmission of electricity as well as most appliances in our homes, while DC/DC converters are used to convert the DC voltage of a PV module to a different DC voltage level. PV systems either have one inverter that converts the electricity generated by all the modules, or microinverters that are attached to each individual module. Advanced inverters, or "smart inverters," allow for a variety of functions that improve the performance of solar systems and also, in cases that include more advanced control schemes, allow them to provide operational services to the grid they are connected to, like traditional power generators do.[25,26]Recently, new wide-bandgap semiconductor materials, like silicon carbide (SiC) and gallium nitride (GaN), have been used in PE devices, demonstrating significant benefits and operating advantages, like smaller device sizes, less weight, and higher efficiencies. Other new ultawide-bandgap semiconductors, like gallium oxide (Ga_2O_3), could become even more promising in the near future. Additionally, solar generation is often coupled with energy storage systems (ESS) and electric vehicle (EV) charging stations, creating the need for centralized, multi-port power electronic devices that can combine and manage all such systems in a unified architecture. This area focuses on multi-port and bidirectional inverters for PV/ESS/EV applications.

Concentrating Solar Power

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[23] https://www.nrel.gov/state-local-tribal/blog/posts/floating-solar-photovoltaics-could-make-a-big-splash-in-the-usa.html

[24] https://www.energy.gov/eere/solar/request-information-technology-and-market-potential-photovoltaic-thermal-pvt-systems

[25] https://www.energy.gov/eere/solar/solar-photovoltaic-system-design-basics

[26] https://www.energy.gov/eere/solar/solar-integration-inverters-and-grid-services-basics

Concentrating solar-thermal power (CSP) technologies use mirrors to reflect and concentrate sunlight onto a receiver. The energy from the concentrated sunlight heats a high-temperature medium in the receiver. This heat can be used to power a turbine to generate electricity, but the same basic technologies can also be used to deliver heat to a variety of industrial applications, like water desalination, enhanced oil recovery, food processing, chemical production, and mineral processing. Concentrating solar-thermal power systems are generally used for utility-scale projects, but smaller CSP systems can also be located directly where power is needed for specific industrial applications. [27,28]

Software Solutions

Software solutions include software systems and software-enabled business models that aim to improve the performance, reliability, and affordability of solar systems by automating processes and procedures during the design, installation, and operation of such systems. Software solutions could involve, but are not limited to, system modeling, simulation, design, installation support or automation, asset performance monitoring and management, plant control and operation optimization, etc.

Bonus Challenge

DOE's Solar Energy Technologies Office is challenging you to develop an innovative business model for a selected novel solar technology of your choice that tackles emerging challenges in the solar industry and aims to improve the performance, affordability, reliability, and value of solar energy in the United States. The business model goal would be to increase the adoption such new solar technology and maximize the performance and/or reduce the costs associated with the components, installation, and operation of solar energy systems.

Additional Resources

- DOE – Solar Energy Technologies Office

  https://www.energy.gov/eere/solar/solar-energy-technologies-office

- DOE – Solar Energy Technologies Office, Quarterly Solar Industry Update

  https://www.energy.gov/eere/solar/quarterly-solar-industry-update

Solar Technologies Background

- DOE/SETO – How Does Solar Work?

  https://www.energy.gov/eere/solar/how-does-solar-work

- DOE/SETO – Solar Energy Success Stories

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[27] https://www.energy.gov/eere/solar/concentrating-solar-thermal-power

[28] https://www.energy.gov/eere/solar/concentrating-solar-thermal-power-basics

https://www.energy.gov/eere/solar/solar-energy-success-stories

- DOE/SETO – Solar Futures Study

  https://www.energy.gov/sites/default/files/2021-09/Solar%20Futures%20Study.pdf

Photovoltaic Technology Background

- DOE/SETO – Photovoltaics

  https://www.energy.gov/eere/solar/photovoltaics

  https://www.energy.gov/eere/solar/solar-photovoltaic-technology-basics

- NREL – Solar Photovoltaic Technology Basics

  https://www.nrel.gov/research/re-photovoltaics.html

- EIA – Solar Explained

  https://www.eia.gov/energyexplained/solar/photovoltaics-and-electricity.php

- SEIA – Photovoltaics

  https://www.seia.org/initiatives/photovoltaics

- SOLAREIS – Solar Photovoltaic Technologies

  https://solareis.anl.gov/guide/solar/pv/index.cfm

Next-Generation Power Electronics for Inverters/Converters

- DOE/SETO – Solar Power Electronic Devices

  https://www.energy.gov/eere/solar/solar-power-electronic-devices

  https://www.energy.gov/eere/solar/advanced-power-electronics-design-solar-applications-power-electronics

  https://www.energy.gov/eere/solar/silicon-carbide-solar-energy

Perovskite Solar Cells

- DOE/SETO – Perovskite Solar Cells

  https://www.energy.gov/eere/solar/perovskite-solar-cells

  https://www.energy.gov/eere/solar/request-information-performance-targets-perovskite-photovoltaic-research-development-and

  https://pubs.acs.org/doi/10.1021/acsenergylett.2c00698

- NREL – Perovskite Solar Cells

  https://www.nrel.gov/pv/perovskite-solar-cells.html

Building-Integrated Photovoltaics (BIPV)

- SEIA – Building-Integrated Photovoltaics
- https://seia.org/photovoltaics/NREL – Building-Integrated Photovoltaic Designs

  https://www.nrel.gov/docs/fy00osti/25272.pdf

- WBDG – Building Integrated Photovoltaics (BIPV)

  https://www.wbdg.org/resources/building-integrated-photovoltaics-bipv

- DOE/SETO – Building-Integrated Photovoltaics (BIPV)

  https://www.energy.gov/eere/solar/request-information-building-integrated-photovoltaics

- Architectural Solar Association (ASA)

  https://www.archsolar.org/

Vehicle-Integrated Photovoltaics (VIPV)

- DOE/SETO – Vehicle-Integrated Photovoltaics (VIPV)

  https://www.energy.gov/eere/solar/request-information-challenges-and-opportunities-vehicle-photovoltaics

- Fraunhofer ISE – Vehicle-Integrated Photovoltaics.

  https://www.ise.fraunhofer.de/en/key-topics/integrated-photovoltaics/vehicle-integrated-photovoltaics-vipv.html

- European PV Technology and Innovation Platform (ETIP PV). VIPV Position Paper – Vehicle-Integrated Photovoltaics as a Core Source for Electricity in Road Transport

  https://etip-pv.eu/publications/etip-pv-publications/download/vehicle-integrated-photovoltaics-vipv-as-a-core-so

Agrivoltaics

- NCAT – AgriSolar Clearinghouse

  https://www.agrisolarclearinghouse.org/

- University of Arizona – What is Agrivoltaics?
- https://biosphere2.org/research/research-initiatives/agrivoltaicsNREL – Benefits of Agrivoltaics Across the Food-Energy-Water Nexus

  https://www.nrel.gov/news/program/2019/benefits-of-agrivoltaics-across-the-food-energy-water-nexus.html

Floatovoltaics

- NREL – Floating Solar Photovoltaics Could Make a Big Splash in the USA

  https://www.nrel.gov/state-local-tribal/blog/posts/floating-solar-photovoltaics-could-make-a-big-splash-in-the-usa.html

- NREL – Enabling Floating Solar Photovoltaic (FPV) Deployment

  https://www.nrel.gov/docs/fy21osti/76867.pdf

Photovoltaic-Thermal

- U.S. General Services Administration – Photovoltaic-Thermal Hybrid Solar System

  Photovoltaic-Thermal Hybrid Solar System | GSA

Concentrating Solar-Thermal Power

- DOE/SETO – Concentrating Solar-Thermal Power

  https://www.energy.gov/eere/solar/concentrating-solar-thermal-power

- DOE/SETO – Concentrating Solar-Thermal Power Basics

  https://www.energy.gov/eere/solar/concentrating-solar-thermal-power-basics

Appendix E – Water Power Technologies Office (WPTO)

Statement of Interest

America has vast marine energy and hydropower resources, and there remains enormous potential to both expand into new markets and applications and to increase generation and flexibility across the nation's sizable hydropower and pumped storage fleet. WPTO challenges you to develop innovative business models to improve or enhance the commercial potential of marine energy, particularly within blue economy markets, or next-generation hydropower and pumped storage systems.

WPTO also seeks to support equitable and just marine energy and hydropower industries and the blue economy, with diversity at all levels of the industry and workforce, and that provides benefits to all.

Bonus Challenge

DOE's WPTO is challenging you to develop an innovative business model for a selected novel marine or hydropower technology of your choice that tackles emerging challenges in the water power industry and aims to improve the performance, affordability, reliability, and value of marine energy or hydropower in the United States.

Evaluation Statement

The entry demonstrates an understanding of the technology and market potential of the chosen technology, and the path to improved technology and/or enhanced adoption is well-articulated and reasonable. The team demonstrates a commitment to diversity, equity, inclusion, and justice.

Content

Introduction

America has vast marine energy and hydropower resources—and the continued development of new technologies and modernization and existing assets will be critical to furthering the nation's shorter-term electricity sector decarbonization goals, and to longer-term economywide focused objectives. Water power has important benefits across multiple infrastructure sectors and to the people who depend on them. There are opportunities to evaluate how to harness and deliver water power, including through building more resilient infrastructure; providing power to produce clean water; unlocking the full potential of all ocean resources (Powering the Blue Economy or PBE), particularly in the context of climate change and its impact on our oceans; and better aligning technology development with end users and communities. Therefore, WPTO is seeking new, innovative business models to improve or enhance the commercial potential of marine energy, particularly within blue economy markets, or next-generation hydropower and pumped storage systems.

Areas of opportunity include advancing marine energy technology to support new and growing industries utilizing waves, currents, tides, and ocean thermal gradients; existing hydropower facilities and non-powered dams that can utilize new technologies to cost-effectively increase generation and flexibility; and innovating on flexible and more rapidly deployable pumped energy storage systems.

Technology Overview

Marine

Marine energy, also known as marine renewable energy (MRE) or marine and hydrokinetic energy (MHK), uses kinetic energy from moving water—including surface waves, tidal power, ocean current power, and other large bodies of moving water—to generate power and electricity. Marine energy technologies are at an early stage of development given fundamental technical challenges involved in generating power from a dynamic, low-velocity, and high-density resource while withstanding corrosive marine environments. However, given the significant resource potential in our oceans and rivers, marine energy offers both a future opportunity to supply electricity to a deeply decarbonized national grid and a near-term solution for distributed energy for isolated and islanded communities.

Hydropower

Hydropower, or hydroelectric power, is one of the oldest and largest sources of renewable energy, which uses the natural flow of moving water to generate electricity. Hydropower currently accounts for 28.7% of total U.S. renewable electricity generation and about 6.2% of total U.S. electricity generation.[29] term to support and complement variable renewable energy (VRE); pumped storage hydro (PSH) systems are one of the most scalable, cost-effective, and long-lived grid-scale storage assets, both now and likely in the future. Hydropower is a flexible, affordable energy source that complements other renewable energy sources.

Market Opportunity

There is enormous potential to both expand into new markets and applications for marine and hydro and to extract more energy from the existing assets on the nation's grid. Areas of opportunity include advancing marine energy technology to support new and growing industries utilizing waves, currents, tides, and ocean thermal gradients; existing hydropower facilities and non-powered dams that can utilize new technologies to cost-effectively increase generation and flexibility; and innovating on flexible and more rapidly deployable pumped energy storage systems.

As marine energy resources are sizable, predictable, reliable, can be developed in an environmentally responsible manner, and geographically diverse, marine energy represents a significant and emerging market across the entire U.S. and particularly in the "blue economy." The term "blue economy" refers to the sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystems. DOE's Powering the Blue Economy initiative seeks to understand the power requirements of coastal and maritime markets and advance technologies that integrate marine renewable energy to relieve these power constraints and enable sustainable growth of the blue economy.

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[29] https://www.eia.gov/energyexplained/hydropower/

In the blue economy, there exist a number of market opportunities that broadly fall within the categories of (1) power at sea, which involves providing power to support ocean-based industries, scientific observations and experiments, and security activities (such as ocean observation and navigation or marine aquaculture) and (2) improving the resiliency of coastal communities by helping to meet their energy and water needs (for example, through desalination or powering microgrids in remote areas).[30]

U.S. hydropower capacity continues to grow through upgrades to existing plants and other types of innovative new projects. Hydropower capacity has increased by a net of 431 MW since 2017, with total net growth of 1,688 MW from 2010–2019, mostly through capacity increases at existing facilities, new hydropower in conduits and canals, and by powering non-powered dams (NPDs).[31]At the end of 2019, an additional 1,490 MW, from 217 projects, were in the U.S. development pipeline, 93% of proposed capacity from powering NPDs and expanding existing facilities. PSH represents a particular area of opportunity, as the vast majority of energy storage capacity in the U.S. is PSH, and PSH is the preferred least cost technology option for energy storage 416 hours in duration. Hydropower and its facilities also present the opportunity to capitalize on several non-power benefits.

Additional Resources

- DOE Water Power Technologies Office

  https://www.energy.gov/eere/water/water-power-technologies-office

- Water Power Technologies Office 2022–2023 Accomplishments Report https://www.energy.gov/eere/water/water-power-technologies-office-2022-2023-accomplishments-report

- Energy I-Corps Resources: Tools and Training for Entrepreneurs

  https://www.osti.gov/biblio/1867238-review-technology-innovations-pumped-storage-hydropower

- Portal and Repository for Information on Marine Renewable Energy (PRIMRE)

  https://openei.org/wiki/PRIMRE

- Marine Energy Collegiate Competition Resources

  https://openei.org/wiki/PRIMRE/STEM/Marine_Energy_Collegiate_Competition_(MECC)/Resources

- Marine Energy Resource Library

  https://openei.org/w/images/3/3f/Marine_Energy_Resource_Library_MECC.pdf

- Powering the Blue Economy

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[30] https://www.energy.gov/sites/prod/files/2019/09/f66/73355-v2.pdf

[31] https://www.energy.gov/eere/water/downloads/us-hydropower-market-report

https://www.energy.gov/eere/water/powering-blue-economy

- Hydropower Explained

  https://www.eia.gov/energyexplained/hydropower/

- HydroSource

  https://hydrosource.ornl.gov/

- National Hydropower Association

  https://www.hydro.org/

- Hydropower Market Report

  https://www.energy.gov/sites/prod/files/2021/01/f82/us-hydropower-market-report-full-2021.pdf

- Hydropower Geotechnical Foundations: Executive Summary

  https://info.ornl.gov/sites/publications/Files/Pub142905.pdf

- Six Non-Power Benefits of Hydropower

  https://www.energy.gov/eere/articles/six-non-power-benefits-hydropower

- A Review of Technology Innovations for Pumped Storage Hydropower

  https://www.osti.gov/biblio/1867238-review-technology-innovations-pumped-storage-hydropower

Appendix F – Hydrogen and Fuel Cell Technologies Office (HFTO) Bonus Focus: End-User Hydrogen Adoption

Statement of Interest

The U.S. clean hydrogen market is poised for rapid growth, accelerated by Hydrogen Hub funding, multiple tax credits, DOE's Hydrogen Shot, and decarbonization goals across the public and private sectors. DOE's National Clean Hydrogen Strategy and Roadmap has identified the potential for up to 10 million metric tonnes (MMT)/year of clean hydrogen production by 2030, 20 MMT/year by 2040, and 50 MMT/year by 2050. Achievement of these goals could enable ~10% reduction in U.S. GHG emissions by 2050, particularly in sectors that are difficult to decarbonize via traditional approaches, such as industrial/chemicals uses and heavy-duty transportation.[32] Achieving commercial liftoff will enable clean hydrogen to play a critical role in the nation's decarbonization strategy.

Bonus Challenge

HFTO challenges you to develop innovative business models to accelerate clean hydrogen and fuel cell technology adoption in the United States. Examples of sectors wherein hydrogen has opportunity for growth are described in the *National Clean Hydrogen Strategy and Roadmap* and the *Pathways to Commercial Liftoff: Hydrogen* report.

Evaluation Statement

The presentation demonstrates a well-reasoned and articulated understanding of the chosen technology, market potential, and sector.

Content

Introduction

Hydrogen is the most abundant element in the universe; however, it is rarely found in its elemental form on Earth. It must be produced from a hydrogen-containing feedstock (e.g., water, biomass, fossil fuels, or waste materials) using an energy source. Once hydrogen is produced, it can be used to store, move, and deliver low- or no-carbon energy to where it is needed. Hydrogen can be stored as a liquid, gas, or chemical compound, and is converted to energy via traditional combustion methods (in engines, furnaces, or gas turbines), through electrochemical processes (in fuel cells), and through hybrid approaches such as integrated combined cycle gasification and fuel cell systems. It is also used as a feedstock or fuel in a number of industries, including petroleum refining, ammonia production, food and pharmaceutical production, and metals manufacturing. Hydrogen can

[32] U.S. National Clean Hydrogen Strategy and Roadmap (energy.gov)

be produced in large centralized production facilities or in smaller distributed production facilities, and can be transported via truck, pipeline, tanker, or other means.[33]

Hydrogen, as a versatile energy carrier and chemical feedstock, offers advantages that unite all our nation's energy resources—renewables, nuclear, and fossil fuels—and enables innovations in energy production and end uses that can help decarbonize three of the most energy intensive sectors of our economy: transportation, electricity generation, and manufacturing.[34]

Technology Overview

The DOE Hydrogen Program Plan lists the following as technology focus areas:

Hydrogen Production

The United States has diverse and abundant natural resources to enable secure, clean, sustainable, large-scale, and affordable carbon-neutral hydrogen production. Global demand for hydrogen across sectors is increasing, with a current worldwide consumption at approximately 70 million metric tonnes (MMT) per year.[35] Of this, the United States currently produces and consumes almost 10 MMT annually, equivalent to just over 1 quadrillion BTUs per year (1% of U.S. energy consumption).[36]

To meet this growing demand, a broad portfolio of hydrogen production pathway technologies are being explored and developed. These include technologies for tapping into fossil resources with CCUS, extracting hydrogen from biomass and waste-stream resources, and splitting water. This wide range of options opens regional opportunities to expand the hydrogen supply base across the country, offering carbon-neutral hydrogen production capacities from a few hundred to hundreds of thousands of kilograms per day.[37]

Hydrogen Delivery

To support a wide range of applications, delivery infrastructure for hydrogen may incorporate multiple technology pathways capable of transporting hydrogen in various forms, including as a gas in pipelines and high-pressure tube trailers, as a liquid via tanker trucks, and using chemical hydrogen carriers. Different technologies for dispensing hydrogen may also be needed depending on how the hydrogen is transported, stored, and utilized. The technologies required to support these delivery pathways are at various stages of development, but they must ultimately be both affordable

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[33] U.S. Department of Energy. November 2020. "Department of Energy Hydrogen Program Plan." https://www.energy.gov/eere/fuelcells/roadmaps-and-program-plans. Pg. 4.

[34] U.S. Department of Energy. November 2020. "Department of Energy Hydrogen Program Plan." https://www.energy.gov/eere/fuelcells/roadmaps-and-program-plans.

[35] U.S. Department of Energy. October 2019. Hydrogen and Fuel Cells Program Record 19002. "Current Hydrogen Market Size: Domestic and Global." https://www.hydrogen.energy.gov/pdfs/19002-hydrogen-market-domestic-global.pdf.

[36] U.S. Department of Energy, October 2019, op. cit.

[37] U.S. Department of Energy. November 2020. "Department of Energy Hydrogen Program Plan." https://www.energy.gov/eere/fuelcells/roadmaps-and-program-plans.

and meet or exceed the level of safety, convenience, reliability, and energy efficiency expected from existing infrastructure for other fuels.[38]

Hydrogen Storage

Hydrogen has nearly three times the energy content of gasoline per unit of mass,[39] but the volumetric energy density of gaseous hydrogen is low, making it difficult to store in compact containers. To overcome this challenge, hydrogen is usually stored using physical processes, as a gas or cryogenic liquid; it can also be stored using material-based processes that incorporate hydrogen in chemical compounds.[40]

Conversion

Hydrogen is an energy carrier that is produced using energy and feedstocks such as water, biomass, natural gas, coal, oil, and wastes such as wastewater and plastics. To be useful, the energy carried by hydrogen must be converted into a different form, such as electricity or heat. This conversion can be accomplished through combustion using turbines or reciprocating engines, or through an electrochemical process using a fuel cell. There are several opportunities to design hybrid energy systems, for example using high- or low-temperature stationary fuel cells integrated with gas turbines in large-scale combined-cycle hybrid systems, which use both conventional and fuel cell energy conversion technologies.[41]

Applications

Hydrogen has the potential for use in diverse applications across multiple sectors, where it can provide substantial environmental and economic benefits, as well as improved energy security and resiliency. Large amounts of hydrogen can be used in the transportation, power generation, and industrial and manufacturing sectors, which can enable economies of scale and support a robust domestic supply chain. Integrated energy systems, which can span sectors, offer additional opportunities by using hydrogen as an energy carrier to improve the economics of existing and emerging electric power generation systems.[42]

Strategies that Enable Benefits of Clean Hydrogen[43]

The US National Clean Hydrogen Strategy and Roadmap is based on ***prioritizing three key strategies*** to ensure that clean hydrogen is developed and adopted as an effective decarbonization tool for ***maximum benefit*** to the United States:

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[38] Ibid

[39] The energy content of hydrogen is 33 kWh/kg, while gasoline's is 12 kWh/kg, based on lower heating value.

[40] U.S. Department of Energy. November 2020. "Department of Energy Hydrogen Program Plan." https://www.energy.gov/eere/fuelcells/roadmaps-and-program-plans.

[41] Ibid

[42] Ibid

[43] U.S. Department of Energy. June 2023. "U.S. National Clean Hydrogen Strategy and Roadmap." https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf.

Target strategic, high-impact uses for clean hydrogen.

This will ensure that clean hydrogen will be utilized in the highest-value applications, where limited deep decarbonization alternatives exist. Specific markets include the industrial sector (e.g., chemicals, steel, and refining), heavy-duty transportation, and long-duration energy storage to enable a clean grid. Additional longer-term opportunities include the potential for exporting clean hydrogen or hydrogen carriers and enabling energy security for our allies.[44]

Reduce the cost of clean hydrogen.

The Hydrogen Energy Earthshot (Hydrogen Shot), launched in 2021, will catalyze both innovation and scale, stimulating private sector investments, spurring development across the hydrogen supply chain, and dramatically reducing the cost of clean hydrogen. Efforts will also address critical material and supply chain vulnerabilities and design for efficiency, durability, and recyclability. Together with investment in midstream infrastructure (storage, distribution), these initiatives can reduce not only the production, but also the delivered cost, of clean hydrogen.[45]

Focus on regional networks.

Investing in and scaling Regional Clean Hydrogen Hubs will enable large-scale clean hydrogen production close to high-priority hydrogen users, allowing the sharing of a critical mass of infrastructure. Also, these investments will drive scale in production, distribution, and storage to facilitate market liftoff. Properly implemented, these regional networks will create place-based opportunities for equity, inclusion, and sustainability. Priorities will include reducing environmental impacts, creating jobs—including good-paying union jobs—securing long-term offtake contracts, and jumpstarting domestic manufacturing and private sector investment.[46]

Additional Resources

- Pathways to Commercial Liftoff: Clean Hydrogen (energy.gov)
- DOE Hydrogen and Fuel Cell Technologies Office
- DOE Office of Clean Energy Demonstration - Regional Clean Hydrogen Hubs
- DOE Hydrogen Shot
- DOE National Renewable Energy Laboratory - Hydrogen and Fuel Cells
- DOE Lawrence Berkeley National Laboratory - Hydrogen
- DOE National Energy Technology Laboratory - Natural Gas Decarbonization and Hydrogen Technologies Program

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44 Ibid

45 Ibid

46 U.S. Department of Energy. June 2023. "U.S. National Clean Hydrogen Strategy and Roadmap." https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/us-national-clean-hydrogen-strategy-roadmap.pdf.

Appendix G – Office of Electricity (OE) Bonus Focus: Long-Duration Energy Storage

Statement of Interest

Long-duration energy storage (LDES) is essential to a reliable, resilient, and decarbonized future electricity system. Cheaper and more efficient storage will make it easier to capture and store renewable clean energy for use when energy generation is unavailable or lower than demand. While shorter-duration storage is currently being installed to support today's level of renewable energy generation, longer-duration storage is needed to support the affordability, reliability, and resilience of a decarbonized, transformed future electricity system.

Bonus Challenge

DOE's Office of Electricity is challenging you to develop an innovative business plan to propose an LDES technology solution, explain the technology's use case, and address market challenges to enable greater adoption of LDES in the U.S. power system. Innovative energy storage use cases are encouraged.

Evaluation Statement

The presentation outlines a clear understanding of LDES technologies and the LDES market space, explores barriers to greater LDES adoption, and proposes an innovative business plan to accelerate LDES deployment for a defined, innovative use case.

Content

Introduction

Grid-scale energy storage is a critical element driving and supporting the evolution of the electricity system. In the past several years, there has been a significant increase in renewable energy deployed on the U.S. grid as the costs of clean energy technologies have substantially dropped. At the same time, there is a renewed focus on grid reliability and resilience, especially considering the drastic system changes. Grid-scale energy storage intersects these transformations: These technologies support decarbonization by providing load when renewable resources have reduced availability, act as a grid-enhancing technology (GET) by increasing the utilization of transmission, and enhance grid flexibility during peak times or when electric vehicle (EV) charging use is high. The importance of energy storage in the power system is growing annually, and projections for energy storage needs in 2035 and 2050 to support decarbonization are significantly above today's levels (some analyses, such as a study performed by the National Renewable Energy Laboratory [NREL], project over 200 GWh of grid storage capacity in 2030).

While short-duration storage (primarily lithium-ion batteries providing less than 10 hours) is the predominant configuration currently being installed, longer-duration storage technologies (providing

10+ hours) are needed to support a variety of clean energy and resilience applications as the amount of renewable energy increases and the electricity system continues transforming.

Technology Overview

Lithium-ion batteries comprise the majority of grid energy storage for durations of less than 10 hours, as well as the majority of new grid deployments. Pumped storage hydropower (PSH), the vast majority of which dates back to the second half of the 20th century, currently provides most of the longer-duration (10 hours and above) storage, with 43 projects in the United States currently providing 21.9 GW of installed capacity. Lithium-ion batteries are the least expensive alternative at shorter durations and are expected to continue to earn significant market share. Grid storage technologies enable greater penetration of renewables through load-shifting and arbitrage, improve grid reliability, reduce congestion, and increase profitability. They also serve other use cases, such as providing ancillary services like frequency regulation or reserves, and helping better utilize existing transmission and distribution assets, thus deferring investments.

While lithium-ion batteries and PSH dominate new and historical deployments, respectively, there are dozens of promising grid storage technologies, including electrochemical, electromechanical, thermal, and chemical storage. Over the last several decades, DOE has funded or supported dozens of different energy storage technologies for a variety of use cases, including long-duration applications. DOE's Office of Electricity did a deep-dive analysis into 10 energy storage technologies as part of the Storage Innovations 2030 initiative, and also ran a prize competition to explore the landscape of emerging, innovative technologies. There are several dozen storage technologies that may have promise for the grid of today or the future.

Barriers still exist to wider deployment of LDES. These barriers include cost, geographical constraints (for some technologies), technology validation, permitting, manufacturing scale-up, and workforce development.

Costs

In 2021, DOE launched the Long-Duration Storage Shot, which established the target to reduce the cost of grid-scale energy storage by 90%, to $0.05/kWh levelized cost of storage (LCOS), for systems that deliver 10+ hours of duration by 2030. The Long-Duration Storage Shot is part of DOE's Energy Earthshots Initiative, which aims to accelerate breakthroughs of more abundant, affordable, and reliable clean energy solutions within the decade. Achieving the Energy Earthshots will help America tackle the toughest remaining barriers to addressing the climate crisis. The Long-Duration Storage Shot considers all types of technologies—whether electrochemical, mechanical, thermal, chemical carriers, or any combination—that have the potential to meet the necessary duration and cost targets for grid flexibility.

Recent DOE announcements have required that proposed LDES technologies show a clear pathway to the $0.05/kWh LCOS goal.

Market Opportunity

Grid energy storage is poised to grow significantly in the United States. NREL's *Storage Futures Study* projects new storage deployments in the range from 100–650 GW of new capacity by 2050, a significant increase from the 23 GW of storage capacity in 2020 (most of which is decades-old PSH). Storage costs are projected to continue to fall, with cost projections described in the Pacific Northwest National Laboratory's (PNNL's) cost and performance report, and the potential for significant cost reductions through R&D analyzed in the Office of Electricity's Long Duration Storage Shot Technology Strategy Assessments. LDES represents a major market opportunity given its critical role in decarbonization and plummeting costs; however, technical and market barriers remain.

Additional Resources

- Long Duration Storage Shot: https://www.energy.gov/eere/long-duration-storage-shot
- Storage Innovations 2030: https://www.energy.gov/oe/storage-innovations-2030
- NREL Storage Futures Study: https://www.nrel.gov/analysis/storage-futures.html
- PNNL Cost and Performance Report 2022: https://www.pnnl.gov/sites/default/files/media/file/ESGC%20Cost%20Performance%20Report%202022%20PNNL-33283.pdf
- Grid Energy Storage Supply Chain Deep Dive Assessment (February 2022): https://energy.gov/sites/default/files/2022-02/Energy%20Storage%20Supply%20Chain%20Report%20-%20final.pdf
- Energy Storage Valuation: A Review of Use Cases and Modeling Tools (2022): https://www.energy.gov/sites/default/files/2022-06/MSP_Report_2022June_Final_508_v3.pdf
- Long Duration Energy Storage Request for Information (May 2022): https://www.energy.gov/oe/articles/long-duration-energy-storage-everyone-everywhere-initiative-notice-intent-and-request

Appendix H – Geothermal Technologies Office (GTO) Focus: Innovation and Inclusiveness

Statement of Interest

Geothermal energy, along with direct use of geothermal resources, presents an extraordinary opportunity to innovators and researchers seeking large-scale, deeply impactful outcomes as our nation aggressively builds toward a net-zero clean energy economy. At >90%, geothermal energy has the highest capacity factor among renewable energy sources, making it an invaluable component to electricity grid stabilization and load balance. GTO actively pursues novel thinking applied to innovative business (and technical) models that can increase the adoption of geothermal technologies by surmounting key exploration and operational challenges, namely those related to cost and risk reduction.

Bonus Challenge

DOE's GTO is challenging you to develop an innovative business model for a selected novel geothermal technology of your choice that tackles emerging challenges in the geothermal industry and aims to improve the performance, affordability, reliability, and value of geothermal energy and/or heat in the United States. The business model goal would be to increase the adoption of such new geothermal technology and maximize the performance and/or reduce the costs associated with the components, installation, and operation of geothermal energy and heat systems.

Evaluation Statement

The entry demonstrates a clear understanding of the technology and market potential for geothermal technologies and presents an innovative business model to significantly address key exploration and operational challenges while engaging a diverse and inclusive cohort.

Content

Introduction

Geothermal energy is heat derived from below the Earth's surface, which can be harnessed as a carbon-free, renewable energy around the clock with a small physical footprint. Geothermal is cosmic in origin—as opposed to atmospheric, such as wind or water—and is constant, non-intermittent, and abundant in supply for as long as the Earth exists. It's an always-on source of secure, reliable, and flexible domestic energy that can be utilized across industrial, commercial, and residential sectors. The use of geothermal energy can also offer important benefits to the nation, including grid stability, greater diversity in the portfolio of affordable energy options, and efficient heating and cooling.

As identified in the *GeoVision* analysis,[47] the high costs and risks associated with geothermal exploration are a major barrier to expanded development of the nation's undiscovered, or "hidden," hydrothermal resources. Similarly, successful development of enhanced geothermal system (EGS) resources—which require active engineering management throughout the life of the system—is dependent on resource characterization improvements, even once a project is in operation.

The *GeoVision* analysis illustrated that geothermal is America's untapped energy giant. Key findings about the potential for geothermal energy include:

- Improving technologies that reduce the costs and risks of geothermal development could increase geothermal power generation nearly 26-fold from today, representing 60 gigawatts-electric (GW_e) of electricity generation capacity by 2050.
- The market potential for geothermal heat pump (GHP) technologies in the residential sector is equivalent to supplying heating and cooling solutions to 28 million households—14 times greater than existing installed capacity.
- The economic potential for district heating systems is more than 17,500 installations nationwide, compared to the 21-total district heating systems installed in the United States as of 2017.
- Improving permitting timelines alone could increase installed geothermal electricity generation capacity to 13 GW_e by 2050—more than double the 6 GW_e projected in the business-as-usual scenario that serves as the baseline for the analysis.

Geothermal Technologies Overview

Geothermal Heating and Cooling

Geothermal heating and cooling utilizes the hot water that already exists in hot springs and geothermal reservoirs near the surface of the Earth, producing heat directly from hot water within the Earth to heat and cool buildings, homes, and communities. Lower-temperature resources can also support other geothermal direct use applications in agriculture, recreation, and industry (e.g., food dehydration, gold mining, and milk pasteurizing).

Geothermal heating and cooling and other direct use systems typically have three components:

- A production facility—usually a well—to bring hot water to the surface
- A mechanical system—piping, heat exchanger, and controls—to deliver the heat to the space or process
- A disposal system—injection well, storage pond, or river—to receive the cooled geothermal fluid (does not apply to systems with "closed loops" where the fluid circulates continuously in the piping).

Direct use geothermal systems, including geothermal heating and cooling, offer great opportunities to significantly expand the impact and reach of geothermal energy to a much wider swath of the country and could provide a large fraction of the energy demand currently supplied by high-grade fossil fuels. According to the *GeoVision* study, deployment of direct use could increase from 23 district heating systems today to as many as 17,500 systems by 2050. There is pronounced

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[47] www.energy.gov/geovision

economic potential for geothermal district-heating systems in the Northeast corridor of the United States, and the Appalachian region is promising for direct use geothermal potential as well.

Geothermal district heating and cooling (GDHC) systems with a variety of different architectures can be designed to provide heating, cooling, and/or water heating to multiple buildings from a shared piping system. GDHC systems using geothermal heat pumps (see next section) are increasing in numbers in the United States. Newer GDHC systems circulate ambient-temperature water (roughly 50°F–80°F) between buildings equipped with geothermal heat pumps. These systems can use a single pipe network to provide space heating, space cooling, and water heating to networks of buildings. Multiple studies and installations have shown that these types of systems can recycle heat between different buildings with different heating needs, thereby reducing capital cost, energy use, and resultant CO_2 emissions. For example, a building with high occupancy and/or many computers may almost always be in a cooling mode. The extracted heat from that building warms the water in the shared pipe, and then another building that has a hot water need or space heating need can recover that heat instead of burning natural gas. These systems are commonly combined with geothermal boreholes to absorb heat or reject heat to the ground as needed.

Geothermal Heat Pumps (GHPs)

Geothermal heat pumps are among the most efficient and comfortable heating and cooling technologies available because they use the Earth's natural heat to provide heating, cooling, and often, water heating. While many parts of the country experience seasonal temperature extremes—from scorching heat in the summer to sub-zero cold in the winter—a few feet below the Earth's surface, the ground remains a relatively constant temperature. The natural ground temperature is cooler than the natural air temperature in summer and warmer than the natural air temperature in winter.

The geothermal heat pump takes advantage of seasonal variation by transferring heat stored in the Earth or in groundwater into a building during the winter and transferring it out of the building and back into the ground during the summer. The ground, in other words, acts as a heat source in winter and a heat sink in summer. The benefit of ground source heat pumps is that they concentrate naturally existing heat, rather than produce heat through the combustion of fossil fuels.

Installing a geothermal heat pump system can be the most cost-effective and energy-efficient home heating and cooling option. Backyard geothermal heat pumps exist in homes in all U.S. states and territories. Geothermal heat pumps are a particularly good option if you are building a new home or planning a major renovation to an existing home by replacing, for example, an HVAC system.

Geothermal heat pumps come in four types of systems that loop the heat to or from the ground and your house. Three of these—horizontal, vertical, and pond/lake—are closed-loop systems. The fourth type of system is the open-loop option. Choosing the one that is best for your site depends on the climate, soil conditions, available land, and local installation costs at the site.

Closed-Loop Systems

- Horizontal: This type of installation is generally most cost-effective for residential installations, particularly for new construction where sufficient land is available. It requires trenches at least 4 feet deep.
- Vertical: This is often used for larger-scale geothermal systems (such as in commercial buildings) where land is limited, or where the soil is too shallow to bury the horizontal

loops in the trenches and some form of drilling into the bedrock is necessary. Vertical loop systems can be more expensive, but they use less land and minimize disturbance to the existing landscape.

- Pond/Lake: If the site has an adequate water body, this may be the least expensive option. A supply line pipe runs underground from the building to the water and coils into circles at least eight feet under the surface to prevent freezing. The coils should only be placed in a water source that meets minimum volume, depth, and quality criteria.

Open-Loop System

This type of system uses well or surface body water as the heat exchange fluid that circulates directly through the geothermal heat pump system. Once it has circulated through the system, the water returns to the ground through the well, a recharge well, or surface discharge. This option is practical only with an adequate supply of relatively clean water and when all local codes and regulations regarding groundwater discharge are met.

Residential Hot Water

In addition to space conditioning, geothermal heat pumps can be used to provide domestic hot water when the system is operating. Many residential systems are now equipped with desuperheaters that transfer excess heat from the geothermal heat pump's compressor to the house's hot water tank. A desuperheater provides no hot water during the spring and fall when the geothermal heat pump system is not operating; however, because the geothermal heat pump is so much more efficient than other means of water heating, manufacturers are beginning to offer "full demand" systems that use a separate heat exchanger to meet all of a household's hot water needs. These units cost-effectively provide hot water as quickly as any competing system.

According to the *GeoVision* study, 28 million geothermal heat pumps could be deployed nationwide by 2050. Geothermal heat pumps help decarbonize the grid by reducing peak and average loads while creating good-paying jobs in every local community and enabling more solar and wind deployment.

Geothermal Electricity Production

The United States generates the most geothermal electricity in the world: more than 3.5 GW, predominantly from the western United States.[48] That's enough to power about 3.5 million homes. A geothermal resource requires fluid, heat, and permeability to generate electricity:

- Fluid – Sufficient fluid must exist naturally or be pumped into the reservoir.
- Heat – The Earth's temperature naturally increases with depth and varies based on geographic location.
- Permeability – To access heat, the fluid must come in contact with the heated rock, either via natural fractures or through stimulating the rock.

Power plants use steam produced from geothermal reservoirs to generate electricity. There are three geothermal power plant technologies being used to convert hydrothermal fluids to electricity—dry

[48] 2021 U.S. Geothermal Power Production and District Heating Market Report (nrel.gov)

steam, flash steam, and binary cycle. The type of conversion used (selected in development) depends on the state of the fluid (steam or water) and its temperature.

- Dry Steam Power Plant – Dry steam plants use hydrothermal fluids that are primarily steam. The steam travels directly to a turbine, which drives a generator that produces electricity. The steam eliminates the need to burn fossil fuels to run the turbine and also eliminates the need to transport and store fuels. These plants emit only excess steam and very minor amounts of gases. Dry steam power plants systems were the first type of geothermal power generation plants built (they were first used at Lardarello in Italy in 1904).[49] Steam technology is still effective today and is currently in use at The Geysers in northern California, the world's largest single source of geothermal power.
- Flash Steam Power Plant – Flash steam plants are the most common type of geothermal power generation plants in operation today. Fluid at temperatures greater than 360°F (182°C) is pumped under high pressure into a tank at the surface held at a much lower pressure, causing some of the fluid to rapidly vaporize, or "flash." The vapor then drives a turbine, which drives a generator. If any liquid remains in the tank, it can be flashed again in a second tank to extract even more energy.
- Binary Cycle Power Plant – Binary cycle geothermal power generation plants differ from dry steam and flash steam systems in that the water or steam from the geothermal reservoir never comes in contact with the turbine/generator units. Low to moderately heated (below 400°F) geothermal fluid and a secondary (hence, "binary") fluid with a much lower boiling point than water pass through a heat exchanger. Heat from the geothermal fluid causes the secondary fluid to flash to vapor, which then drives the turbines and subsequently, the generators. Binary cycle power plants are closed-loop systems, and virtually nothing (except water vapor) is emitted to the atmosphere. Because resources below 300°F represent the most common geothermal resource, a significant proportion of geothermal electricity in the future could come from binary-cycle plants.

Additional Resources

DOE – Geothermal Technologies Office

Geothermal Energy 101

The Drill Down: GTO's monthly newsletter captures the latest in geothermal news, including open funding opportunities, competitions and prizes, publications, events, and more.

GeoVision report: An analysis initiated by DOE's GTO to assess geothermal deployment potential. The report states that geothermal electricity generation capacity in the United States has the potential to increase to more than 60 GW by 2050 (8.5% of all U.S. electricity generation).

2021 U.S. Geothermal Power Production and District Heating Market Report: This report provides current information and data on 2019 geothermal power production and trends in U.S. district heating markets and technologies.

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[49] Larderello - The oldest geothermal power plant in the world (power-technology.com)

U.S. Department of Energy Geothermal Data Repository (GDR): The GDR is the submission point for all data collected from researchers funded by DOE's GTO. The GDR is powered by OpenEI, an energy information portal sponsored by DOE and developed by the National Renewable Energy Laboratory in support of the Open Government Initiative to make energy data transparent, participatory, and collaborative.

National Geothermal Data System (NGDS): The NGDS catalog documents and datasets that provide information about geothermal resources located primarily within the United States. This complete and current catalog of available data, which is funded by the DOE's GTO, is designed to accelerate the development of U.S. geothermal resources.

Office of Scientific and Technical Information (OSTI): DOE's OSTI database contains over 70 years of energy-related research results and citations collected by OSTI, consisting of nearly 3 million citations.

Stanford/IGA Conference Database: This database contains papers and proceedings from a variety of geothermal-focused conferences, including the World Geothermal Congress, the Stanford Geothermal Workshop, and the New Zealand Geothermal Workshop, among others.

Regulatory and Permitting Information Desktop (RAPID) Toolkit: A toolkit to help users access permit documents, processes, best practices, manuals, and related information in the geothermal industry.

Geothermal Prospector: A tool that provides information about geothermal energy in the United States, known geothermal resource areas and exploration regions, including state geothermal maps, potential for enhanced geothermal systems (EGS), low-temperature geothermal resources, and identified hydrothermal sites.

Tribal Energy Atlas: A tool that explores techno-economic renewable energy potential on Tribal lands, including wind, solar, geothermal, hydro, woody biomass, and biomethane.

Geo-Heat Digital Library: The library provides a large range of documents about geothermal energy. This collection is a partnership between the Oregon Institute Technology Libraries and the Geo-Heat Center of the Oregon Renewable Energy Center.

Appendix I – Office of Electricity (OE) Bonus Focus: Grid Enhancing Technologies

Statement of Interest

Grid enhancing technologies (GETs) have been identified as a way to maximize transmission of electricity through the power system. These technologies can be used in the near term to defer larger infrastructure investments and reduce overall power grid congestion, which protects the consumers from higher electricity costs.

Bonus Challenge

DOE's Office of Electricity is challenging you to develop innovative models to increase the adaption of GETs to benefit the U.S. power grid.

Evaluation Statement

The presentation captures a clear understanding of GETs and the market potential for GETs to be implemented by various utility entities—i.e., regional transmission operators (RTOs), independent system operators (ISOs), wind plant developers, etc.—in a way that decreases congestion and reduces electricity costs.

Content

Introduction

A modern grid requires modern infrastructure, including new devices enabled by digital technology or simply new paths for electricity to flow. GETs can be used to reduced congestion across the existing electricity transmission system through a range of technologies that include sensors, power flow control devices, and analytical tools. GETs can be used to enhance transmission operations and improve planning, as well as provide benefits for N-1 contingency cases for utilities.[50]

Technology Overview

GETs fall into a number of different categories of technologies that can benefit the grid reliability.

Dynamic line ratings (DLRs) are a set of methods for determining conductor ratings using current or forecasted conditions. DLRs utilize the same calculations from the IEEE738 standard,[51] but use time-varying components instead of static ratings, which use conservative assumptions on weather as constant for a seasonal basis. DLR systems are typically either weather-based systems or are asset-based systems measuring the conductor state directly. A subset of DLR methods is ambient

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[50] U.S. Department of Energy. "Grid-Enhancing Technologies: A Case Study on Ratepayer Impact." February 2022.

[51] IEEE 738, Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors. 2012.

adjusted ratings (AARs), where the static assumptions for the wind and solar are still used, but the ambient temperature used in the IEEE738 calculations is allowed to change with local weather conditions. Idaho National Laboratory (INL) has led several WETO-funded projects over the years in weather-based DLR and has peer-reviewed publications that can be referenced in this regard.[52,53,54] In general, many transmission corridors can be positively impacted through DLR, but the degree to which available ampacity is available varies widely between regions, and weather pattern relations to static assumptions need to be studied on a case-by-case basis. An overview of other DLR-type approaches can be found in the INL-led DOE report.[55]

Power flow controllers (PFCs) can balance overloaded lines with underutilized transmission corridors within a transmission network. Some PFCs work by adjusting the impedance of the transmission lines, which can allow for utilities to push power to avoid congested lines or pull power onto underutilized transmission corridors.

Topology Optimization is a set of software solutions for automatically finding reconfigurations to re-route flow around congested or overloaded facilities. This takes advantage of the meshed nature of the overall power grid, and typically the reconfigurations adjust the high voltage circuit breakers to more evenly distribute electricity flow across the network.

While other technologies can help with the transmission lines, other limitations in the electricity transmission systems exist. Transformers can remain a limitation as they adjust voltages in the system. The IEEE/American National Standards Institute C57.91 provides a standard for guidance of transformer ratings.[56] Dynamic transformer ratings (DTRs) can be used to provide additional transformer capacity to prevent congestion if local weather conditions allow for limiting the thermal impact on the asset health.

Costs

In a 2018 DOE report, the sum of real-time congestion costs among the major system operators was calculated to be $4.8 billion.[57] In California between 2009 and 2017, the increase reflected on ratepayers' bills was $683 million in congestion-related costs.[58] Standard transmission expansion

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[52] Bhattarai, B. P., Gentle, J. P., McJunkin, T., Hill, P. J., Myers, K. S., Abboud, A. W., Renwich, R. & Hengst, D. (2018). Improvement of transmission line ampacity utilization by weather-based dynamic line rating. IEEE Transactions on Power Delivery, 33(4), 1853–1863.

[53] Abboud, A. W., Fenton, K. R., Lehmer, J. P., Fehringer, B. A., Gentle, J. P., McJunkin, T. R., Le Blanc, K.L., Petty, M.A. & Wandishin, M. S. (2019). Coupling computational fluid dynamics with the high resolution rapid refresh model for forecasting dynamic line ratings. Electric Power Systems Research, 170, 326–337.

[54] Abboud, A. W., Gentle, J. P., McJunkin, T. R., & Lehmer, J. P. (2019). Using computational fluid dynamics of wind simulations coupled with weather data to calculate dynamic line ratings. IEEE Transactions on Power Delivery, 35(2), 745–753.

[55] U.S. Department of Energy. "Dynamic Line Rating." Jun 2019.

[56] IEEE PES Transformers Committee, "PES Transformers Committee," IEEE, April 2021. [Online]. Available: https://www.transformerscommittee.org/.

[57] U.S. Department of Energy, "Annual U.S. Transmission Data Review," 2018.

[58] I. Penn, "Why Wall Street gets a cut of your power bill," Los Angeles Times, 15 December 2017. [Online]. Available: https://www.latimes.com/projects/la-fi-electricity-capacity-investments/.

projects can be quite costly and totaled over $20 billon every year between 2014 and 2016.[59] Due to the old age (1960–1980s) of most of the transmission infrastructure in the United States, one estimate shows the replacement costs will continue to increase by $1.2–$3.2 billion per year.[60] Line reconductoring can be a way to increase capacity on exiting transmission pathways but can cost from $1–$8 million per mile, depending on the voltage.[61]

The DOE Office of Electricity released [*Grid-Enhancing Technologies: A Case Study on Ratepayer Impact*], a report focusing on the impacts of integrating grid enhancing technologies (GETs) onto existing transmission lines. The GETs Case Study report, led by INL, performed a top-down approach to identify regions of the country that could benefit from GETs due to plans for increased renewable penetration combined with congested transmission line corridors. This case study narrowed in on a smaller region of western New York showing that DLR can reduce congestion costs by $1.7 million, and combined utilization of DLR and PFCs could reduce costs by $9.1 million at a lower cost to the ratepayer than traditional upgrades. The nationwide overview included in the GETs study may give responders to this call regions they could begin to focus their own case studies on. Several other studies have shown the potential cost impact of GETs. An analysis of a hypothetical DLR installation on historically observed weather conditions showed $11.1 million in savings over the target line.[62] A study shows that the deployment of DLR could provide congestion savings of $0.26 million in only a short four-hour window and that cost savings from utilizing topology control could range from $18 to $44 million annually.[63]

A study in locations in Minnesota, Wisconsin, and Colorado showed potential DLR increases of about 13% with an investment of $12.5 million.[64] A study by IRENA on lines in Texas showed increases of 6%–14% with an investment cost of $4.833 million.[65] A pilot case in the PJM region showed an 8.4:1 return on the investment cost of DLR with an installation cost of about $500 thousand.[66] A study by Brattle Group over a range of PFCs shows costs of $81–$137 million could be projected to save $67 million per year.

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[59] U.S. Energy Information Administration, "Utilities continue to increase spending on transmission infrastructure," 2018. [Online]. Available: https://www.eia.gov/todayinenergy/detail.php?id=34892.

[60] J. Pfeifenberger, J. Chang and J. Tsoukalis, "Investment Trends and Fundamentals in U.S. Transmission and Electricity Infrastructure," The Brattle Group, 2015.

[61] J. McCall and T. Goodwin, "Dynamic Line Rating as a Means to Enhance Transmission Grid Resilience," in CIGRE U.S. National Committee 2015 Grid of the Future Symposium, 2015.

[62] J. Marmillo, N. Pinney, B. Mehraban, S. Murphy, and N. Dumitriu. "Simulating the economic impact of a dynamic line rating project in a regional transmission operator (RTO) environment." In Proc. CIGRE US Nat. Committee Grid Future Symp., pp. 1–8. 2018.

[63] T. Tsuchida and R. Gramlich. The Brattle Group/Grid Strategies LLC. “Improving Transmission Operation with Advanced Technologies.” 2019.

[64] National Grid. “Enabling Renewable Energy with LineVision.” 2021. https://www.ngpartners.com/stories/connecting-the-grid-and-renewables-

[65] International Renewable Energy Agency. “Dynamic Line Rating Innovation Landscape Brief.” 2020.

[66] S. Murphy and N. Dumitriu. PJM. Introduction to Dynamic Line Rating. Emerging Technologies Forum, Aug 2020.

Market Opportunity

The market opportunity for GETs may vary by region due to energy market activity and participation, climate, technology, and the cost of electricity in a particular utility/market region. A DOE study on congestion shows the costs vary widely by region, with over $1 billion each in the NYISO region and PJM regions, $0.7 billion in the MISO region, $0.5 billion in the CAISO region, and only $0.1 billion in the ISO-NE region.[67] Areas with high transmission congestion that have active and saturated energy markets are one of the areas expected to benefit from GETs due to high energy prices associated with transmission congestion. The benefit of some GETs, such as DLR, will also vary widely based on local weather conditions.

The values associated with GETs are not typically prioritized by transmission planning for a wide variety of reasons. An area in which market participant compensation and encouragement has proved challenging is in providing auxiliary services. Mechanisms and motivations have developed over time to encourage market participants to engage in auxiliary services for the electricity markets, and the goal is to find and establish similar motivating mechanisms for GETs.

The flexibility and operational optimization across the year are not valued in a world where reliability planning is tantamount. FERC recently announced an Advance Notice of Proposed Rulemaking (ANOPR), Building for the Future Through Electric Regional Transmission Planning and Cost Allocation and Generator Interconnection, which would formalize this consideration.[68] The incentives to leverage GETs are often misaligned with those who benefit most. Transmission owners, generation developers, utilities, independent system operators/regional transmission organizations (RTOs), and clean energy advocacy groups have various primary objectives, but their primary focus is not solely on the efficient economic planning and operation of the power system. It would be beneficial to work with RTOs to provide actionable suggestions for deployment of GETs to benefit the ratepayers.

Additional Resources

- https://watt-transmission.org/wp-content/uploads/2021/02/Brattle__Unlocking-the-Queue-with-Grid-Enhancing-Technologies__Final-Report_Public-Version.pdf90.pdf
- https://www.energy.gov/sites/prod/files/2019/08/f66/Congressional_DLR_Report_June2019_final_508_0.pdf
- https://www.energy.gov/sites/default/files/2022-04/Grid%20Enhancing%20Technologies%20-%20A%20Case%20Study%20on%20Ratepayer%20Impact%20-%20February%202022%20CLEAN%20as%20of%20032322.pdf

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67 U.S. Department of Energy. "National Electric Transmission Congestion Study." September 2020.

68 Federal Energy Regulatory Commission, "Advance Notice of Proposed Rulemaking: Building for the Future Through Electric Regional Transmission Planning and Cost Allocation and Generator Interconnection," 15 July 2021. [Online]. Available: https://www.ferc.gov/news-events/news/advance-notice-proposed-rulemaking-building-future-through-electric-regional

- https://www.cmu.edu/ceic/assets/docs/seminar-files/2013-2014/heidelcmuseminarpresentation09262013.pdf
- https://www.energy.gov/sites/default/files/2020/10/f79/2020%20Congestion%20Study%20FINAL%2022Sept2020.pdf
- https://www.sciencedirect.com/science/article/pii/S0378779619300471
- https://ieeexplore.ieee.org/abstract/document/8747532
- https://ieeexplore.ieee.org/abstract/document/8269366

Appendix J – Office of Technology Transitions: National Lab IP Licensing Bonus Prize

Statement of Interest

The mission of the Office of Technology Transitions (OTT) is to expand the public impact of the department's research, development, demonstration, and deployment (RDD&D) portfolio to advance the economic, energy, and national security interests of the nation. OTT is the front door to U.S. Department of Energy (DOE) products, facilities, and expertise. The office integrates "market pull" into its planning to ensure the greatest return on investment from DOE's RDD&D activities to the taxpayer.[69]

Hosting one of the world's largest science research enterprises, DOE helps power and secure America's future through technological advancement and strategic support. DOE's RDD&D capabilities, and the innovations they enable, help maintain the United States' role as the global leader in science and technology. In particular, technology transfer supports the maturation and deployment of DOE-powered innovation, providing ongoing economic, security, and environmental benefits for all Americans.[70]

In 2015, the Secretary of Energy authorized the formation of OTT to be responsible for developing and overseeing delivery of DOE's strategic vision and goals for technology commercialization and engagement with the business and industrial sectors across the United States. OTT's statutory authority is derived from the Bayh-Dole Act of 1980, Stevenson-Wydler Technology Innovation Act of 1980, Energy Policy Act of 2005, and Energy Act of 2020. OTT's mission is to expand the commercial impact and public benefit of DOE's RDD&D portfolio to advance the economic, energy, and national security interests of the nation.[71]

Bonus Challenge

DOE's OTT is challenging you to develop innovative business models to help accelerate technology commercialization for technologies available on the Lab Partnering Service.

Evaluation Statement

The entry demonstrates a clear understanding of a technology listed on the OTT's Lab Partnering Service and presents an innovative business model to help accelerate technology commercialization.

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[69] https://www.energy.gov/technologytransitions/mission-0

[70] https://www.energy.gov/technologytransitions/mission-0

[71] https://www.energy.gov/technologytransitions/mission-0

Content

Introduction

OTT serves as the central hub for the technology transfer activities across DOE's extensive R&D enterprise. At OTT, we work to ensure groundbreaking scientific discoveries achieve their maximum public return and impact, advancing the economic, energy, and national security interests of the United States. Getting that done means streamlining access to our user facilities at our 17 national labs and sites, our world-class scientific researchers, and our sprawling portfolio of intellectual property—fostering strong internal and external partnerships that guide innovations from the lab toward the marketplace.[72]

Technology transfer is a complex and dynamic process, and OTT is here to help you connect with DOE-powered innovation to advance discoveries and commercialize transformative, impactful technologies.[73] One of the best ways to expand the commercial impact of the department is raising awareness to investors and industry about the capabilities and expertise housed among the agency's 17 national laboratories and facilities.[74]

Lab Partnering Service Tool

The DOE OTT's Lab Partnering Service (LPS) offers unprecedented access to the world's most advanced scientific facilities and researchers across the department's national lab complex. LPS provides investors—and other parties looking to advance energy innovation—a single online platform to connect with leading DOE national laboratory technical experts to quickly answer innovation questions, as well as discover opportunities for building partnerships. Visitors can easily search hundreds of technologies, patents, experts, facilities, and success stories tailored to their individual needs. Applicants can search for technologies in LPS with the "EnergyTech University Prize" tag to find technologies identified for this competition.[75]

Resources

Lab Partnering Service:

https://labpartnering.org/ (and search for "EnergyTech University Prize" in the "Discover…" search bar)

Office of Technology Transitions:

https://www.energy.gov/technologytransitions/office-technology-transitions

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72 https://www.energy.gov/technologytransitions/office-technology-transitions

73 https://www.energy.gov/technologytransitions/office-technology-transitions

74 https://www.energy.gov/technologytransitions/office-technology-transitions

75 https://www.energy.gov/technologytransitions/lab-partnering-service

Success Stories

- 2022 first-place team leveraged a technology from Ames National Laboratory: Mechanochemical Recovery of Co, Li, and Other Essential Components From Spent Lithium-Ion Batteries.
- Lab Partnering Service Success Stories: https://labpartnering.org/search?typ%5B%5D=success_stories

Appendix K– Arctic Energy Office: Eyes on Alaska Bonus Prize

Statement of Interest

Alaska and the Arctic have unique energy interests, as the Arctic is warming at four times the rate of the rest of the globe. This prize will encourage students from Alaska to submit innovative business ideas that will help address energy challenges in the Arctic. For instance, one current energy challenge is the imminent declining natural gas reserves in Cook Inlet. This area is Alaska's Railbelt electrical grid—which serves about 75% of the state's population. Natural gas powers about 70% of Railbelt electricity generation, and it is also used to heat a large fraction of the state's population and businesses. The shortfall is expected to begin around 2027, though some related impacts have already started to appear.

Other challenges abound in other parts of the state as well, related to energy access, affordability, sustainability, and security. Alaska is home to more than 200 rural communities powered by microgrids. Many of these communities utilize wood for heat, but many others do not have forests nearby that are large enough for this resource to be a reliable long-term option. They often use fossil fuels for heat. Most of these communities are single community microgrids that range in size from a few MW to less than 100 kW, but some microgrids are interconnected microgrid networks of similar size. These microgrids are typically either owned and operated by a local entity - such as the city, tribe, or a small coop - or by either the Alaska Village Electric Coop or Alaska Power and Telephone.

Bonus Challenge

The Arctic Energy Office challenges you to demonstrate and propose an innovative business model for an emerging energy technology that helps meet the energy, science, and security needs of the U.S. and its Arctic allies. Your work must be in line with goals of the DOE Arctic Strategy and focus on one or more of these three goals: 1) decreasing energy costs in Alaska; 2) meeting critical energy demands in a reliable way for Alaska residents 3) and/or developing pathways for workforce capacity growth to meet Alaska's infrastructure and community energy needs.

Evaluation Statement

The eligible team must be comprised of a majority of Alaska-based students or students that attend an accredited school in Alaska. The team should present an entry that demonstrates a clear understanding of the technology and its market potential for the Arctic region and should present an innovative

business model to significantly increase the Arctic's clean energy transition, reduce reliance on imported fuel in rural communities, and/or lower emissions and energy burdens for Alaskans/Arctic people.

Content

Introduction

Alaska is experiencing rapid changes due to the climate crisis. The Department of Energy's Arctic Energy Office was created by the U.S. Congress to take on these challenges, reduce energy costs in Alaska, and boost international cooperation on energy issues.

The Climate Resilience Center at the University of Alaska Fairbanks, funded through the Department of Energy's Office of Science, works on three approaches that students may want to bring into their business model: 1) enhance communication with Alaska communities about existing DOE science, 2) develop meaningful collaborations between communities and the DOE, and 3) incorporate DOE science into educational pathways and opportunities. Through the Department of Energy's work, especially through our Climate Resilience Center, we are working to create more conduits to recruit the next generation of climate investigators, with an emphasis on rural and traditionally underserved communities. Your team should be thinking about how to bring in these or similar perspectives or address their associated needs through your business.

Technology Overview

Your technology should account for the unique needs of the Arctic environment, the Arctic geography, and the Arctic's energy needs. Currently, approximately 47% of the state's electricity generation is derived from natural gas, 25% is from hydropower, 25% is from petroleum and coal, and the remainder (<3%) is from other renewable sources. Heating needs are more challenging to quantify but are also a significant part of Alaskans' energy consumption.
Carbon Emissions Reduction in Alaska: In order to meet the goal of decarbonizing electricity by 2035, Alaska would need to decarbonize 72% of its electricity generation by either sequestering the carbon or by replacing it with renewable sources. The largest opportunities for carbon reduction might be found in changes to the state's energy production economy. This could happen by making the existing system more efficient, by adding renewable technologies to the energy generation mix (e.g., powering oil and gas operations or the pipeline with renewables), by capturing and storing or using the carbon emissions from the system, or by producing sustainable aviation fuels (SAFs).

Renewable Energy Potential: Alaska has vast renewable energy resources that could be developed, including offshore wind [>12,000 TWh/yr, or 41,000 TBtu/yr] (Doubrawa Moreira et al., 2018), land-based wind [5,400 TWh/yr, or 19,000 TBtu/yr] (EIA, 2023b; Lopez et al., 2021), geothermal (technical potential unknown), solar [11,000 TWh/yr, or 37,000 TBtu/yr] (Schwabe, 2016), tidal [210 TWh/yr, or 700 TBtu/yr], hydropower [>21 TWh/yr, or 72 TBtu/yr], and wave energy [540 TWh/yr, or 1,800 TBtu/yr] (Kilcher et al., 2021).

Critical Minerals: Alaska holds vast deposits of critical minerals like zinc, graphite, tin, and rare earth elements. Despite this potential, the United States heavily relies on foreign countries for initial processing, underscoring the need for investment in domestic or allied processing capabilities.

Carbon Capture and Sequestration: Technical reports by DOE have estimated that the total storage for saline basins and coal seam with potential for sequestration could be approximately 5,700,000 MMT and approximately 50,000 MMT, respectively. Economically and physically, the most suitable storage for both hydrogen and CO_2 is in geologic formations.

Clean Hydrogen Derivatives Production: Alaska does not currently have any operational ammonia or methanol plants, but there is a formerly operational ammonia plant in Nikiski. There have been discussions about bringing the plant back online as well as work toward building a methanol plant in northern Alaska. Although it is not yet clear which of these fuels will reach widespread adoption globally, it would still be worthwhile to investigate the infrastructure requirements for producing these products in Alaska.

Hydrogen from Fossil Fuel Production: Whereas oil shale producers in the contiguous United States are in the early stages of fugitive emissions control, Alaska's industry has employed best practices for capturing fugitive emissions since operations began in 1977. Hydrogen production via steam methane reforming is currently the most typical pathway for hydrogen production worldwide. In Alaska, hydrogen development from natural gas, biomass, or other renewable resources could unlock currently stranded assets across the energy landscape. For instance, the North Slope's natural gas has remained one of the world's largest stranded energy assets.

Costs

Solar and Wind: By 2030, the total combined levelized cost of energy in Alaska, dominated by wind, has the potential to reach approximately \$57–\$63/MWh for land-based wind and approximately \$83–\$136/MWh for offshore wind, depending on the exact location and the type of turbine structural form (Meadows et al., 2023).

Hydrogen: The Department of Energy's Hydrogen Shot calls for a goal of reducing the cost of clean hydrogen to \$1 per 1 kg within 1 decade through technological innovation, deployment at scale, and fostering partnerships. This means that electrolysis costs will need to be reduced by more than 80% and those of SMR with carbon capture by 30%. This will require dramatically reducing capital and energy costs as well as improving the efficiency, durability, and reliability of hydrogen production technologies. That would mean reducing electrolyzer uninstalled capital costs from approximately \$1300/kW to \$150/kW and reducing energy costs from approximately \$50/MWh to \$20/MWh (Satyapal, 2023).

The Clean Hydrogen Production Tax Credit (federal, 45V) — created in the Inflation Reduction Act — introduced a tiered emissions-based tax credit that awards a maximum of \$0.6 – \$3/kg H2 depending on the hydrogen production pathway. The incentive can be claimed in the first 10 years of projects as long as they begin construction by 2033. The PTC can be stacked with the renewable energy PTC and zero-emission nuclear credit, but it cannot be stacked with the Carbon Capture, Utilization, and Storage Tax Credit (45Q). The PTC tiers are provided in Table 2. The maximum credit is awarded by following prevailing wage standards and apprenticeship requirements (DOE, 2023).

Carbon Capture and Storage: The Carbon Capture, Utilization, and Storage Tax Credit (45Q) federal tax credit pays up to \$85 per every ton of CO_2 captured and stored permanently or used, i.e., it is subsequently used as feedstock to produce low-carbon fuels, chemicals, and building materials. The credit lasts for up to 12 years, and it is available for projects that begin construction before 2033. The 45Q tax credits cannot be used in combination with other credits and incentives (Cooper et al., 2022; IEA, 2023b).

Market Opportunity

Understanding Alaska's current energy production and use provides context for the scale of possible energy business and technology opportunities in the state. Alaska is an energy-producing state, and energy production is a major pillar of the state's economy, alongside fishing, mining, and tourism. The state produces more than 1,300 trillion Btu (TBtu) of energy annually. The majority of the state's produced energy (68% in 2021) is in the form of crude oil on the North Slope that is transported south via the Trans-Alaska Pipeline System. Natural gas production comprises another 29%, with the remaining 2% from coal, biomass, and renewables (EIA, 2023).

Alaska consumed more than 675 TBtu of energy in 2021 (EIA, 2023a). More than half of the state's energy consumption occurred in the industrial sector, of which 305 TBtu occurred in oil field operations (i.e., on the North Slope and in the Cook Inlet region). Statewide electricity generation consumed 49 TBtu (7% of the state's total energy consumption) of energy to deliver 6,600 GWh (22 TBtu) of electricity.

Most communities powered by microgrids are eligible for Alaska's Power Cost Equalization (PCE) program, which provides financial assistance where electricity costs are three to five times higher than in urban areas. The program covers residential use up to 750 kWh per month and community facility consumption up to 70 kWh per resident, excluding schools, businesses, and industry. As a result, the program only supports about one-third of total electricity sold. The Regulatory Commission of Alaska sets the reimbursement rates, while the Alaska Energy Authority administers the program. Without PCE, the median power cost in these communities is $0.67/kWh, with some paying over $1.50/kWh. PCE effectively reduces the price to levels comparable to the Railbelt, highlighting the importance of keeping Railbelt rates affordable as a baseline for statewide assistance.

Across rural Alaska, communities frequently express a desire for low-cost, reliable power, and they also want grid infrastructure that they can operate and maintain themselves – rather than being dependent on external expertise or hard-to-find components. On the other hand, many rural Alaskan communities are experiencing challenges from climate change firsthand and, having deep cultural roots of self-reliance and land stewardship, are eager to be part of the solution. These perspectives have driven many rural Alaskan communities to be early innovation partners in emerging energy technologies.

Additional Resources

- Arctic Energy Office: www.energy.gov/arctic
- DOE Arctic Strategy and the National Strategy for the Arctic Region: https://www.energy.gov/arctic/arctic-related-publications
- Alaska Hydrogen Opportunities Report: https://www.energy.gov/sites/default/files/2024-04/Alaska_hydrogen_report_ACEP_publication.pdf
- Critical Minerals in the Arctic Policy Briefs: https://www.wilsoncenter.org/critical-minerals-arctic

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Appendix L– Office of Electricity: Grid-Scale Power Electronics Bonus Prize

Statement of Interest

Power electronics (PE) refers to the broad set of technologies (e.g., materials, components, subsystems, and systems) necessary for the control and conversion of electricity. A power electronic system (PES) is a self-contained, fully functional collection of hardware and software that safely and efficiently converts current-type (e.g., AC to DC, DC to AC), voltage (e.g., DC to DC), frequency (e.g., AC to AC), or any combination thereof, and conditions electric power according to application-specific requirements.

Bonus Challenge

DOE's Office of Electricity is challenging you to develop innovative business models to stimulate the adoption of advanced power electronics in the U.S power grid.

Evaluation Statement

The presentation emphasizes a clear understanding of the technology and market potential for advanced power electronics and presents an innovative business model to significantly increase their adoption.

Content

Introduction

Applications of PES are diverse and numerous; low-power systems are integral elements of computers, cell phones, and nearly all other consumer electronics. As PE technology matures and power handling capabilities continually improve, PESs are becoming disruptive influences in new industries and applications. PESs are at the core of research and commercialization efforts in transportation electrification, integration of distributed energy resources, and electric grid modernization.

PESs are already widespread in electric power systems for a variety of applications. At present, 30% of electric power passes through some form of PES; by 2030, this figure is expected to rise to 80%.[1]

Technology Overview

While there are numerous technologies that can be called a PES (e.g., inverters, converters, motor drives); their designs are typically unique and oriented towards a particular application. Key considerations for system designers include power density, efficiency, weight, cost, and reliability—attributes that impact the overall performance and market viability of a given technology. This particular power electronics bonus challenge is geared towards grid applications (e.g., HVDC, FACTS, etc.)

High voltage DC transmission (HVDC) systems deliver power over long distances more efficiently than their AC counterparts. The converter stations on both ends of the line require high efficiency and reliability due to the large amount of power delivered and the criticality of grid operations. Cost is also an important attribute due to the sheer scale of these systems and electricity being priced as a commodity, whereas weight and power density are of minimal importance since they are often located in remote sites where real estate is cheap.

Flexible AC transmission system (FACTS) devices improve the quality and performance of the grid by allowing a utility to maximize the amount of power that can be delivered through existing transmission infrastructure. Similar to HVDC and other grid hardware technologies, reliability, efficiency, and cost are important attributes. Weight and power density are of lesser concern but still important since these technologies can also be used at industrial facilities.

Photovoltaic (PV) inverters require high efficiency to extract maximum power from PV panels. Cost and reliability are also important characteristics to enable large scale PV deployment. Since PV systems are fixed, stationary installations, the importance of weight and power density is comparatively low.

Converters for Battery Energy Storage Systems (BESS) demand high efficiency to ensure economic viability due to frequent charge and discharge cycles during normal operation. Cost and reliability are also important attributes, especially for grid-scale applications. Similar to solar PV, weight and power density are not as critical to their adoption.

Market Opportunity

The market opportunity for PESs may vary by region due to energy market activity and participation, climate, technology, and the cost of electricity in a particular utility/market region. The values associated with grid-scale PES may not be prioritized by distribution and transmission planning for a wide variety of reasons.

Additional Resources

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