EnergyTech University Prize
2023 Official Rules Document

FEBRUARY 2023

EnergyTech UP

U.S. DEPARTMENT OF ENERGY | OFFICE OF Technology Transitions

AMERICAN MADE
U.S. DEPARTMENT OF ENERGY

Contents

Welcome to the EnergyTech University Prize

Welcome to the U.S. Department of Energy Office of Technology Transitions EnergyTech University Prize (EnergyTech UP)! In EnergyTech UP, student teams will compete for $370,000 in cash prizes for successfully identifying a promising energy technology, assessing its market potential, and creating a business plan for commercialization.

EnergyTech UP aims to cultivate the next generation of energy innovators while accelerating the transfer of energy technologies to market. This prize seeks to attract the talented students of today and help them develop 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.

This prize is sponsored by the Office of Technology Transitions (OTT) at the U.S. Department of Energy (DOE), as well as several other program offices. 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 business proposal. Students interested in participating in this prize will be provided with a curated list of National Lab technologies that are ready for commercialization and that can be used for 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 notifying prize competitors of the revised document.

This prize program consists of three phases—the Explore Phase, the Refine Phase, and the Pitch Phase—as summarized in Figure 1.

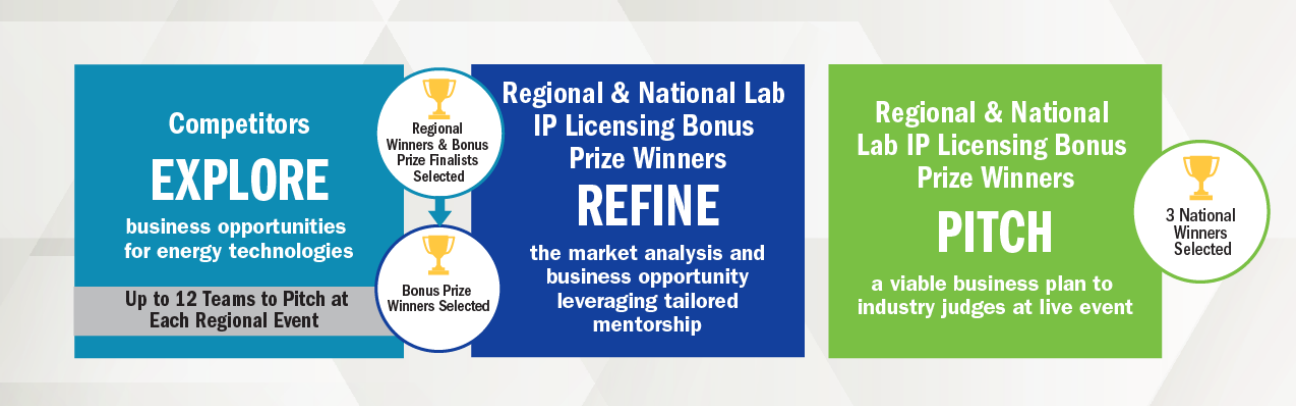

Figure 1: Phases of EnergyTech UP

Explore Phase

In the Explore Phase, competitor teams will present their ideas at one of the regional events.

Competitors: Teams apply to become regional competitors by completing the registration entry form on the HeroX platform. Applicants will submit a 200-word statement describing their proposed technology and associated business plan. 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.

Competitor teams will then be invited to participate in a regional event. A maximum of 12 competitor teams will present at each of approximately 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 ten minutes to explain their idea to a panel of judges (seven minutes for their initial pitch and three minutes for a Q&A period).

Regional Winners: At the conclusion of the Explore Phase, the Regional Winner from each of the regional events will be awarded $3,000 and invited to the Refine and Pitch Phases. A maximum of $45,000 total will be awarded to Regional Winners. The Regional Winners will move on to the national competition to compete for the National Prizes.

Technology Bonus Prize Finalists and Winners: Each regional convener may also identify up to one (1) Technology Bonus Prize Finalist from the presenting teams for each Technology Bonus Prize offered.

After the conclusion of the Explore Events, a single Technology Bonus Prize Winner per Technology Bonus Prize will be selected from the pool of all Technology Bonus Prize Finalists across all Explore Events. Selection will be based on materials submitted at the regional Explore Events. The Technology Bonus Prize Winner from each of the Technology Bonus Prizes will be awarded $25,000. These winners do not compete for the National prizes unless they are also Regional Winners.

National Lab IP Licensing Bonus Prize Finalists and Winners: Each regional convener may also identify up to one (1) National Lab IP Licensing Bonus Prize Finalist.

After the conclusion of the Explore Events, a single National Lab IP Licensing Bonus Prize Winner will be selected from the pool of all National Lab IP Licensing Bonus Prize Finalists across all Explore Events. Selection will be based on materials submitted at the regional Explore Events. The National Lab IP Licensing Bonus Prize Winner will be awarded $25,000 and will move on to the national competition to compete for the National Prizes.

Refine Phase

In the Refine Phase, Regional Winners and the National Lab IP Licensing Bonus Prize Winner will be provided with exclusive mentorship and continued free access to OTT's Energy I-Corps curriculum to help them refine their ideas throughout the month of March.

Regional Winners and the National Lab IP Licensing Bonus Prize Winner will be paired with a mentor or mentors from industry, a National Lab, or the Department of Energy. Mentors will give competitors insights into technology development and feedback on their business plan in preparation for their presentation during the national Pitch Event. Competitors are also encouraged to explore the Other Relevant Programs and Opportunities (described below) during this phase.

Pitch Phase

The Regional Winners and the National Lab IP Licensing Bonus Prize Winner will pitch their refined business plans at Zpryme's Energy Thought Summit in Austin, Texas, in April 2023. Teams are expected to present in person at the event on April 3, 2023.

National Winners: The National First-Place Winner will be awarded $50,000, the National Second-Place Winner will be awarded $30,000, and the National Third-Place Winner will be awarded $20,000. A total of $100,000 in National Prizes will be awarded.

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

About the Office of Technology Transitions

This prize is sponsored by DOE's Office of Technology Transitions (OTT). DOE's primary mission is to ensure America'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 (MRI) 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. But it's almost never easy—so in 2015, the Secretary of Energy authorized the formation of OTT, and in 2020, Congress formalized its establishment.

OTT serves as the steward of DOE's Research, Development, Demonstration, and Deployment (RDD&D) continuum and is sponsoring this prize to aid technologies in their progression to commercialization. More information about OTT can be found at https://www.energy.gov/technologytransitions/office-technology-transitions.

Summary of Important Dates

For the exact dates and latest information, visit www.herox.com/energytechup/timeline.

- September 29, 2022: Program Announcement Date
- October 26, 2022: Informational Webinar
- December 6, 2022: Informational Webinar
- January 17, 2023, at 3 p.m. ET: Recruiting Webinar and Team-Building Networking Event
- January 26, 2023: Final Registration Deadline
- February 9, 2023: List of Competing Teams Announced
- February 13, 2023–February 28, 2023: Explore Events Occur
    - Exact dates and times to be determined; these will be different for each region
- March 7, 2023: Regional Winners and Technology Bonus Prize Winners Announced
- March 23, 2023: Business Plans Due from Regional Winners and National Lab IP Licensing Bonus Prize Winner
- March 30, 2023: Final Presentation Files Due from All Winners
- April 3, 2023: Final National Competition Event at Zpryme Energy Thought Summit

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 community colleges, colleges, universities, and graduate schools.
    - Postsecondary students of any level are eligible to compete.
    - Students will self-certify their eligibility as part of registration for the competition.
    - 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.
- The team captain must be a U.S. citizen or permanent resident.
- The final submission must come from the team captain's HeroX account.
- The team may have non-student team members or advisors who provide input and guidance and support the development of the idea, but only students may present to judges, and student team members must be a majority of the team makeup.
- Expert reviewer panel members, 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.
- To be eligible to compete for the National Prizes, the team must be selected as a Regional Winner and/or as a National Lab IP Licensing Bonus Prize Winner.
- 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[1] 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

[1] 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[2] are not eligible to compete.

Technology Areas of Interest

Submissions must focus on technologies that produce energy, store energy, improve the efficiency of consumption or 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 American 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.

Teams may focus their submissions on technologies developed at a National Laboratory or on technologies developed by other entities. Teams are not required to have secured a license or rights to a technology in order 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 $25,000 each in Technology Bonus Prizes for the best teams in their respective fields. Teams searching for a technology around which to build a business plan are encouraged to engage with the Lab Partnering Service described below.

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, including people of color and others who have been historically underserved, marginalized, and adversely affected by persistent poverty and 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.

[2] Currently, the list of countries of risk includes Russia, Iran, North Korea, and China.

> By advancing equity across the Federal Government, we can create opportunities for the improvement of communities that have been historically underserved, which benefits everyone.[3]

As part of this whole-of-government approach, this competition seeks submissions that will benefit members of disadvantaged communities and underrepresented groups. Teams are highly encouraged to include individuals from groups historically underrepresented in science, technology, engineering, and mathematics (STEM) on their project teams. Teams are also highly encouraged to develop business plans that would benefit disadvantaged communities and/or underrepresented groups.

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

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 or to consider follow-on opportunities.

Lab Partnering Service

OTT's Lab Partnering Service (LPS) is a free online service that gives investors, innovators, and institutions direct access to the vast array of expertise, research, and capabilities present across all 17 National Labs and three sites. LPS serves as a generation tool for partnering with DOE Labs. LPS allows users to submit inquiries to the Technology Transfer Office at each Lab based on the Lab profile, technology summaries, experts, and facilities. Any technology indicated on the LPS is eligible for consideration as part of the program.

In support of EnergyTech UP, a custom "popular topic" tab has been created that highlights technology summaries, experts, facilities, and success stories 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 Patent Search (VPS). This tool enables a unique, visually facilitated search of the patent content in the LPS. This patent content consists of published U.S. patent applications and issued U.S. patents resulting from DOE-funded research and development (R&D), as well as a portion of patents from NASA and the Department of Homeland Security. The patents are pulled from the United States Patent and Trademark Office patent database and show patents and patent applications from the last 20 years.

LPS can be found at www.labpartnering.org, and VPS can be found at https://vps.labworks.org/. The LPS page developed to support the EnergyTech UP prize can be found at https://energytechup.labpartnering.org/.

[3] 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/

Energy I-Corps

Energy I-Corps, a key initiative of OTT, pairs teams of researchers with industry mentors for an intensive two-month training in which the researchers define technology value propositions, conduct customer discovery interviews, and develop viable market pathways for their technologies. Researchers return to their home institutions with 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 is ensuring our investment in the National Labs is maintaining and strengthening U.S. competitiveness over the long term.

All Competing Teams will receive access to the Energy I-Corps curriculum and associated materials for all team members. These materials are typically available only to National Lab researchers.

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 100 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.

Competitors are encouraged to visit the American-Made Network and explore resources that are available to support their efforts in this prize and beyond.

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. 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 a nearly $30 million 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 transitions system with a forward-looking and competitive approach to Lab-industry partnerships.

Energy Program for Innovation Clusters

The DOE Energy Program for Innovation Clusters (EPIC) is a two-part program sponsored by OTT to encourage the robust growth of regional energy innovation ecosystems across the United States. EnergyTech UP competitors should consider reaching out to winners of the EPIC program for possible synergies.

With EPIC, OTT funds local innovation clusters, which increase the productivity of area companies, drive the direction and pace of innovation, and stimulate the formation of new businesses. OTT also published a funding opportunity announcement (FOA) that sought to recognize innovation-accelerating organizations focused on stimulating energy hardware development and related supportive ecosystems. In June 2021, DOE awarded $9.5 million to 10 incubators and accelerators across the country as part of the EPIC FOA. Learn more about the winning projects here.

The second round of the EPIC prize opened on August 2, 2022 and closes October 25, 2022.

Summer Entrepreneurship Program

The annual OTT Summer Entrepreneurship Program is an exciting internship opportunity for undergraduate students looking to experience DOE's world-class National Lab system, boost entrepreneurial thinking, and explore market opportunities. Competitors of EnergyTech UP should consider applying to this internship program.

The Summer Entrepreneurship Program includes the following:

- The program is a 10-week internship that pairs students with technologies and mentors from the DOE National Labs to develop strategies for commercialization.
- Students undergo intensive training to understand and advance cutting-edge technologies in fields spanning machine learning and artificial intelligence, computing, data science, biofuels, energy, materials, and more.
- Parallel to this technical training, students also undergo intensive training in commercialization through the Energy I-Corps curriculum.
- At the end of the program, students present their individual work in the form of business plan presentations, which are judged by a panel of experts in technology commercialization.
- The program benefits participants by enhancing their education and training in entrepreneurship and energy-technology-related fields and increasing their future marketability in these disciplines.

Prizes To Win

Explore Phase

Regional Winners: At the conclusion of the Explore Phase, each of the Regional Winner teams will be awarded $3,000. A maximum of $45,000 will be awarded. All regional winners will be invited to present to judges as part of the national Pitch Event and will be eligible to win the National Prizes.

Technology Bonus Prize(s): At the conclusion of the Explore Phase, all finalists for each Technology Bonus Prize will be evaluated based on the materials submitted at the regional Explore Event. Eight (8) Technology Bonus Prizes of $25,000 each may be awarded. The focus areas of each Technology Bonus Prize are provided in Table 7.

National Lab Technology IP Licensing Bonus Prize: At the conclusion of the Explore Phase, all finalists for each National Lab IP Licensing Bonus Prize will be evaluated based on the materials submitted at the regional Explore Event. One National Technology Bonus Prize of $25,000 may be awarded. The focus area of the National Lab IP Licensing Bonus Prize is provided in Table 7. The winner will be invited to present to judges as part of the national Pitch Event and will be eligible to win the National Prizes.

Pitch Phase

At the conclusion of the Pitch Phase, DOE will award three National Prizes.

National Prizes: The National First-Place Winner will be awarded $50,000, the National Second-Place Winner will be awarded $30,000, and the National Third-Place Winner will be awarded $20,000. A total of $100,000 in National Prizes will be awarded.

A single team may win both a National Prize and one or more Technology Bonus Prizes, a single prize in either category, or no prize at all.

How To Enter

EnergyTech UP will utilize the HeroX website as its competition platform. This platform empowers people to create, compete in, and share contests that address and solve global problems.

Go to https://www.herox.com/EnergyTechUP and follow the instructions for registering and submitting all required materials before the deadlines identified in the Summary of Important Dates section. Deadlines are also displayed on the HeroX website.

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 necessary form items, and then choose "Save & Preview." This step is when the team identifies their collegiate institution (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. Select the appropriate region for your team. If there is a regional convener in the same state as the team captain's collegiate institution, the team must select that regional convener. If there is not, select the closest regional convener geographically.
6. Registration entries received by the deadline are deemed applicant teams.
7. Multiple teams from a single school may compete.
8. Teams may have students from multiple schools.
9. 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.
10. Following registration, the Prize Administrators will review all registrations and may reallocate teams across regional conveners to ensure an appropriate and fair competition.
11. Up to 180 teams (12 teams at each of 15 Explore Events) will be invited to compete in the Explore Phase.
12. Email questions to the organizers at ott.energytechup@nrel.gov.

Regional Convener Explore Events

Select EnergyTech UP applicant teams will be invited to attend and compete at one of the regional convener Explore Events that will be held across the United States. These 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 present live at the regional convener Explore Event. If a team has a faculty or industry advisor, the advisor is also encouraged to attend the Explore Event. All Explore Events will be held virtually. Each regional convener will have the ability to host 12 teams. Faculty, non-student team members, and industry advisors may not participate in the team presentation.

The following regions and locations are confirmed:

Table 1: Regional Explore Events

Region	Convener
Coastal Northwest	University of Washington Buerk Center for Entrepreneurship
East Texas	Rice Alliance for Technology and Entrepreneurship
Florida & Alabama	Florida High Tech Corridor
Great Lakes	Evergreen Climate Innovations
Mid-Atlantic	Wilton E. Scott Institute for Energy Innovation at Carnegie Mellon University
Mountain West	WY Ranch
National Capital Region	NREL
Northeast	Cleantech Open Northeast
Northern Plains	Grid Catalyst
New York City Metro	Syracuse Center of Excellence at Syracuse University
South Atlantic	Research Triangle Cleantech Cluster
South Central & U.S. Islands	Elemental Excelerator
Southeast	University of Kentucky
Southern California	CleanTech San Diego
Southwest	University of Arizona Center for Innovation

Teams must register in the region where the team captain's collegiate institution is located. Following the close of registration, the organizers may reassign teams to a relevant alternate region if necessary to balance participation opportunities.

National Pitch Event

Regional Winners and the National Lab IP Licensing Bonus Prize Winner will present their business plans to industry judges on April 3, 2023. Technology Bonus Prize Winners are invited to share their business plans with event attendees on the same date as part of Zpryme's 2023 Energy Thought Summit in Austin, Texas.

Attendees 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 Regional Winner or Technology Bonus Prize Winner team to attend the Energy Thought Summit, though attendees are required to coordinate and pay for their own travel and lodging expenses.

What To Submit

Registration

- A 200-word written summary addressing the energy technology to be leveraged in the business opportunity.
- Optionally, a slide deck that summarizes your business plan, including the suggested content identified in Table 3.
- 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 in the business opportunity.
- A slide deck that summarizes your business plan, including the suggested content identified in Table 5 and optionally in Table 7.

Pitch Phase

- A written business plan that addresses the suggested content identified in Table 9.
- A video (up to 90 seconds) explaining the technology to be leveraged and the business opportunity.
- A slide deck that summarizes your business plan, including the suggested content identified in Table 9.

How Explore Phase Teams Are Determined

Eligibility Review

The Prize Administrator screens all completed registrations for eligibility and regional balance and shares all eligible applications with the appropriate regional conveners. Each regional convener will review submissions for their region according to the evaluation criteria described in this document and will make the final selection of competing teams for their respective regions.

How We Score Team Registrations

Each regional convener will individually evaluate all eligible registration submissions and written statements given in Table 3 for their region using the Scoring Scale shown in Table 2.

Table 2: Scoring Scale

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

Registration Submission Evaluation Statements

As part of their registration, teams provide information about their team makeup and submit an initial 200-word summary that addresses the energy technology to be leveraged and the business opportunity. Teams may optionally submit a slide deck that summarizes their business plan, including some or all of the suggested content identified in Table 3. Each regional convener will evaluate the eligible teams in their region using the evaluation statement provided in Table 3. Teams will be evaluated based on the extent to which the registration submission aligns with the evaluation statement.

Table 3: Registration Submission Evaluation Statement

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

Based on this review criteria, the regional conveners will select the teams who are invited to compete in that regional convener's Explore phase event. These teams will then be asked to provide the submission materials described for the Explore phase. During the Explore phase, teams present their business plan to regional judges as part of a live event held virtually.

How Explore Phase Winners Are Determined

Each regional convener will identify and secure a panel of judges to witness 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 5 and in Table 7 based on a presentation given by each team to judges as part of a live event held virtually. Immediately following the conclusion of the Explore Phase presentations, judges will meet to determine which team will advance to the Refine Phase. Scores will not be shared with any of the teams. Only the Regional Winner and Technology Bonus Prize Finalists will be determined and announced. Each bullet listed in the Explore Phase evaluation statements will receive a score from 1 to 6. Teams will be judged based on the extent to which the judging panel agrees with the evaluation statements according to the scale shown in Table 4.

Table 4: Scoring Scale

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

Explore Phase Content and Evaluation Statements

For the Explore Phase, teams will present an initial business idea that leverages a National Lab-developed or other promising energy technology. The business idea should be developed independently by students. Teams will be given seven minutes to present their technology and business plan, followed by three 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 evaluation statements in Table 5 and in Table 7.

A panel of expert judges will read, score, and comment on each submission. The evaluation statements 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. The regional judging panel will consider individual scores when deciding the Regional Winner and Bonus Prize Finalists for their Explore Event.

This prize seeks to encourage inclusivity and diversity, commercialization of National Lab tech, 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 will take reviewer scores, team presentation performance, reviewer deliberation, and program policy factors listed in the Additional Terms and Conditions into account. Winners are not determined based on the likelihood that the presenting team will implement the business plan, but rather on the quality and innovativeness of the plan itself, should a qualified team of individuals attempt to execute the business plan.

Table 5: Explore Phase Content and Evaluation Statements

1. Technology Identification	
Suggested Content: A. What is the energy technology to be leveraged?	**Evaluation Statement:** The team deeply understands their technology of choice and explained it clearly.
2. Market Assessment	
Suggested Content: A. Who will buy the product or service and why do they need it? B. Who is currently serving this market and how? C. What unmet market need will this technology help to fill?	**Evaluation Statement:** 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 Content: A. What might customers be willing to pay for this product or service? B. How much might it cost the business to produce this product or service?	**Evaluation Statement:** 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 Content: A. Who will benefit should this business succeed? B. What role will this business play in the energy transition?	**Evaluation Statement:** The proposed business includes thoughtful and specific activities that will advance equity and inclusion, including for members of disadvantaged communities[4] (e.g., those

[4] 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.

	that are affected by persistent poverty, job loss due to the energy transition, etc.), and the team has outlined a realistic vision for the role they see this business playing in the energy transition.
5. Overall Business Plan	
Suggested Content: A. How is success defined? B. What people and resources are needed to put this plan into action?	**Evaluation Statement:** 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.

How Bonus Prize Winners Are Determined

The Prize Administrator screens all completed submissions and, in consultation with DOE, assigns expert reviewers to independently score the content of each submission. 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 Pitch Phase reviewers' scores and comments as well as the program policy factors described in these rules.

How We Score Bonus Prizes

Subject matter experts selected by the Prize Administrator and OTT will individually evaluate the Bonus Prize Finalist team pitches based on the pitch content and the written submission given in Table 7. Judges will meet after the Explore Phase presentations to discuss the teams with high average scores, update their scores to reflect all the information available, and determine winner(s).

Table 6: Scoring Scale

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

Bonus Prize Challenge and Evaluation Statements

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 statements provided in Table 7. Teams will be judged based on the extent to which the judging panel agrees with the evaluation statements.

Table 7: Bonus Prize Challenge and Evaluation Statements

Office of Technology Transitions (OTT)	
Challenge Statement: Leverage the OTT's LPS to identify a National Lab-developed technology available for license and propose an innovative business model to commercialize the technology.	**Evaluation Statement:** The entry demonstrates a clear understanding of the technology and market potential and presents an innovative business model to significantly increase its adoption.
Building Technologies Office (BTO)	
Challenge Statement: Develop innovative business models to increase the adoption of 120V heat pump water heaters for all climate zones and space locations.	**Evaluation Statement:** The entry demonstrates a clear understanding of the technology and market potential for 120V heat pump water heaters (HPWHs) and presents an innovative business model to significantly increase their adoption, including if increases with respect to recovery rate and first-hour ratings are realized.
Geothermal Technologies Office (GTO)	
Challenge Statement: Develop innovative business models to increase the adoption of geothermal technologies that address key exploration and operational challenges.	**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 increase key exploration and operational challenges.
Office of Fossil Energy and Carbon Management (FECM)	
Challenge Statement: Develop innovative business models to increase the adoption of carbon dioxide removal (CDR) technologies.	**Evaluation Statement:** The presentation emphasizes a clear understanding of the technology and market potential for CDR and proposes an innovative business model that can increase the likelihood of CDR technology adoption.

Office of Nuclear Energy (NE)	
Challenge Statement: Develop innovative business models to accelerate the development and deployment of advanced technologies supporting advanced reactors and fuel cycle technologies.	**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.
Office of Electricity (OE) - Grid Enhancing Technologies (GETs)	
Challenge Statement: Develop innovative business models to increase the adaption of GETs to benefit the United States power grid.	**Evaluation Statement:** 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 (OE) - Large Power Transformers (LPTs)	
Challenge Statement: Develop innovative business models to stimulate the adoption of flexible LPTs in the electric sector.	**Evaluation Statement:** The presentation emphasizes a clear understanding of the technology and market potential for flexible LPTs and presents an innovative business model to significantly increase their adoption.
Solar Energy Technologies Office (SETO)	
Challenge Statement: Develop innovative business models to improve the affordability, reliability, and value of solar technologies on the U.S. grid and to tackle emerging challenges in the solar industry.	**Evaluation Statement:** The presentation 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.

Water Power Technologies Office (WPTO)	
Challenge Statement: Develop innovative business models for a selected novel hydropower or marine technology of your choice that tackles emerging challenges in the water power industry and aims at improving the performance, affordability, reliability, and value of hydropower or marine energy in the United States.	**Evaluation Statement:** The submission demonstrates an understanding of the technology and market potential of the chosen technology, and the path to improving the technology and/or increasing its adoption is well-articulated and reasonable.

How Pitch Phase 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 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. The Pitch Phase final judge, a representative of OTT, will make final selection of winners based on the Pitch Phase reviewers' 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 We Score the Pitch Phase

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 evaluation statements receives a score from 1 to 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 reviewer's 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 Lab tech, 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 take reviewer scores, team presentation performance, reviewer deliberation, and program policy factors listed in the Additional Terms and Conditions into account.

Table 8: Scoring Scale

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

Pitch Phase Content and Evaluation Statements

For the Pitch Phase, teams present a comprehensive business plan that leverages a National Lab-developed or other promising energy technology. Successful teams will demonstrate a clear understanding of the technology and its commercialization potential, the existing relevant market, and a convincing plan for commercialization. Teams will be given 10 minutes to present and 5 minutes for Q&A from the reviewers. The judging panel will evaluate the teams using the evaluation statements in Table 9. Teams will be judged based on the extent to which the judging panel agrees with the evaluation statements. Winners are not determined based on the likelihood that the presenting team will implement the business plan, but rather on the quality and innovativeness of the plan itself, should a qualified team of individuals attempt to execute the business plan.

Table 9: Pitch Phase Content and Evaluation Statements

1. Technology Identification	
Suggested Content: A. What is the energy technology to be leveraged?	**Evaluation Statement:** A. The team deeply understands their technology of choice and explained it clearly.
2. Market Assessment	
Suggested Content: A. Who will buy the product or service, and why do they need the product or service? B. Who is currently serving this market? C. How can this technology help enable a business to better serve the market? D. How will the business find and secure customers?	**Evaluation Statement:** A. The team deeply understands the range of potential customers for their identified technology, including what pain points this technology might solve for the customer. B. The team has evaluated the entire relevant market of potential competitors. C. The team has clearly identified a strategy to serve a sizeable unmet market need. D. The team has developed a comprehensive strategy for finding and securing customers.

3. Economic Feasibility Analysis	
Suggested Content: A. What are customers willing to pay for this product or service? B. How much will it cost the business to produce this product or service? C. How will the business become financially sustainable?	**Evaluation Statement:** A. 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). B. The team deeply understands the steps necessary to produce and deploy the product/service and has thoroughly justified its cost of production. C. 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 Content: A. Who will benefit should this business succeed? B. What role will this business play in the energy transition?	**Evaluation Statement:** A. The proposed business includes thoughtful and specific provisions for advancing equity and inclusion, including for members of disadvantaged communities(See footnote 2 on page 16) (e.g., those that are affected by persistent poverty, job loss due to the energy transition, etc.). B. 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 Content: A. How is success defined? B. What people and resources are needed to put this plan into action?	**Evaluation Statement:** A. 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. B. The team has comprehensively identified what personnel, equipment or other assets, and partnerships are necessary to achieve success, as they have defined it.

Additional Terms and Conditions

Universal Contest Requirements

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

- 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 hand-written 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 non-substantive 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.

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 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 in order 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

The U.S. Department of Energy is solely responsible for administrative decisions, which are final and binding in all matters related to the contest.

Neither the U.S. Department of Energy 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.

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 (NEPA) Compliance

DOE's administration of this prize is subject to 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 non-cash prizes be returned to the government.

Appendix – Technology Office Bonus Prize Resource Documents

Building Technologies Office Bonus Focus: 120V Heat Pump Water Heaters

Statement of Interest

The Biden administration has set a goal to decarbonize the U.S. built environment by 2050. To meet this goal, we must address our existing, aging building stock, an effort that includes electrifying water heating with 120V heat pump water heaters (HPWHs). DOE's Building Technologies Office is challenging you to develop an innovative business model to increase the adoption of 120V HPWHs in residential and multifamily dwellings.

Bonus Challenge

DOE's Building Technologies Office is challenging you to develop an innovative business model to increase the adoption of 120V HPWHs in all climate zones and spaces (garages, attics, etc.) that will come close to replicating the recovery rate and first-hour ratings of 240V HPWHs.

Evaluation Statement

The presentation captures a clear understanding of the technology and market potential for 120V HPWHs and presents an innovative business model to significantly increase their adoption. The presentation includes a clear explanation of whether increases with respect to recovery rate and first-hour ratings will be realized.

Content

Introduction

President Biden has set a goal for the United States to achieve net-zero emissions by 2050.[5] Residential buildings, which account for approximately 21% of the country's total energy consumption, will be part of that solution.[6] About 19% of the energy consumed by buildings is spent on water heating,[7] and much of that is wasted due to older and inefficient non-heat-pumping technologies, among other factors. Water heaters are the second biggest energy user in a typical household in the United States, after space heating and cooling. If all residential water heaters sold in the United States were ENERGY STAR certified, energy cost savings would grow to almost $7.6 billion annually, preventing more than 130 billion pounds of greenhouse gas emissions—equal to the emissions from nearly 13 million vehicles every year.[8]

Heat pumps are a technology for water and space heating that is up to three times more energy efficient than other methods. Most HPWHs in use today require 240V electrical connections, limiting their retrofit potential. The 240V connection is currently needed to power both the heat pump system

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[5] https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/
[6] https://rpsc.energy.gov/energy-data-facts
[7] https://www.eia.gov/consumption/residential/data/2015/c&e/pdf/ce3.1.pdf
[8] https://www.energystar.gov/sites/default/files/tools/Electric_WH_Infographic_02-16-2021_v2.pdf

and the electric resistance elements (which are not being used for 120V units). 120V, 15-amp (under 900-W) HPWHs are a potentially game-changing technology, allowing homeowners to easily switch out older HPWHs without expensive electrical panel upgrades. Not requiring electrical panel upgrades for gas water heaters is a key benefit for 120V HPWHs in general, and for building electrification overall. Low-income multifamily buildings and communities can potentially benefit from this technology. The American Council for an Energy-Efficient Economy (ACEEE) conducted a study[9] to evaluate the feasibility of electrifying water heaters in multifamily buildings. The results of this study showed that, although water-heating system retrofits for multifamily buildings are an effective way to reduce greenhouse gas emissions, the average payback period was 20 years for an in-unit water heater, or 30 years for a central water heater. Switching from gas-powered heat to electricity can increase environmental benefits, as electricity can be generated from cleaner sources such as wind or solar technology. Opportunities remain for electrification efforts in the United States by promoting 120V HPWHs.

DOE's Building Technologies Office is challenging you to develop an innovative business model to increase the adoption of 120V HPWHs for all climate zones and spaces (garages, attics, etc.).

Technology Overview

Electric HPWHs extract low-grade heat from the air and transfer that heat to water. HPWHs can be integrated models that fully replace standard electric water heaters. Despite the increase in sales of ENERGY STAR-qualifying water heaters in recent years, most water heaters sold in the United States still only meet the minimum efficiency standard. The key barriers to implementing high-efficiency equipment and systems for hot water production and distribution include (first) cost, price premiums that are difficult to upsell due to a lack of non-energy benefits, emergency replacements that require immediate product availability and prevent discussion of higher-efficiency alternatives, and split incentives (in new construction). Today's HPWHs can be installed almost anywhere a regular water heater would go. HPWHs perform best in spaces that range from 40°–90°F. Basements are often perfect locations—even in very cold climates. HPWHs will work if the air temperature immediately around the water heater doesn't drop below freezing, and they will efficiently deliver hot water in temperatures above 37°F.

Heat pumps are more efficient than other forms of water heating because they simply move heat, rather than generating it. HPWHs make the same amount of hot water using 70% less electricity than conventional electric water heaters. Most air-source heat pumps, including water heaters, can deliver as much as three times as much energy in heat as the electrical energy required for the process.[10] By comparison, the most efficient gas-powered water heaters are 90% efficient, meaning that 90% of the energy (gas) used by the water heater is turned into heat.

Costs

There are two costs to consider when comparing heat pumps to other water heaters. The first is the upfront cost to install the technology, and the other is the cost to operate it. HPWHs make the same amount of hot water using 70% less electricity than conventional electric water heaters.[11] An ENERGY STAR certified HPWH can save a household of four approximately $425 per year on its

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[9] Perry, C., A. Khanolkar, and H. Bastian. 2021. Increasing Sustainability of Multifamily Buildings with Heat Pump Water Heaters. Washington, DC: ACEEE. https://www.aceee.org/research-report/b2101

[10] https://www.energy.gov/energysaver/air-source-heat-pumps

[11] HPWH_BuyingGuide_May2021.pdf (energystar.gov)

electric bills compared to a standard electric water heater, and more than $3,700 over its lifetime. Larger families—which typically use more hot water—will save even more.[12]

Market Opportunity

The market opportunity for heat pumps may vary by region due to climate, technology, and the cost of natural gas and electricity. With millions of storage water heaters sold every year, the potential market for this equipment is extensive, and the savings potential is very high. The market includes residential and commercial water heater customers. The equipment replacement market is critical to reaching economies of scale in the water heating market. Most residential water heater replacements occur as emergency sales, where immediate availability is essential to maintaining comfort and function (whether in a home or a restaurant). Most emergency replacements are filled with the equipment on the plumber's truck, so upgrading to more energy-efficient units is not feasible due to availability, installation requirements, or both. Utility-level financing options, such as equipment leasing, could be an option to reduce the upfront cost of efficient equipment. In new constructions, the building or installation contractor more commonly chooses the equipment than the homeowner, a situation known as a split incentive; in commercial scenarios, the building owner may make the decision, but upfront cost often takes priority. Similarly, more efficient hot water distribution systems can be designed and installed in new buildings, but they are almost invisible to developers and are completely invisible (barring a catastrophic failure leading to flooding and/or loss of hot water) to consumers.

There are approximately 120 million households in the United States, and in 2015, just 55 thousand HPWHs were sold in the United States.[13] The HPWH market is expected to project a notable compound annual growth rate of 5.7% in 2030. The HPWH market is projected to surpass $3.7 billion by 2030 (up from $1.2 billion in 2019) at a CAGR of 6.9% throughout the forecast period (2020–2030).[14] There are therefore tens of millions of potential new customers for HPWHs today.

Additional Resources

- DOE – Heat Pump Systems
  https://www.energy.gov/energysaver/heat-pump-systems
- Energy Star – How Does a Heat Pump Work?
  https://www.energystar.gov/products/ask-the-experts/how-does-a-heat-pump-work
- Residential Energy Consumption Survey
  https://www.eia.gov/consumption/residential/index.php
- The Cost of Decarbonization and Energy Upgrade Retrofits for US Homes
  https://eta-publications.lbl.gov/sites/default/files/final_walker_-_the_cost_of_decarbonization_and_energy.pdf
- The Economics of Electrifying Buildings: How Electric Space and Water Heating Supports Decarbonization of Residential Buildings
- https://rmi.org/wp-content/uploads/2018/06/RMI_Economics_of_Electrifying_Buildings_2018.pdf DOE – Storage Water Heaters
  Storage Water Heaters | Department of Energy

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[12] HPWH_SalesGuide_May2021.pdf (energystar.gov)
[13] https://cmadmin.energystar.gov/sites/default/files/asset/document/ENERGY%20STAR%20and%20Connected%20Water%20Heaters%20Stakeholder%20Meeting_%203%2020%202018_final.pdf
[14] Heat Pump Water Heater Market: Market Segments (globenewswire.com)

- Choose an ENERGY STAR Heat Pump Water Heater
  HPWH_BuyingGuide_May2021.pdf (energystar.gov)
  HPWH_SalesGuide_May2021.pdf (energystar.gov)

Geothermal Technologies Office Bonus 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. Geothermal energy has the highest capacity factor (>90%) among renewable energy sources, making it an invaluable component of electricity grid stabilization and load balance. DOE's Geothermal Technologies Office (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 Geothermal Technologies Office is challenging you to develop an innovative business model for a 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 should be to increase the adoption of new geothermal technologies and maximize the performance and/or reduce the costs of 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 that can be harnessed as a carbon-free, renewable energy source with a small physical footprint around the clock. Geothermal is cosmic in origin—as opposed to atmospheric, such as wind or water—and will be 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. Geothermal energy can also offer important benefits to the nation, including grid stability, a greater diversity of affordable energy options, and efficient heating and cooling.

As identified in the *GeoVision* analysis,[15] 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:

[15] www.energy.gov/geovision

- Improving technologies that reduce the costs and risks of geothermal development could increase geothermal power generation nearly 26-fold by 2050, representing 60 gigawatts-electric (GW_e) of electricity-generation capacity.
- 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 that hot water to heat and cool buildings, homes, and communities. Lower-temperature resources can also support other direct-use geothermal 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 target space or process
- A disposal system—an injection well, storage pond, or river—to receive the cooled geothermal fluid (this 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,[16] deployment of direct use could increase from 23 district heating systems today to as many as 17,500 systems by 2050. There is pronounced economic potential for geothermal district-heating systems in the Northeast corridor of the United States, and the Appalachian region is also a promising candidate for direct-use geothermal.

Geothermal district heating and cooling (GDHC) systems with a variety of 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°–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

[16] www.energy.gov/geovision

different buildings with different heating needs, thereby reducing capital cost, energy use, and 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. Although 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.

Geothermal heat pumps take advantage of seasonal variation by transferring heat stored in the Earth or in ground water into buildings during the winter and transferring heat out of buildings 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 producing 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 for those who 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 a house. Three of these—horizontal, vertical, and pond/lake—are closed-loop systems. The fourth is an open-loop system. Choosing the one that is best for a given site depends on the climate, soil conditions, available land, and local installation costs at the site.

Closed-Loop Systems

1. Horizontal: This type of installation is generally most cost-effective for residential installations, particularly for new constructions where sufficient land is available. It requires trenches at least 4 feet deep.
2. 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.
3. Pond/Lake: If the site has an adequate body of water, this may be the least expensive option. A supply line pipe runs underground from the building to the water and coils in 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

4. 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. 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,[17] 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.[18] 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 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 in turn produces electricity. The steam eliminates the need to burn fossil fuels to run the turbine, and it also eliminates the need to transport and store fuels. These plants emit only excess steam and

[17] www.energy.gov/geovision
[18] 2021 U.S. Geothermal Power Production and District Heating Market Report (nrel.gov)

very minor amounts of gases. Dry steam power plants were the first type of geothermal power generation plant built (they were first used at Larderello in Italy in 1904).[19] 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 plant 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 ("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 into the atmosphere. Because geothermal resources below 300°F are most common, 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 GTO to assess geothermal deployment potential. The report states that geothermal electricity generation capacity in the Untied 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.
- U.S. Department of Energy Geothermal Data Repository (GDR): The GDR is the submission point for all data collected from researchers who are funded by 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 catalogs documents and data sets that provide information about geothermal resources located primarily within the United States. This complete and current catalog of available data, which is funded by 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, consisting of nearly 3 million citations.
- Stanford/International Geothermal Association Conference Database: This database contains papers and proceedings from a variety of geothermal-focused conferences,

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

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 and known geothermal resource areas and exploration regions, including state geothermal maps, potential for enhanced geothermal systems (EGSs), 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.

Office of Electricity Bonus Focus: Grid Enhancing Technologies

Statement of Interest

Grid enhancing technologies (GETs) have been identified as a way to maximize the 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 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—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 reduce congestion across the existing electricity transmission system through a range of technologies, including sensors, power flow control devices, and analytical tools. GETs can be used to enhance transmission operations and improve planning, as well as to provide benefits for N-1 contingency cases for utilities.[20]

Technology Overview

GETs fall into a number of different categories of technologies that can benefit 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 IEEE 738 standard,[21] but use time-varying components instead of static ratings, which make conservative assumptions about weather as constant for a seasonal basis. DLR systems are typically either weather-based systems or asset-based systems that measure the conductor state directly. One subset of DLR methods includes ambient adjusted ratings (AARs), where the static assumptions for wind and solar are still used, but the ambient temperature used in the IEEE 738 calculations is allowed to change with local weather conditions. Idaho National Llab has led several Wind Energy Technology Office (WETO)-funded projects over the years in weather-based DLR and has peer-reviewed relevant publications.[22,]

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[20] U.S. Department of Energy. "Grid-Enhancing Technologies: A Case Study on Ratepayer Impact." February 2022.
[21] IEEE 738, Standard for Calculating the Current-Temperature Relationship of Bare Overhead Conductors. 2012.
[22] Bhattarai, B. P., Gentle, J. P., McJunkin, T., Hill, P. J., Myers, K. S., Abboud, A. W., Renwich, R., and Hengst, D. (2018). Improvement of transmission line ampacity utilization by weather-based dynamic line rating. IEEE Transactions on Power Delivery, 33(4), 1853-1863.

[23, 24] In general, 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.[25]

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 utilities to push power to avoid congested lines or pull power into underutilized transmission corridors.

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

Although 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 on transformer ratings.[26] 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.[27] In California between 2009 and 2017, the increase in congestion-related costs reflected on ratepayers' bills was $683 million.[28] Standard transmission expansion projects can be quite costly, and have totaled over $20 billon every year between 2014 and 2016.[29] Due to the old age of most of the transmission infrastructure in the United States (established between 1960 and the 1980s), one estimate shows that the replacement costs will continue to increase by $1.2–$3.2 billion per year.[30] Line reconductoring can be a way to increase capacity on exiting transmission pathways, but can cost $1–$8 million per mile, depending on the voltage.[31]

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[23] 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., and 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.
[24] 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.
[25] U.S. Department of Energy. "Dynamic Line Rating." Jun 2019.
[26] IEEE PES Transformers Committee, "PES Transformers Committee," IEEE, April 2021. [Online]. Available: https://www.transformerscommittee.org/.
[27] U.S. Department of Energy, "Annual U.S. Transmission Data Review," 2018.
[28] 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/.
[29] U.S. Energy Information Administration, "Utility continue to increase spending on transmission infrastructure," 2018. [Online]. Available: https://www.eia.gov/todayinenergy/detail.php?id=34892.
[30] J. Pfeifenberger, J. Chang and J. Tsoukalis, "Investment Trends and Fundamentals in U.S. Transmission and Electricity Infrastructure," The Brattle Group, 2015.
[31] 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.

The DOE Office of Electricity released Grid-Enhancing Technologies: A Case Study on Ratepayer Impact, a report focusing on the impacts of integrating GETs into existing transmission lines. The GETs case study report, led by Idaho National Laboratory, performed a top-down analysis to identify regions of the country that could benefit from GETs due to plans for increased renewable penetration combined with congested transmission line corridors. The case study narrowed in on a smaller region of western New York, which showed 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 on which they could begin to focus their own case studies. Several other studies have shown the potential cost impacts of GETs. An analysis of a hypothetical DLR installation on historically observed weather conditions showed $11.1 million in savings over the target line.[32] Another study showed that the deployment of DLR could provide congestion savings of $0.26 million in a four-hour window, and that cost savings from utilizing topology control could range from $18–$44 million annually.[33]

A study in Minnesota, Wisconsin, and Colorado showed potential DLR increases of about 13% with an investment of $12.5 million.[34] A study by the International Renewable Energy Agency (IRENA) on lines in Texas showed increases of 6%–14% with an investment of $4.833 million[35]. A pilot case in the PJM utility region showed an 8.4:1 return on the investment cost of DLR with an installation cost of about $500 thousand.[36] A study by the Brattle Group over a range of PFCs shows that costs of $81–$137 million could be projected to save $67 million per year.

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 showed that costs vary widely by region, with over $1 billion each in the New York Independent System Operator (NYISO) region and PJM regions, $0.7 billion in the Midcontinent Independent System Operator (MISO) region, $0.5 billion in the CAISO region, and only $0.1 billion in the ISO-NE region.[37] 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. 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

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[32] 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.
[33] T. Tsuchida and R. Gramlich. The Brattle Group/Grid Strategies LLC. “Improving Transmission Operation with Advanced Technologies.” 2019.
[34] National Grid. “Enabling Renewable Energy with LineVision.” 2021. https://ngpartners.com/case-study/enabling-renewable-energy-with-linevision/.
[35] International Renewable Energy Agency. “Dynamic Line Rating Innovation Landscape Brief.” 2020.
[36] S. Murphy and N. Dumitriu. PJM. Introduction to Dynamic Line Rating. Emerging Technologies Forum, Aug 2020.
[37] U.S. Department of Energy. “National Electric Transmission Congestion Study.” September 2020.

participants to engage in auxiliary services for electricity markets, and the goal is to find and establish similar motivating mechanisms for GETs.

Flexibility and operational optimization across the year are not valued in a world where reliability planning is tantamount. Federal Energy Regulatory Commission (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.[38] The incentives to leverage GETs are often misaligned with those who benefit most. Transmission owners, generation developers, utilities, independent system operators/regional transmission organizations, 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 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
- 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

[38] 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.

Office of Electricity Bonus Focus: Large Power Transformers

Statement of Interest

The Biden administration goal to decarbonize the U.S. economy by 2050 will require substantial electrification. Increasing clean energy delivery capacity requires address our existing, aging electric sector infrastructure, including large power transformers (LPTs). The average age of installed LPTs in the United States is approximately 40 years, with 70% of LPTs being 25 years or older.[39] DOE's Office of Electricity is challenging you to develop innovative business models to stimulate the adoption of flexible LPTs in the electric sector.

Bonus Challenge

DOE's Office of Electricity is challenging you to develop innovative business models to stimulate the adoption of flexible LPTs in the electric sector.

Evaluation Statement

The presentation should capture a clear understanding of the technology and market potential for flexible LPTs and present an innovative business model to significantly increase their adoption.

Content

Introduction

Securing energy technology supply chains as the energy sector transitions to clean energy is critical to current and future U.S. national security. Earlier this year, DOE laid out the federal government's first-ever comprehensive strategy for securing U.S. energy supply chains.[40] In June 2022, President Biden issued presidential determinations to DOE to utilize the Defense Production Act (DPA) authority to accelerate domestic manufacturing and deployment of five key energy technologies, including LPTs.

LPTs are custom-designed equipment that entail significant capital expenditures and long lead times due to a complex procurement and manufacturing process. Procurement and manufacturing of LPTs requires prequalification of manufacturers, a competitive bidding process, the purchase of raw materials, and special modes of transportation due to the size and weight of LPTs. Production times can be elongated due to the time required to set up a manufacturing line for a custom design. In some cases, if the manufacturer has difficulty obtaining certain key parts or materials, delivery times can stretch up to 36 months.[41]

DOE's Office of Electricity has supported research and development to develop flexible LPTs that could reduce the need for custom-designed LPTs and reduce manufacturing lead times. The goal of this prize is to accelerate the manufacture and adoption of flexible LPTs.

Technology Overview

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[39] Large Power Transformers and the U.S. Electric Grid (energy.gov)
[40] Office of Electricity Releases Deep-Dive Supply Chain Assessment of Grid Energy Storage and Electric Grid Components | Department of Energy
[41] Next Generation Transformers – Flexible and Adaptable Designs | netl.doe.gov

LPTs are a critical component of the electric delivery system, with more than 90 percent of consumed electricity passing through one at some point. The term LPT is broadly used to describe a power transformer with a maximum nameplate rating of 100 megavolt-amperes (MVA) or higher, unless otherwise noted. These components are used to "step up" the voltage at generation facilities for efficient, long-haul transmission of electricity and to "step down" the voltage at distribution substations to levels more readily used by customers. LPTs are also needed at every point in the transmission system where there is a change in voltage.[42]

Due to the significant capital expenditure, long lead time, and unique specifications associated with the procurement and manufacturing of a replacement LPT, there is an opportunity to adopt more flexible and adaptable LPT designs that can facilitate transformer sharing and long-term replacement in the event of catastrophic failures, thereby increasing grid resilience. Additionally, there is an opportunity to integrate enhanced functionality in these new designs to support operation and evolution of the future grid.

Costs

The costs of regular LPTs vary by manufacturer and by size; an LPT can cost between $2 and $7 million and weigh between approximately 100 and 400 tons (or between 200,000 and 800,000 pounds).[43] On the other hand, the cost of a flexible LPT is unclear due to the novelty of the technology. General Electric (GE) recently developed and installed the world's first flexible LPT in partnership with DOE. This flexible LPT is rated at 165 kV and 60/80/100 MVA, and it has 3 Low Voltage (LV) ratings (57.5/69/80.5 kV) and an online adjustable impedance of 4.3%–9.2% system.[44] Other flexible LPT designs could further reduce the need for customization, in turn reducing long lead and wait times for production.

Market Opportunity

There is a significant market opportunity for flexible LPTs, as the United States is one of the world's largest markets for power transformers and holds the largest installed base of LPTs—and this installed base is aging. The average age of installed LPTs in the United States is approximately 40 years, with 70% of LPTs being 25 years or older. Although the life expectancy of a power transformer varies depending on how it is used, aging power transformers are subject to an increased risk of failure.

Additionally, the currently challenging LPT supply chain and lead time considerations highlight the opportunity for flexible LPTs that can facilitate transformer sharing and long-term replacement and potentially reduce lead times.

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[42] An overview of Large Power Transformer - LPT (Characteristics, Costs and Pricing) (electrical-engineering-portal.com)
[43] Strategic Transformer Reserve Report - FINAL.pdf (energy.gov)
[44] GE Research and Prolec GE Power Up World's 1st Large Flexible Transformer to Enhance the Resiliency of America's Grid | GE News

Office of Fossil Energy and Carbon Management Bonus Focus: Carbon Dioxide Removal

Statement of Interest

Deep decarbonization pathways that can be realistically applied in the United States were modeled to keep the global temperature change within a 2°C, 1.5°C, and 1°C rise (Paris Agreement). The results illustrated that, in addition to mitigation strategies such as energy efficiency, renewable electricity production, and process electrification, the capture and storage of carbon dioxide (CO_2) in a manner intended to be permanent (e.g., geological sequestration or long-lived products) will be required to reach net-zero emissions.[1] According to the Intergovernmental Panel on Climate Change (IPCC), carbon dioxide removal (CDR) will be required to meet the targets described in the Paris Agreement and CO_2 removal technologies will play a vital role in carbon management.[2] Therefore, DOE's Office of Fossil Energy and Carbon Management (FECM) is challenging you to develop innovative business models to increase the adoption of CDR technologies, which may include direct air capture (DAC) with storage, biomass carbon removal and storage (BiCRS), enhanced mineralization, and marine pathways.

Bonus Challenge

DOE's FECM is challenging you to develop innovative business models to increase the adoption of CDR technologies.

Evaluation Statement

The presentation emphasizes a clear understanding of the technology and market potential for CDR and proposes an innovative business model that can increase the likelihood of CDR technology adoption.

The proposed business model should be inclusive of all relevant unit flows for the applicable system and should clearly demonstrate that more CO_2 is removed from the atmosphere than emitted. The business model can be multifaceted to be inclusive of any disaggregated product system. CDR processes must strive to maximize energy efficiencies and minimize costs.

Content

Introduction

President Biden has set a goal for the United States to achieve a 50%–52% reduction from 2005 levels in economywide net greenhouse gas pollution by 2030.[3] This target builds on progress to date and positions American workers and industries to tackle the climate crisis.[3] The 2030 emission target, set by the National Climate Task Force and known as the "nationally determined contribution" or "NDC," supports President Biden's aim of reaching net-zero emissions economywide by no later than 2050.[3]

In contrast to most CO_2 abatement technologies that reduce emissions from point sources, CDR technologies remove CO_2 from the atmosphere and durably store it in a manner intended to be permanent.[2] Paired with the simultaneous deployment of mitigation measures and other carbon management practices, CDR is a tool to address emissions from the sectors that are hardest to decarbonize (e.g., agriculture and transportation) and eventually, to remove legacy CO_2 emissions from the atmosphere.[4] To meet the goal of achieving net-zero emissions by 2050, FECM funds research, development, demonstration, and deployment (RDD&D) of CDR technologies and conducts

rigorous techno-economic and life cycle analyses, all while maintaining a deep commitment to environmental justice.

Technology Overview

DAC technologies for CDR removal can be coupled with other techniques to store CO_2 from the atmosphere. DAC involves the direct removal of CO_2 from the atmosphere using chemicals or some other medium, which can be regenerated for reuse.[2] Atmospheric CO_2 is very dilute (e.g., 415 ppm) and therefore much harder to capture than the CO_2 found in industrial flue gases, as more dilute CO_2 streams require more energy for separation.[2] Comparatively large volumes of air must be handled for each tonne captured, and larger capture equipment is needed, so DAC projects typically cost more than industrial carbon capture and storage (CCS) applications with similar capacities.[2]

Biomass carbon removal and storage (BiCRS) projects leverage photosynthesis to capture CO_2 from the atmosphere and store it in the form of biomass. This biomass can then be combusted or converted into heat, electricity, hydrogen, or liquid fuels, where the resulting CO_2 emissions are captured and stored in a manner intended to be permanent.[2] Biomass can also be directly converted into marketable, long-lived products (e.g., biochar and bio-based building materials) or bioliquids or bio-oils, which can then be injected in depleted underground oil fields without the need for carbon capture units or further processing steps. Biomass conversion is generally considered to be carbon-neutral, as the amount of CO_2 released is removed from the atmosphere during growth. Implementing carbon removal and storage with biomass conversion is a promising net-negative emissions technology that could ultimately support the 2050 target goal.

Enhanced mineralization processes accelerate the natural weathering process whereby rocks and minerals with high magnesium (Mg), calcium (Ca), or iron (Fe) content react with CO_2 to form a stable and inert carbonate.[4] CO_2 mineralization reactions can utilize various materials in different settings, and include the in-situ CO_2 mineralization of basalts or ultramafic rocks and the ex-situ mineralization of alkaline mine tailings or wastes.[4] In-situ mineralization involves injecting CO_2-containing fluids into subsurface rocks without first mining or crushing the rocks (e.g., basalts and ultramafic rocks).[4] Another method to store CO_2 through mineralization is by ex-situ reaction with crushed material at the surface.[4] Available crushed solid reactants include mine tailings derived from mafic or ultramafic rocks and alkaline industrial wastes. Often, these rocks are in the form of crushed mining waste, such as asbestos mine tailings. Carbon mineralization of asbestos mine tailings has the added benefit of reducing the risks associated with exposed asbestos.[5] Stockpiles of alkaline waste provide a large sink for CO_2 and a potential opportunity to generate side-stream products or address expensive and hazardous wastes. The mineral carbonation process has been leveraged to produce building construction materials such as binders for cement and aggregates. CDR technologies that aim to pull carbon out of the atmosphere and store legacy emissions in durable products like building materials are gaining attention and investment on a global scale.

Recently, several marine CDR pathways have been proposed to improve the ocean's ability to remove CO_2 from the atmosphere. Many approaches involve increasing the ocean's alkalinity in response to ocean acidification.[6] For example, some approaches involve adding alkaline substances to oceans to convert inorganic CO_2 into carbonates and bicarbonates, thereby increasing the pH. Others involve an electrodialysis process that aims to separate CO_2 from ocean water in the form of a pure stream for subsequent durable storage. Sequestering organic matter deep in the ocean where it is biologically inaccessible (e.g., kelp farming and sinking or artificial fertilization of

phytoplankton) can also allow for durable storage of biomass. Protecting and restoring blue carbon ecosystems can also boost the storage of organic carbon in marine soils.

Market Opportunity

Around half of the anticipated emissions reductions required to reach net-zero emissions by 2050 will come from technologies that are not yet commercially deployed, and these new technologies will become increasingly important after 2030.[7] CDR technologies, such as DAC and BiCRS, which help offset residual emissions, also need to scale up significantly, giving rise to negative emissions.[7] A roadmap to net-zero emissions by 2050 showed that for the G7 members (Canada, France, Germany, Italy, Japan, the United Kingdom, the United States), CDR from BiCRS and DAC with storage offset residual emissions of around 1.9 gigatonnes (Gt) of CO_2, mainly from the transport and industry sectors.[7] Therefore, it is apparent that CDR technologies have an essential role to play in achieving net-zero emission targets by 2050 in the global market. Many variables can impact the success of technologies, and these are likely to vary both temporally and regionally.[2] However, in general, the market opportunity can be determined via a complete analysis of economic viability and environmental impacts, through techno-economic analysis (TEA) and life cycle analysis (LCA), respectively. It is imperative to perform the LCA on a cradle-to-grave basis when analyzing the environmental impacts of CDR technologies.

Resources

- https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2020AV000284
- Global CCS Institute, 2021. The Global Status of CCS: 2021. Australia.
- https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/
- Carbon Dioxide Mineralization Feasibility in the United States. Scientific Investigations Report 2018–5079. U.S. Department of the Interior and U.S. Geological Survey. U.S. Geological Survey, Reston, Virginia: 2019
- https://www.usgs.gov/news/featured-story/making-minerals-how-growing-rocks-can-help-reduce-carbon-emissions
- Ocean Carbon Dioxide Removal (CDR) - ClimateWorks Foundation
- Achieving net-zero electricity sectors in G7 members. International Energy Agency. October 2021.Carbon Utilization Program | netl.doe.gov
- NETL CO_2U LCA TRAINING RESOURCES | netl.doe.gov
- Conference Proceedings | netl.doe.gov

Office of Nuclear Energy Bonus Focus: Accelerated Development and Deployment

Statement of Interest

The mission of DOE's Office of Nuclear Energy (NE) is to advance nuclear energy science and technology to meet U.S. energy, environmental, and economic needs. NE has identified 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. Develop advanced nuclear fuel cycles and spent nuclear fuel management options.

There is enormous potential to expand into new markets and applications for nuclear energy, from the existing fleet on the nation's grid to advancedreactors and fuel cycle technologies.

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 existing fleet capabilities in the United States.

Evaluation Statement

The entry demonstrates an understanding of the technology and the 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 advanced capabilities that span innovation from materials development through system design and construction. NE investments offer the promise of dramatically improved performance to meet U.S. energyneeds, as stated above, while maximizing the impact of DOE resources.

NE strives to promote integrated and collaborative research conducted by national laboratory, university, industry, and international partners in conjunction with NE's programs, and to deploy innovative nuclear energy technologies in order 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 nuclear energy challenges.

Technology Overview

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

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

The mission of the FC R&D program is to develop used nuclear fuel management strategies and technologies to manage and dispose of the nation's commercial used nuclear fuel and waste and to develop sustainable fuel cycle technologies and options that improve resource utilization and energy generation, reduce waste generation, enhance safety, and limit proliferation risk.

The program's vision is that by 2050, strategies and technologies for safe, long-term management and eventual disposal of U.S. commercial used nuclear fuel, and any associated fuel cycle technologies that enhance the accident tolerance of light water reactors and enable sustainable fuel cycles, are demonstrated and deployed. Together, these technologies and solutions support the enhanced availability, affordability, safety, and security of nuclear-generated electricity in the United States.

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

The RC RD&D program conducts RD&D on existing and advanced reactor designs and technologies to enable industry to address technical challenges involved in maintaining the existing fleet of nuclear reactors, and to promote the development of a robust pipeline of advanced reactor designs and technologies and supply chain capabilities. Program activities are designed to address technical, cost, safety, and security issues associated with the existing commercial light water reactor fleet and advanced reactor technologies, such as small modular reactor (SMR) and microreactor designs, fast reactors using liquid metal coolants, and high-temperature reactors using gas or liquid salt coolants.

Nuclear Energy Enabling Technologies (NEET)

The NEET program conducts R&D in crosscutting technologies that directly support and enable the development of new and advanced reactor designs and fuel cycle technologies. These technologies will advance the state of nuclear technology, improve its competitiveness, and help meet our nation's energy and environmental challenges. The activities undertaken in this program complement those within the RC RD&D and FC R&D programs. The knowledge generated through these activities will allow NE to address key challenges affecting nuclear reactor and fuel cycle deployment, with a focus on crosscutting technologies. Research areas include advanced modeling and simulation, advanced sensors and instrumentation, advanced materials and manufacturing technologies, nuclear cybersecurity, and integrated energy systems.

Market Opportunity

There exist a number of market opportunities 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 fleet, (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

- Nuclear Energy Enabling Technologies
  https://www.energy.gov/ne/nuclear-energy-enabling-technologies-neet
- 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
- Science, Technology, Engineering, and Math (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
- Versatile Test Reactor
  https://www.energy.gov/ne/versatile-test-reactor
- Space Power Systems
  https://www.energy.gov/ne/nuclear-reactor-technologies/space-power-systems

Office of Technology Transitions Bonus Focus: National Lab IP Licensing

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 DOE's 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.[45]

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.[46]

In 2015, the Secretary of Energy authorized the formation of OTT to develop and oversee the delivery of DOE's strategic vision and goals for technology commercialization and engagement with business and industry across the United States. OTT's statutory authority is derived from the Bayh-Dole Act of 1980, the Stevenson-Wydler Technology Innovation Act of 1980, the Energy Policy Act of 2005, and the 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.[47]

Bonus Challenge

OTT is challenging you to develop innovative business models to help accelerate the commercialization of 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.

Content

Introduction

OTT serves as the central hub for technology transfer activities across DOE's extensive R&D enterprise. At OTT, we work to ensure that groundbreaking scientific discoveries achieve their maximum public return and impact, advancing the economic, energy, and national security interests of the United States. That 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—

[45] https://www.energy.gov/technologytransitions/mission-0
[46] Ibid.
[47] Ibid.

fostering strong internal and external partnerships that guide innovations from the lab toward the marketplace.[48]

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.[49] One of the best ways to expand DOE's commercial impact is raising awareness among investors and industry about the capabilities and expertise housed at the agency's 17 national laboratories and facilities.[50]

Lab Partnering Service Tool

OTT's Lab Partnering Service (LPS) offers unprecedented access to the world's most advanced scientific facilities and researchers across DOE'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.[51]

Resources

- Lab Partnering Service https://labpartnering.org/ (search for "EnergyTech University Prize" in the "Discover…" search bar)
- Office of Technology Transitions https://www.energy.gov/technologytransitions/office-technology-transitions

Success Stories

- 2022 first-place team leveraged a technology from Ames National Laboratory: Mechanochemical Recover 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

[48] https://www.energy.gov/technologytransitions/office-technology-transitions
[49] Ibid.
[50] https://www.energy.gov/technologytransitions/lab-partnering-service
[51] Ibid.

Solar Energy Technologies Office 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.

Bonus Challenge

DOE's Solar Energy Technologies Office (SETO) is challenging you to develop an innovative business model for a 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 should be to increase the adoption of new solar technologies and maximize the performance and/or reduce the costs associated with the components, installation, and operation of solar energy systems.

Evaluation Statement

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

Content

Introduction

President Biden has set goals for the United States to create a carbon pollution-free power sector by 2035 and to achieve net-zero emissions, economy-wide, by 2050.[52] Solar energy, being the fastest-growing electricity source,[53] is expected to be key part of the U.S. strategy to achieve these goals. Solar generation satisfied about 3% of total U.S. electricity demand in 2020, and it is projected to serve 37%–42% of electricity demand by 2035.[54] Such substantial growth needs to be supported by technology innovation that addresses emerging challenges in the solar industry 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. However, solar radiation is not a form of energy that can be used directly. Solar technologies capture this radiation and convert sunlight into useful forms of energy. For example, photovoltaic (PV) technologies convert sunlight into electricity that can

[52] https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/
[53] https://www.c2es.org/content/renewable-energy/
[54] https://www.energy.gov/sites/default/files/2021-09/Solar%20Futures%20Study.pdf

be used directly or stored in batteries. Alternatively, mirrors can concentrate solar radiation to produce heat, which can generate electricity or be stored thermally.[55]

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 solar cells most commonly used in commercially available solar panels are made of crystalline silicon and have efficiencies typically ranging from 18%—22%.[56] PV installations can exist as large-scale electric utility plants or (more commonly) as residential, commercial, or industrial distributed energy resources (DERs) on building rooftops. Often, they are combined with energy storage (batteries), which are charged with solar energy and supply energy during 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 fluid, which can then be used to produce electricity, drive a variety of industrial applications, or be stored for later use. CSP is used primarily in very large power plants.[57]

Costs

Solar system costs comprise 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)[58] is a typical measure of the cost of energy production. LCOE is a measure of the average net present cost of electricity generation for a generating plant over its lifetime. It is used for investment planning and to compare different methods of electricity generation on a consistent basis.[59]

Over the past decade, solar energy has achieved significant cost reductions, resulting in very competitive LCOE.[60] Although the cost may vary drastically based on the amount of sunlight and type of solar panels installed, currently, the residential solar energy cost is about $0.08—$0.10 per kWh on average, while the commercial or utility-scale solar power cost is about $0.06—$0.08 per kWh.[61] DOE is targeting a LCOE for solar of $0.02—$0.05 per kWh by 2030.[62]

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.

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[55] https://www.energy.gov/eere/solar/how-does-solar-work
[56] https://www.energy.gov/eere/solar/crystalline-silicon-photovoltaics-research
[57] https://www.energy.gov/eere/solar/concentrating-solar-thermal-power-basics
[58] https://www.energy.gov/sites/prod/files/2015/08/f25/LCOE.pdf
[59] https://en.wikipedia.org/wiki/Levelized_cost_of_energy#:~:text=The%20levelized%20cost%20of%20energy,generation%20on%20a%20consistent%20basis.
[60] https://www.energy.gov/eere/solar/goals-solar-energy-technologies-office
[61] https://homeguide.com/costs/solar-panel-cost
[62] Ibid.

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 between 30kW$_{DC}$ and 1MW$_{DC}$. Such systems can be grid-connected systems or isolated, stand-alone systems and are often coupled with energy storage systems (ESS) or electric vehicle (EV) charging systems. SETO is interested in technologies that can reduce installation costs of 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.

Photovoltaic Cell Technologies and Materials

About 95% of the solar panels on the market today use either monocrystalline silicon or polycrystalline silicon as the semiconductor.[63] But silicon cells have a maximum theoretical efficiency of about 32%, so researchers are exploring new materials and cell designs that can improve conversion and performance, such as[64]:

- 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.[65] BIPV and PVBM exist in various forms, integrating solar panels on roofing products, building facades, curtain walls, fences, canopies, shade structures, or balcony balustrades.

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 allows agricultural activities to continue, with agricultural production taking place underneath solar panels, around 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.[66] Solar panels can be used in both open-field agriculture, in the form of solar arrays above crops or arrays with spacing in between where crops can grow, as well as in controlled-climate agriculture, at greenhouses that use sunlight (not indoor farming with artificial light).

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[63] https://www.energy.gov/eere/solar/articles/pv-cells-101-primer-solar-photovoltaic-cell
[64] https://www.energy.gov/eere/solar/articles/pv-cells-101-part-2-solar-photovoltaic-cell-research-directions
[65] https://www.nrel.gov/docs/fy00osti/25272.pdf
[66] https://www.energy.gov/eere/solar/seto-2020-solar-and-agriculture

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.[67] This technology, also referred to as 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 bodies of water, like freshwater reservoirs, wastewater ponds, or hydropower reservoirs.

Power Electronics

Power electronic (PE) devices are used to extract electric energy from solar panels and make it available for use by other devices. Inverters are used to convert the direct current (DC) electricity generated by PV modules into alternating current (AC) electricity, which is used for local transmission of electricity, as well as most appliances in our homes. DC/DC converters, on the other hand, 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 a solar system.[68, 69] Inverters and other PE converters typically use silicon-based power electronics. Recently, new wide-bandgap semiconductor materials, like silicon carbide (SiC), have been used in PE devices, demonstrating significant benefits and operating advantages, like smaller device sizes, lower weights, and higher efficiencies.[70]

Additional Resources

General

- DOE – Solar Energy Technologies Office
  https://www.energy.gov/eere/solar/solar-energy-technologies-office

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
  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

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[67] https://www.nrel.gov/state-local-tribal/blog/posts/floating-solar-photovoltaics-could-make-a-big-splash-in-the-usa.html
[68] https://www.energy.gov/eere/solar/solar-photovoltaic-system-design-basics
[69] https://www.energy.gov/eere/solar/solar-integration-inverters-and-grid-services-basics
[70] https://www.energy.gov/eere/solar/silicon-carbide-solar-energy

- U.S. Energy Information Administration (EIA) – Solar Explained https://www.eia.gov/energyexplained/solar/photovoltaics-and-electricity.php
- Solar Energy Industries Association (SEIA) – Photovoltaics https://www.seia.org/initiatives/photovoltaics
- Solar Energy Development Programmatic EIS (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
- NREL – Perovskite Solar Cells https://www.nrel.gov/pv/perovskite-solar-cells.html

Building Integrated Photovoltaics (BIPV)

- SEIA – Building Integrated Photovoltaics https://www.seia.org/initiatives/building-integrated-photovoltaics
- NREL – Building Integrated Photovoltaic Designs https://www.nrel.gov/docs/fy00osti/25272.pdf
- Whole Building Design Guide (WBDG) – Building Integrated Photovoltaics https://www.wbdg.org/resources/building-integrated-photovoltaics-bipv

Agrivoltaics

- National Center for Appropriate Technology (NCAT) – AgriSolar Clearinghouse https://www.agrisolarclearinghouse.org/
- University of Arizona – What is Agrivoltaics? https://research.arizona.edu/stories/what-is-agrivoltaics
- NREL – 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

- Sustainable Energy Coalition – Floatovoltaics: A solution for water and energy conservation? http://sustainableenergy.org/floatovoltaics-a-solution-for-water-and-energy-conservation/
- 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

Relevant Lab Partnering Service (LPS) Technologies

1. Improved Method for Measuring Solar Irradiance (Sandia) – https://doelps.org/HYOP2z
   Inexpensive, efficient, and accurate method of measuring the irradiance from solar reflections using a digital camera.
2. Alternating Current Photovoltaic Building Block (Sandia) – https://doelps.org/QW3bv7
   Fully integrated and self-containing AC PV building block device and method that allows PV applications to become true plug-and-play devices.
3. Enhanced Thin Film Organic Photovoltaic Devices (Brookhaven National Laboratory) – https://doelps.org/eVGpwF
   A novel structure design for thin-film OPV devices provides a system for increasing the optical absorption in the active layer.
4. Molten Salt Heat Transfer Fluid (HTF) for Solar Thermal Power Plant Applications (Sandia) – https://doelps.org/zkJkv9
   Heat transfer fluid for use as thermal-energy storage medium at elevated temperatures that has a lower freezing point than any molten salt mixture available commercially.

Relevant Lab Partnering Service (LPS) Success Stories

Photovoltaic Cells and Panels

1. Sandia-Led Center To Advance Understanding of New Solar Panel Technology (Sandia – 2021)
   https://www.labpartnering.org/stories/651979fe-3e7d-49a9-b72d-eebe8dcdc0a1
   Research center to support perovskite technology performance, reliability, and bankability.
2. Sandia Scientists Provide Technical Assistance to Rocking Solar, an American-Made Solar Prize Finalist With a Product That Could Transform the Urban Landscape (Sandia – 2021)
   https://www.labpartnering.org/stories/f1ce61a2-8292-4d97-b6c5-2d88243486d2
   Single-axis tracking design for commercial rooftop solar.
3. Sandia-Developed Solar Cell Technology Reaches Space (Sandia – 2021)
   https://www.labpartnering.org/stories/68d77320-c444-4ec4-b3a4-f47affdd122b
   Solar cell technology of highly interconnected photovoltaic cells ("solar glitter") that reduces cost and increases efficiency.
4. Miniature Flexible Solar Panels (Sandia – 2020)
   https://www.labpartnering.org/stories/424e1775-62bc-4082-b1f2-3bb9211a0308
   Microsystems-enabled photovoltaics (MEPV) technology ("solar glitter") with improved flexibility and ability to conform to shapes.
5. New Research Finds Power in Techno-Economic Comparison of Bifacial and Tracking PV Systems Combinations (Sandia – 2020)
   https://www.labpartnering.org/stories/dd5a9fd1-1d0f-4809-bf93-1d98d1cb510a
   Techno-economic comparison of combinations of bifacial and tracking PV systems.
6. SunPower and Sandia Partnership Leads to Demonstration of Innovative New Module Technology (Sandia – 2020)
   https://www.labpartnering.org/stories/2c30dda0-53ad-4b31-9873-bfbec180bebc
   Experimental photovoltaic PV system at the New Mexico Regional Test Center (RTC), co-located with Sandia's Photovoltaic Systems Evaluation Laboratory (PSEL).
7. Crystal Solar and NREL Team Up To Cut Costs (NREL – 2014)
   https://www.labpartnering.org/stories/4c090bdd-a1e4-45e9-bd4c-3901b1a4acc4
   A faster and cheaper way to manufacture silicon solar cells by growing high-quality, high-efficiency silicon wafers at 100 times the usual throughput and half the cost.

8. Award-Winning Etching Process Cuts Solar Cell Costs (NREL – 2013)
   https://www.labpartnering.org/stories/3d7e261a-9cd0-4c32-ab83-1e32ca4af238
   Award-winning etching process allowing solar cells to absorb more than 98% of incident sunlight and reducing solar cell costs.

Concentrating Solar Power (CSP)

1. Sandia's Expertise Puts a Round 4 American-Made Solar Prize Winner's Innovation to the Test (Sandia – 2021)
   https://www.labpartnering.org/stories/c17a15f8-9cdd-4f12-9abc-afdd1bf30f5c
   Flat plate collector system, which integrates a novel aerogel insulating material within non-concentrating, flat-plate collectors, enabling them to achieve high efficiencies with peak temperatures exceeding 150°C.
2. Testing Heat Exchangers Helps Move Solar Plans Forward (Sandia – 2021)
   https://www.labpartnering.org/stories/2d7fa4fb-0077-4a8e-a4ef-2ef83a9e2b2a
   Evaluation of heat exchanger performance for concentrating solar power (CSP) projects.
3. STARS Harnessing the Sun To Make Gases and Chemicals (Pacific Northwest National Laboratory – 2019)
   https://www.labpartnering.org/stories/4445a9d8-3be6-4955-aadb-2672b81e37dd
   Technology that captures sunlight in a parabolic dish and concentrates it to drive a chemical reaction producing chemical energy with 70% efficiency.
4. Falling Particle Receiver for Concentrated Solar Energy (Sandia – 2018)
   https://www.labpartnering.org/stories/ec7e7c03-1c47-490e-b30d-9a14a357103f
   A falling particle receiver for concentrating solar power systems (CSP) that moves sand-like ceramic particles, known as proppant, past the intensely concentrated sunlight beam to capture and store the heat more efficiently than the molten salts used in other CSP systems.

Solar Inverters and Power Electronics

1. NREL SolarCity and the Hawaiian Electric Companies (NREL – 2018)
   https://www.labpartnering.org/stories/ab659062-9685-4d6f-be61-12cd928ed4c6
   Addressing the safety, reliability, and stability challenges of interconnecting high penetrations of distributed PV with the electric power system.
2. Hawaiian Electric Advances Solar Inverters (NREL – 2016)
   https://www.labpartnering.org/stories/5f0e6edf-89a3-44b8-a63c-5e43730debf9
   Testing and performance demonstration of solar inverter functionality.
3. NREL + SOLECTRIA (NREL – 2015)
   https://www.labpartnering.org/stories/f30ce8ab-aab4-4742-bac5-e8ed311fc6d9
   Development of 500- and 750-kilowatt PV inverters with advanced features that can support the electric grid.
4. NREL GOOGLE (NREL – 2015)
   https://www.labpartnering.org/stories/3f312a2b-10f3-4963-a7e5-e57f7e771723
   Little Box Challenge: an open competition challenging engineers to build smaller power inverters for use in PV power systems.

Hybrid PV + Storage Systems

1. Sandia App Assesses Value of Energy Storage for Businesses Utilities (Sandia – 2021)
   https://www.labpartnering.org/stories/58dbdabe-c0b0-4fb8-a11a-088bee9b2c68
   Software (Quest) to evaluate different energy storage scenarios and model the potential of new solutions.

2. Stafford Hill Microgrid (ORNL – 2018)
   https://www.labpartnering.org/stories/a9d40ab4-bad9-4dc9-9268-cd675d92be76
   A 4MW/3.4-MWh battery system coupled with over 2 MW of solar PV located in western Vermont.
3. REopt Lite Tool To Optimize PV and Battery System Sizes (NREL – 2018)
   https://www.labpartnering.org/stories/4194b840-d882-4805-8ee3-48efa41d5898
   Free online tool to help with siting, sizing, and financially evaluating PV and battery storage projects.

Solar System Performance Evaluation

1. Sandia Uncovers Hidden Factors That Affect Solar Farms During Severe Weather (Sandia – 2021)
   https://www.labpartnering.org/stories/0d99c201-87e1-42e1-a8bd-ceac058e015b
   Advanced machine learning to study the impacts of severe weather on U.S. solar farms.
2. Rooftop Solar Panels Get Boost From Sandia Tool That Previews a Year on Grid in Minutes (Sandia – 2019)
   https://www.labpartnering.org/stories/9558995c-edbf-4996-a092-0f6c813972cd
   Simulation software that shows utility companies how rooftop solar panels at a specific house or business would interact with a local electrical grid throughout the year.
3. MOU Launches Collaboration To Study Photovoltaic Performance and Reliability Worldwide (Sandia – 2019)
   https://www.labpartnering.org/stories/d5565f18-0fe4-49d7-bd72-c8b98d5b346f
   Platform for studying photovoltaic performance and reliability in multiple diverse environments and climates.
4. SGHAT Software (Sandia – 2018)
   https://www.labpartnering.org/stories/d6539eba-66f6-493b-9838-87a4ebcb0814
   Solar Glare Hazard Analysis Tool (SGHAT) is a web-based software platform capable of evaluating the potential of glint/glare while optimizing energy production.

Safety/Security

1. Materials Developed at Sandia Help Extinguish Solar Panel Fires Before They Ignite (Sandia – 2020)
   https://www.labpartnering.org/stories/53462aa9-9ec6-426d-b5ac-faebbd6307fc
   Development of electrical in-line connectors that automatically predict and prevent PV arc-faults before they can ignite electrical fires.
2. Ensuring Cybersecurity in Solar Energy Systems (Sandia – 2020)
   https://www.labpartnering.org/stories/65ec6f76-dca0-45a3-9f57-1557594c8240
   Creation of cybersecurity standards and best practices for distributed energy resources.

Water Power Technologies Office Bonus Focus: Powering the Blue Economy

Statement of Interest

America has vast marine energy and hydropower resources, and there remains enormous potential to expand into new markets and applications and to increase generation and flexibility across the nation's sizable hydropower and pumped storage fleet. DOE's Water Power Technologies Office (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. (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.)

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

Bonus Challenge

WPTO is challenging you to develop an innovative business model 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.

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 of existing assets will be critical to furthering the nation's shorter-term electricity sector decarbonization goals and longer-term economywide objectives. Areas of opportunity include existing hydropower facilities and non-powered dams that can utilize new technologies to cost-effectively increase generation and flexibility; flexible and more rapidly deployable pumped energy storage systems; and marine energy technology, which can support new and growing industries utilizing waves, currents, tides, and ocean thermal gradients.

Water power also has important benefits across multiple infrastructure sectors and 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.

Technology Overview

Hydropower

Hydropower, or hydroelectric power, is one of the oldest and largest sources of renewable energy. It uses the natural flow of moving water to generate electricity. Hydropower currently accounts for 37% of total U.S. renewable electricity generation and about 7% of total U.S. electricity generation.[71] Hydropower technologies generate power by using the elevation difference, created by a dam or diversion structure, of water flowing in on one side and out on the other. Hydropower offers flexibility in both the short and long 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.

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, 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.

Market Opportunity

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

U.S. hydropower capacity continues to grow through upgrades to existing plants and other new, innovative 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 powering of non-powered dams (NPDs).[72] At the end of 2019, an additional 1,490 MW, from 217 projects, were in the U.S. development pipeline, 93% of which was slated to come from powering NPDs and expanding existing facilities.[73] PSH represents a particular area of opportunity, as the vast majority of energy storage capacity in the United States is PSH, and PSH is the preferred least-cost technology option for energy storage between 4 and 16 hours in duration.[74] Hydropower and its facilities also present an opportunity to capitalize on several non-power benefits.[75]

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[71] https://www.eia.gov/energyexplained/hydropower/
[72] https://www.energy.gov/eere/water/downloads/us-hydropower-market-report
[73] Ibid.
[74] https://www.eia.gov/energyexplained/hydropower/where-hydropower-is-generated.php.
[75] https://www.energy.gov/eere/articles/six-non-power-benefits-hydropower.

Because marine energy resources are sizable, predictable, reliable, geographically diverse, and can be developed in an environmentally responsible manner, marine energy represents a significant and emerging market across the entire United States, and particularly in the "blue economy." DOE's Powering the Blue Economy initiative seeks to understand the power requirements of coastal and maritime markets and to advance technologies that integrate marine renewable energy to relieve these power constraints and enable sustainable growth of the blue economy.

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 meet their energy and water needs (for example, through desalination or powering microgrids in remote areas).[76]

Additional Resources

- DOE Water Power Technologies Office
  https://www.energy.gov/eere/water/water-power-technologies-office
- Water Power Technologies Office 2020–2021 Accomplishments Report
  https://www.energy.gov/eere/water/water-power-technologies-office-2020-2021-accomplishments-report
- Energy I-Corps Resources: Tools and Training for Entrepreneurs
  https://www.osti.gov/biblio/1867238-review-technology-innovations-pumped-storage-hydropower
- 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
- 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

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

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

- Powering the Blue Economy
  https://www.energy.gov/eere/water/powering-blue-economy