Department of Energy (DOE)
Office of Energy Efficiency and Renewable Energy (EERE)

Industrial Efficiency and Decarbonization Office (IEDO) FY23 Multi-Topic FOA

Funding Opportunity Announcement (FOA) Number: DE-FOA-0002997
FOA Type: Initial
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FOA Issue Date:	03/15/2023
Submission Deadline for Concept Papers:	04/17/2023 5:00pm ET
Submission Deadline for Full Applications:	06/23/2023 5:00pm ET
Expected Submission Deadline for Replies to Reviewer Comments:	07/25/2023 5:00pm ET
Expected Date for EERE Selection Notifications:	September 2023
Expected Timeframe for Award Negotiations:	September – December 2023

a. Applicants must submit a Concept Paper by 5:00pm ET on the due date listed above to be eligible to submit a Full Application.

b. To apply to this FOA, applicants must register with and submit application materials through EERE eXCHANGE at https://eere-eXCHANGE.energy.gov, EERE's online application portal.

Applicants must designate primary and backup points-of-contact in EERE eXCHANGE with whom EERE will communicate to conduct award negotiations. If an application is selected for award negotiations, it is not a commitment to issue an award. It is imperative that the applicant/selectee be responsive during award negotiations and meet negotiation deadlines. Failure to do so may result in cancelation of further award negotiations and rescission of the selection.

c. **Unique Entity Identifier (UEI) and System for Award Management (SAM) - Each applicant (unless the applicant is excepted from those requirements under 2 CFR 25.110) is required to: (1) Be registered in the SAM at https://www.sam.gov before submitting its application; (2) provide a valid UEI number in its application; and (3) continue to maintain an active SAM registration with current information at all times during which it has an active federal award or an application or plan under consideration by a federal awarding agency. DOE may not make a federal award to an applicant until the applicant has complied with all applicable UEI and SAM requirements and, if an applicant has not fully complied with the requirements by the**

time DOE is ready to make a federal award, the DOE will determine that the applicant is not qualified to receive a federal award and use that determination as a basis for making a federal award to another applicant.

NOTE: Due to the high demand of UEI requests and SAM registrations, entity legal business name and address validations are taking longer than expected to process. Entities should start the UEI and SAM registration process as soon as possible. If entities have technical difficulties with the UEI validation or SAM registration process they should utilize the HELP feature on SAM.gov. SAM.gov will work entity service tickets in the order in which they are received and asks that entities not create multiple service tickets for the same request or technical issue. Additional entity validation resources can be found here: GSAFSD Tier 0 Knowledge Base - Validating your Entity.

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I. Funding Opportunity Description

A. Background and Context

i. Background and Purpose

This Funding Opportunity Announcement (FOA) is issued by the Industrial Efficiency and Decarbonization Office (IEDO), which builds on the legacy of the Advanced Manufacturing Office (AMO) to lead U.S. efforts to reduce emissions from the industrial sector. IEDO provides funding, management, and the strategic direction necessary for a balanced national program of research, development, and demonstration (RD&D) as well as technical assistance and workforce development to drive improvements in energy, materials, and production efficiency, and to accelerate decarbonization across the industrial sector. IEDO and its programs are critical to putting the nation on a pathway to achieve net-zero carbon emissions by 2050.[1]

Building a clean and equitable energy economy and addressing the climate crisis is a top priority of the Biden Administration. This FOA will advance the Biden Administration's goals to achieve carbon pollution-free electricity by 2035 and to "deliver an equitable, clean energy future, and put the United States on a path to achieve net-zero emissions, economy-wide, by no later than 2050"[2] to the benefit of all Americans. The Department of Energy (DOE) is committed to pushing the frontiers of science and engineering, catalyzing clean energy jobs through research, development, demonstration, and deployment (RDD&D), and ensuring environmental justice and inclusion of underserved communities.

This funding opportunity is part of an integrated industrial decarbonization technology development strategy for DOE's basic and applied research offices. Rooted in the principles identified in the 2022 Industrial Decarbonization Roadmap, DOE is building an innovation pipeline to accelerate the development and adoption of industrial decarbonization technologies with investments spanning foundational science; RD&D; and technical assistance and workforce development.[3] DOE's highly coordinated RD&D investments – leveraging resources and expertise from the Offices of Energy Efficiency and Renewable Energy, Fossil Energy and Carbon Management (FECM), Nuclear Energy (NE), and Science (SC) – are designed to achieve deep decarbonization across the industrial sector, targeting both industry-specific innovations and crosscutting technologies. This technology development strategy complements the

[1] Section 6003 of the Energy Act of 2020, as codified at 42 U.S.C. § 17113 et seq.
[2] Executive Order 14008, "Tackling the Climate Crisis at Home and Abroad," January 27, 2021.
[3] DOE, "Industrial Decarbonization Roadmap," 2022, https://www.energy.gov/eere/doe-industrial-decarbonization-roadmap.

demonstration and deployment efforts led by DOE's Offices of Clean Energy Demonstrations (OCED) and Manufacturing and Energy Supply Chains (MESC) and the Loan Programs Office (LPO).

Decarbonizing the industrial sector is critical to achieving net-zero emissions, economy-wide, by no later than 2050. In 2020, the industrial sector accounted for 33% of the nation's primary energy use and 30% of energy-related carbon dioxide (CO_2) emissions.[4] However, the industrial sector is considered one of the most difficult to decarbonize due to the diversity and complexity of energy inputs, processes, and operations.[5] Achieving net-zero emissions across the U.S. economy by 2050 will require an aggressive, multidimensional approach to eliminating industrial emissions.

In addition to consuming significant amounts of energy, resulting in greenhouse gas (GHG) emissions, many processes used in industrial facilities produce air pollutants with harmful impacts on respiratory and cardiovascular health, including nitrogen oxides (NO_x), carbon monoxide (CO), and particulate matter (PM). In the United States, racial and ethnic minority groups as well as lower-income groups are disproportionately exposed to elevated levels of air pollution and, consequently, experience higher rates of adverse health impacts compared to the general population.[6] Addressing pollution from industrial energy use is an integral step towards achieving environmental justice by remediating social, economic, and health burdens on those disproportionately harmed by industrial sector emissions.[7] Assessing community-level impacts and prioritizing energy justice help ensure the benefits of investments to decarbonize industry will flow to disadvantaged communities.[8] For additional insights, a broader look at environmental impact factors and associated lifecycle analysis is provided in the Quadrennial Technology Review 2015 technology assessment focused on sustainable manufacturing.[9]

[4] U.S. Energy Information Administration, Annual Energy Outlook 2021 with Projections to 2050, 2021.
[5] National Academies of Sciences, Engineering, and Medicine, Accelerating Decarbonization in the United States Energy Sector, February 2021. Available at: https://www.nap.edu/catalog/25932/accelerating-decarbonization-of-the-us-energy-system.
[6] Liu, et al., "Disparities in Air Pollution Exposure in the United States by Race/Ethnicity and Income, 1990–2010," *Environmental Health Perspectives* (2021). https://doi.org/10.1289/EHP8584; Tessum, et al. "PM2.5 polluters disproportionately and systemically affect people of color in the United States." *Science Advances* (2021). https://doi.org/10.1126/sciadv.abf4491.
[7] DOE Office of Economic Impact and Diversity. "How Energy Justice, Presidential Initiatives, and Executive Orders Shape Equity at DOE." January 3, 2022. https://www.energy.gov/diversity/articles/how-energy-justice-presidential-initiatives-and-executive-orders-shape-equity.
[8] Sec. 223 "Justice40 Initiative," Executive Order 14008 of Jan 27, 2021 "Tackling the Climate Crisis at Home and Abroad." https://www.federalregister.gov/d/2021-02177/p-163.
[9] See "Chapter 6: Innovating Clean Energy Technologies in Advanced Manufacturing | Sustainable Manufacturing - Flow of Materials through Industry Technology Assessment." DOE. Available at: https://www.energy.gov/sites/prod/files/2016/05/f31/QTR2015-6L-Sustainable-Manufacturing.pdf.

Specifically, this FOA will fund high-impact, applied research and development and prototype or pilot-scale technology validation and demonstration projects to advance the transformational technologies and innovations necessary to reduce energy use and GHG emissions in the industrial sector. This FOA advances the strategies identified in the *Industrial Decarbonization Roadmap*[10] and will focus on cross-sector approaches for industrial decarbonization (thermal processing, exploratory cross-sector topics, and low carbon fuels utilization) along with high GHG-emitting subsectors (chemicals, iron and steel, food and beverage, cement and concrete, and forest products). The focus will be energy-related emissions as well as non-energy-related process emissions (e.g., CO_2 from the calcination process in cement production). Cross-sector approaches include RD&D on components and equipment systems, technologies with broad applications across the industrial sector, and the integration of technology in industry-specific conditions.

By accelerating the development and adoption of sustainable technologies that increase efficiency and eliminate industrial GHG emissions, the RD&D activities to be funded under this FOA will contribute to a clean and equitable energy economy, bolster the technological and economic competitiveness of domestic manufacturing, and boost the viability and competitiveness of U.S. industrial technology exports.

This FOA and its associated projects are distinct from any existing or forthcoming efforts funded under the Bipartisan Infrastructure Law or Inflation Reduction Act, including activities related to Industrial Demonstration Projects.[11]

ii. Technology Space and Strategic Goals

In recent years there has been increasing recognition of the importance of industrial decarbonization. New approaches and technologies must be developed that will reduce absolute emissions from the industrial sector while allowing for growth and increasing productivity. The United States has the opportunity to take a leadership role in developing, demonstrating, and deploying technologies that will reduce U.S. GHG emissions. While some companies across different industrial subsectors have started making investments and setting decarbonization goals, more investment is needed to

[10] DOE, "Industrial Decarbonization Roadmap," 2022, https://www.energy.gov/eere/doe-industrial-decarbonization-roadmap.

[11] Section 41008 of the Bipartisan Infrastructure Law (the Infrastructure Investment and Jobs Act, Public Law 117-58) and Section 50161 of the Inflation Reduction Act (Public Law 117-169) authorized appropriations for demonstration projects that test and validate industrial emissions reduction technologies and invest in facility projects and retrofits. Associated activities will be led by the DOE Office of Clean Energy Demonstrations in DE-FOA-0002935 (https://oced-exchange.energy.gov/Default.aspx#FoaId17338316-4d87-4ff7-87e6-619175602ce3).

make significant carbon reductions across the industrial sector in the next few decades.

DOE's Industrial Decarbonization Roadmap[12] identifies strategies to reduce industrial emissions across five of the most energy- and carbon-intensive subsectors where decarbonization technologies can have the greatest impact: chemicals; petroleum refining; iron and steel; food and beverage; and cement (Figure 1). Together, these industries represent approximately 51% of energy-related CO_2 emissions in the U.S. industrial sector and 15% of U.S. economy-wide total CO_2 emissions. To reduce emissions across these sectors, the Roadmap focuses on four key pillars, accelerating the innovation and adoption of: energy efficiency technologies; industrial electrification technologies; low-carbon fuels, feedstocks, and energy sources (LCFFES); and carbon capture, utilization, and storage (CCUS) technologies. For each pillar, the roadmap identified the primary barriers and opportunities, as well as key research, development, and demonstration (RD&D) needs. Scenario modeling was utilized to show the potential application of these pillars and the effects they have toward achieving net-zero CO_2 emissions for the industrial sector. Relevant activities that address the four pillars are funded by a variety of offices in the Department of Energy. Some of these efforts are also addressed by the Bipartisan Infrastructure Law and Inflation Reduction Act, including provisions for industrial emission reduction demonstration and deployment projects which are separate from this FOA.

In particular, IEDO works closely with the Advanced Materials and Manufacturing Technologies Office (AMMTO). To realize its vision of a competitive U.S. manufacturing sector that accelerates the adoption of innovative technologies in support of a clean, decarbonized economy, AMMTO advances energy-related materials and manufacturing technologies to increase domestic competitiveness and build a clean, decarbonized economy. This FOA includes one subtopic (Subtopic 3b) that will directly support AMMTO's goals in manufacturing and scale-up of materials technologies that enable industrial efficiency and decarbonization.

[12] DOE, Industrial Decarbonization Roadmap, 2022, https://www.energy.gov/eere/doe-industrial-decarbonization-roadmap.

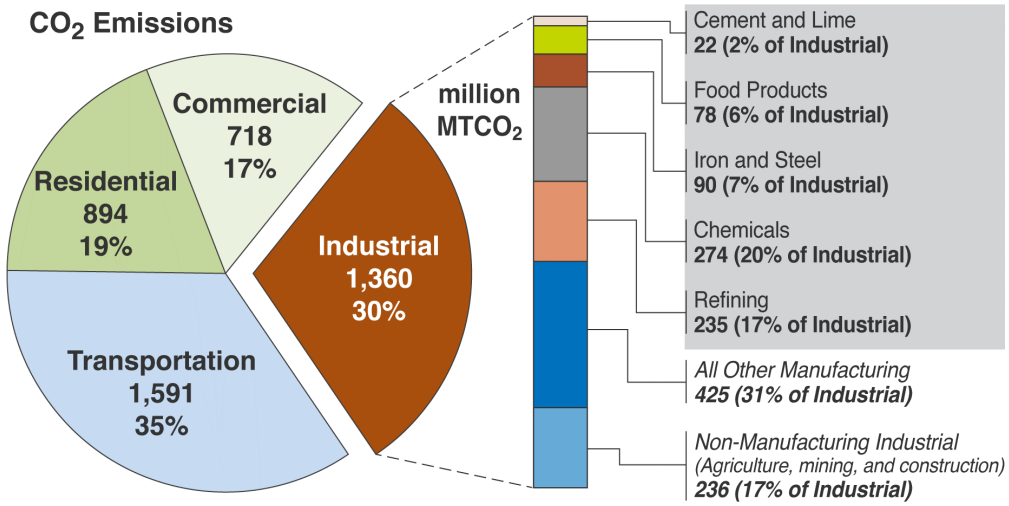

Figure 1. U.S. primary energy-related CO_2 emissions, in millions of metric tons, by end use sector (left pie chart) and a breakout by industrial subsector (right stacked chart) in 2020 from DOE's Industrial Decarbonization Roadmap.

To support the industrial decarbonization approaches identified in the Roadmap, DOE recently launched the Industrial Heat Shot™, a new Energy Earthshot™ aimed at dramatically reducing the cost, energy use, and carbon emissions associated with industrial heat demand.[13] The Industrial Heat Shot™ seeks to develop cost-competitive solutions for industrial heat with at least 85% lower GHG emissions by 2035. If this target is achieved, the American industrial sector will be on course to reduce its carbon equivalent emissions by 575 million metric tons by 2050, roughly equal to the annual emissions generated by all passenger cars currently on the road.

IEDO is issuing this FOA to fund high-impact, applied research, development, and pilot-scale technology validation and demonstration projects to advance the transformational technologies and innovations necessary to reduce energy use and GHG emissions in the industrial sector. This FOA advances the strategies identified in the Industrial Decarbonization Roadmap and supports the goals of the Industrial Heat Shot™ through its focus on cross-sector approaches for industrial decarbonization along with high GHG-emitting subsectors.

B. Topic Areas

The topics in this FOA align with DOE's shared strategic framework for development of industrial decarbonization technologies: (1) energy efficiency (advanced by all topics); (2) industrial electrification (Topics 1, 3, 4, 5, and 8); (3)

[13] DOE, Energy Earthshots – Industrial Heat Shot Fact Sheet, https://www.energy.gov/sites/default/files/2022-09/earth-shot-industrial-heat-fact-sheet.pdf.

low-carbon fuels, feedstocks, and energy sources (Topics 2, 3, 4, 5, 6, 7, and 8); (4) carbon capture, utilization, and storage (Topics 4 and 7); and (5) manufacturing technology innovation (Topic 3).

IEDO intends to fund high-impact, applied research and development (R&D) and pilot-stage technology validation and demonstration activities through this funding opportunity announcement (FOA). Proposed requested funding levels and project durations should be commensurate with the work scope necessary to advance the technology to the proposed technology readiness level (TRL). See Appendix F for EERE's definitions of TRLs. In general, efforts should primarily include work scopes between TRL 4 and TRL 7 to develop and validate technology advancements to facilitate industrial decarbonization.

All work under EERE funding agreements must be performed in the United States. See Section IV.J.iii. and Appendix C.

Tiers: Awards will be made at one of two funding levels, with maximum award amount by tier and topic indicated in the table below:

A. **Tier 1 projects** are primarily focused on TRL 4 and TRL 5 R&D activities to validate technology components in a laboratory or relevant environment. For select areas of interest (AOIs) (Topic 1 AOIs 1 and 2, Topic 2 AOIs 1 and 2, Subtopic 3a AOI 1, Subtopic 3b, and Topic 4), efforts can begin in TRL 3. The cost share for Tier 1 projects must be at least 20% of the total allowable costs.
B. **Tier 2 projects** can include activities in TRL 4 and 5 but must also include scope to include TRL 6 and/or TRL 7 to conduct system/subsystem prototype or pilot-scale technology validation in a relevant or operational environment. Tier 2 projects should be organized into distinct phases and should include Phase 2 and/or Phase 3, below:
    a. Phase 1: Research and development (optional)
    b. Phase 2: Design and testing
    c. Phase 3: Installation and demonstration

Tier 2 applications with technology demonstration integrated into industrial operations must include Phase 3. The cost share for Phase 1 and Phase 2 must be at least 20% of the total allowable costs. For Phase 3, the demonstration phase, the cost share must be at least 50% of total allowable costs.

Total allowable costs represent the sum of the government share, including FFRDC costs if applicable, and the recipient share of allowable costs for the project. See Appendices A and B for further discussion regarding cost-share.

Topic Area	Tier 1 Maximum Funding Level	Tier 2 Maximum Funding Level
1. Decarbonizing Industrial Heat	$3 million	$6 million
2. Low-Carbon Fuels Utilization R&D	$3 million	$5 million
3a. Enabling Flexible Industrial Energy Use	$3 million	$5 million
3b. Enhanced Thermal Conductivity Materials	$1.5 million	N/A
4. Decarbonizing Chemicals	$3 million	$10 million
5. Decarbonizing Iron and Steel	$4 million	$10 million
6. Decarbonizing Food and Beverage Products	$3 million	$8 million
7. Decarbonizing Cement and Concrete	$4 million	$10 million
8. Decarbonizing Paper and Forest Products	$3 million	$8 million

Applicants should note that Topic 3b will be funded and managed by the Advanced Materials and Manufacturing Technologies Office (AMMTO).

Industry Partners: All applications in Topics/Subtopics 1, 2, 3a, 4, 5, 6, 7, and 8 (i.e., all except Subtopic 3b) are strongly encouraged to include an industry partner on the project team. The term "Industry Partner" includes non-profit and for-profit entities engaged in production, processing, or equipment manufacturing in an industry relevant to the topic.

Metrics and Benchmarks: Applications must clearly identify the starting and ending TRL for the project and justify the TRLs assigned. Energy and GHG intensity analyses should be included, including a comparison of the current, commercially available state-of-the-art technology with the proposed advancement for both a unit level and national level if broadly implemented.

For all topics and subtopics, the applicant must identify key technical and market barriers to successful achievement of topic/subtopic goals. Applicants must identify key metrics and targets to address those barriers, consistent with technical and market analysis of their application space, and clearly indicate how the proposed innovations will satisfy those metrics. Applicants are expected to explicitly compare their proposed technology advancement to an existing state-of-the-art baseline, in terms of both cost and performance, with justification as to why that technology is the appropriate baseline. Successful applicants will be required to have periodic assessments of their metrics during the award to evaluate potential impacts, and applications should include project-specific experimental metrics that can be evaluated at interim and end-of-project milestones. Examples of potential metrics are provided in each topic description.

Note on FY22 Industrial Efficiency and Decarbonization FOA: Many of the Topics and Areas of Interest (AOIs) covered in this FOA are similar in scope to those included in DE-FOA-0002804 (Industrial Efficiency and Decarbonization

FOA, henceforth "FY22 FOA"). Full applications submitted to the FY22 FOA are currently under review. For topic areas within this FOA with substantially similar AOIs as the FY22 FOA, applicants that responded to the FY22 FOA are strongly discouraged from resubmitting largely identical applications to those currently under review.

Topic Area 1: Decarbonizing Industrial Heat

Topic 1 Background and Opportunity: Process heating, or thermal processing, is essential to manufacture a wide variety of industrial and consumer products, including those made from metal, plastic, rubber, carbon fiber, concrete, glass, ceramics, and biomass. Thermal energy is needed to transform materials through processes such as drying, curing, melting, forming, sintering, calcining, and smelting.[14]

Process heating represents the largest energy use and the largest source of GHG emissions in the manufacturing sector. In 2018, process heating accounted for 31% of sectoral energy use (7.5% of economy-wide energy use) and 51% of sectoral energy-related GHG emissions (10% of economy-wide energy-related GHG emissions).[15] Direct energy use for process heating in the manufacturing sector includes fuel combustion (66%), steam (30%), and electricity (4%). When the fuel used to generate steam and electricity is considered, at least 95% of energy used for process heat is derived from combustion, including both fossil fuels and waste/byproduct fuels. Furthermore, about one-third of energy consumed in providing process heat is ultimately lost as waste heat.

The DOE Industrial Decarbonization Roadmap highlights the significant opportunity for cross-sector impact in developing technologies to reduce the emissions impact of thermal processing.[16] Addressing the heterogenous array of processes and industries with varied process heating requirements will require a competitive portfolio of low- and zero-carbon solutions, including clean sources of thermal energy, transformative low-thermal-budget technologies, waste heat management technologies, and other supplemental technologies.[17] This portfolio approach will enable individual plants to determine the options best suited to their needs, weighing application, economics, geography, and other

[14] DOE, Quadrennial Technology Review 2015, Technology Assessment 6I: Process Heating Systems, https://www.energy.gov/sites/prod/files/2016/06/f32/QTR2015-6I-Process-Heating.pdf.
[15] DOE AMO, Manufacturing Energy and Carbon Footprints (2018 MECS), 2021, https://www.energy.gov/eere/amo/manufacturing-energy-and-carbon-footprints-2018-mecs.
[16] DOE, Industrial Decarbonization Roadmap, 2022, https://www.energy.gov/eere/doe-industrial-decarbonization-roadmap.
[17] DOE AMO, Thermal Process Intensification: Transforming the Way Industry Uses Thermal Process Energy, 2022, https://doi.org/10.2172/1871912.

factors. Within this portfolio of industrial heating technologies, electrification will be an essential strategy for decarbonization as the carbon intensity of the electric grid decreases.

Topic 1 Technology Focus: This topic will accelerate high-impact technology innovations for equipment and components to decarbonize thermal processes across the industrial sector, contributing toward the goal of DOE's Industrial Heat Shot: to develop a cost-competitive portfolio of industrial heat decarbonization technologies with at least 85% lower GHG emissions by 2035.[18]

Because existing thermal processes are often relatively inefficient—for example, fossil-fuel-based thermal dehydration processes often operate with thermal efficiencies in the range of 20% to 60%—many electrified heating technologies, alternative low-thermal budget processes, and other low-carbon technologies have the potential to improve efficiency and reduce energy use.[19] Electromagnetic heating technologies, for example, can reduce thermal losses by precisely delivering energy directly into materials. Industrial heat decarbonization technologies can also offer non-energy and non-emissions co-benefits, which may include improved product quality, increased productivity, lower water consumption, and improved air quality. Many of these co-benefits are not considered as part of industrial plants' investment decision-making processes, partly because they have not been clearly quantified and monetized.[20] Identification and quantification of co-benefits as part of the RD&D process can accelerate commercialization and adoption of these technologies. Applications are encouraged to include elements addressing the identification and quantification of non-energy and non-emissions co-benefits.

Topic 1 is focused on cross-sectoral impact and seeks applications pursuing advancements that will contribute to decarbonization of thermal processes across multiple industries. Thus, applications and concept papers must discuss the potential for cross-sectoral impact to justify the cross-sector nature of the proposed technology. Applicants are encouraged to assemble project teams that include advisers from multiple relevant industries. Applications focused on technologies or processes relevant to only a single subsector are not of interest for Topic 1.

In many cases, deploying innovative process heating technologies may require industrial plants to modify interconnected thermal transport systems, including

[18] Industrial Heat Shot | Department of Energy. https://www.energy.gov/eere/industrial-heat-shot.
[19] A.S. Mujumdar and Z.H. Wu, "Thermal Drying Technologies New Developments and Future R&D Potential; HEFAT2007 5th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics".
[20] Laaguidi, et al., The Non-Energy Benefits for Industrial Electric Technologies, ACEEE Summer Study on Energy Efficiency in Industry 2021, https://www.aceee.org/sites/default/files/pdfs/ssi21/panel-2/Laaguidi.pdf.

heat exchangers, heat transfer media, and other components. For all AOIs in Topic 1, applicants are encouraged to consider what process integration challenges may arise when their technologies are deployed and how these challenges might be addressed or eliminated.

Topic 1 seeks both Tier 1 and Tier 2 applications. During the award performance period, an assessment of carbon emissions, energy intensity, and cost must be validated via lifecycle analysis (LCA) and techno-economic analysis (TEA). Applications submitted under this topic must address at least one of the AOIs stated below.

Area of Interest 1 – Electrification of Industrial Heat: This AOI seeks applications for the development, optimization, and/or integration of electrified thermal processing equipment that can utilize clean electricity to reduce the emissions intensity of existing processes. With these technologies, fundamental process steps and parameters may remain the same, but the method of supplying heat may change significantly. In addition to energy and emissions reductions, application of electrified heating technologies may offer reduced heating time, improved temperature uniformity, reduced manufacturing cost, improved product quality, higher product yield, reduced waste byproducts, and other co-benefits.

Technologies of interest include, but are not limited to, furnaces, boilers, ovens, heaters, and other thermal processing equipment powered by electric resistance, induction, electric arc/plasma, and electric infrared heating. Technologies of interest also include hybrid systems that utilize a combination of process heating technologies based on different heating principles and/or energy sources (at least one of which is electricity), including systems powered by multiple electrotechnologies and systems powered by a combination of electricity and combustion. Innovative electrified process heating technologies beyond the specific examples listed here are also encouraged. This AOI highly encourages applications focused on addressing equipment development needs at commercially relevant scales.

Area of Interest 2 – Innovative Low- and No-Heat Processes: This AOI seeks applications to enable transformative low-thermal-budget processes, which achieve similar end products to current processes while utilizing significantly less thermal energy. Replacing or supplementing currently used processes with low- or no-thermal-budget methods can also offer benefits beyond energy and emissions reductions such as reduced cost, improved product quality or yield, reduction in waste byproducts, and/or use of alternative feedstocks.

Examples of innovative low- and no-heat processes include, but are not limited to:

- Application of electromagnetic radiation (e.g., UV, microwave) to utilize unique material–wave interactions
- Mechanical separations
- Thermomagnetic processing
- Acoustic, microwave, and other advanced drying processes.

Innovative low-thermal-budget process technologies beyond the specific examples listed here are also encouraged.

Because low-thermal-budget processes represent fundamental shifts in the way that energy is delivered to materials, this AOI encourages applications that incorporate modeling-, design-, and/or equipment-based approaches to optimize and integrate the technology in various applications and to elucidate the underlying physics of the process as part of their workplan. Potential approaches include, but are not limited to, materials characterization, multiphysics modeling, machine learning/artificial intelligence, co-design of processes and equipment, conformable/adaptable applicators, and use of sensors and controls. This AOI highly encourages applications focused on addressing equipment development needs at commercially relevant scales.

AOI 1 and AOI 2 Candidate Metrics and Targets: Proposals should justify that their technology will have a significant impact on reducing fossil fuel consumption and/or CO_2 emissions. Applications will be evaluated based on the potential to reduce carbon emissions annually within the industrial sector at the national level if broadly implemented. Applicants must clearly explain how the proposed technology will meet the following metric:

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Reduce carbon intensity of thermal processes	% carbon intensity change as measured by ton CO_2 equivalent (CO_2e)/kg product	85%	>90%	*Applicant defined*

Additional metrics and critical criteria that will lead to successfully meeting the goal above should also be identified, including non-energy/non-emissions co-benefits. Metrics should be specific to the proposed technology and must define

appropriate benchmarks or baselines, minimum targets, and stretch targets. Examples of applicant-identified metrics include the following:

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Reduce energy consumption	Btu/kg product	10%	30%	*Applicant Defined*
Increase throughput	Production per unit of time	10%	30%	*Applicant Defined*
Decrease operating cost	$/kg product	10%	30%	*Applicant Defined*
Reduce criteria air pollutant emissions	% Pollutant change as measured by ton pollutant / ton product	*Applicant Defined*	*Applicant Defined*	*Applicant Defined*

Area of Interest 3 – Industrial Heat Pumps: This AOI seeks applications on innovations in the design and integration of industrial heat pumps (IHPs). Compared to other electrified heating technologies that can approach 100% efficiency, heat pumping technologies can most often significantly exceed this metric by moving heat, bypassing the limitations of energy conversions. Using electrical energy to move thermal energy also enables and leverages the availability of onsite or locally sourced low-grade heat (low-temperature heat source) that is wasted or goes unused, increasing its conversion into higher-quality heat (high-temperature heat sink) and making IHPs more cost-effective and higher-performing. Despite the energy and emissions advantages of IHPs, adoption by U.S. industry lags behind other nations, and additional RD&D is needed to lower costs, simplify integration, reduce direct GHG emissions, and expand the application space for IHPs.[21]

For this AOI, innovative solutions to simplify system design and integration are of high interest. Such technologies can drive adoption by lowering costs and technical hurdles. Integration of IHPs in existing industrial processes will require a systems approach because waste heat is not constant during operation and application. Technologies of interest include, but are not limited to, standardized or modular designs for common applications, standardized components, and approaches for system design and optimization (e.g., advancement of pinch

[21] American Council for an Energy-Efficient Economy, Industrial Heat Pumps: Electrifying Industry's Process Heat Supply, 2022, https://www.aceee.org/research-report/ie2201.

analysis methods; novel machine learning/artificial intelligence-based methods for system design, heat integration, and/or operational strategies). Innovative approaches for system design and integration beyond the specific examples listed here are also encouraged.

Additionally, this AOI seeks research advances for all IHP components, including, but not limited to: next-generation low-global warming potential (GWP < 10) refrigerants with high critical temperatures and low critical pressures; new construction materials that can reduce capital costs; temperature-resistant components; heat exchanger materials and design; and compressors. Highly innovative technologies such as non-refrigerant-based solutions (e.g., non-vapor compression solutions, functional materials), heat-activated heat pumps, and steam-generating heat pumps are also encouraged. Applications targeting sink temperatures up to 200°C are encouraged.

AOI 3 Candidate Metrics and Targets: Proposals should justify that their technology will have a significant impact on reducing fossil fuel consumption and/or CO_2 emissions. Applications will be evaluated based on potential to reduce carbon emissions annually within the industrial sector at the national level if broadly implemented.

Applicants must identify and justify appropriate metrics for their technologies and clearly indicate how the proposed innovations will satisfy those metrics. Given the wide range of technology suitable for this AOI, targets for specific use applications are not defined but innovations must exceed the state-of-the-art performance significantly. Metrics should be specific to the proposed technology and must define appropriate benchmarks or baselines, minimum targets, and stretch targets. Applicants are encouraged to consider the following metrics as examples:

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Improve payback period, cost-effectiveness	Years	*≤ 3 years*	*≤ 2 years*	*Applicant Defined*
Coefficient of performance (COP) @ highest supply temperature	Percent	*≥ 45% Carnot COP*	*≥ 55% Carnot COP*	*Applicant Defined*

Energy intensity reduction	Percent	*≥ 40%*	*≥ 70%*	*Applicant Defined*
Lifetime	Years	*≥ 12 years*	*≥ 20 years*	*Applicant Defined*
Reduce direct GHG emissions (refrigerants)	GWP value	*≤ 10*	*≤ 3*	*Applicant Defined*

Not of interest in Topic 1: Applications focused on technologies or processes relevant to only a single subsector are not of interest for Topic 1. Additionally, DOE is not interested in funding applications in this topic focused on carbon capture, utilization, and sequestration (CCUS), onsite electricity generation, or the production of fuels/chemicals from byproducts or wastes.

Topic Area 2: Low-Carbon Fuels Utilization R&D

Topic 2 Background and Opportunity: Low-carbon fuels, feedstocks, and energy sources present a significant opportunity for decarbonization for hard-to-abate industrial subsectors. Approximately 90% of manufacturing process heat energy is provided by fossil fuels;[22] as the DOE Industrial Decarbonization Roadmap identifies, alternative low-carbon energy sources have the potential to provide the same heat with significantly reduced emissions.[23] Low-carbon fuels such as hydrogen are especially attractive for subsectors and processes that require higher temperatures (> 300°C) or direct heating, such as iron & steel, cement, glass, and refining.[24] Among five of the most CO_2-emitting industrial subsectors alone, high-temperature heat (> 300°C) was responsible for over 2,000 TBtu of heat energy used, with processes going well above 1100°C.[25] In alignment with the Industrial Heat Energy Earthshot, clean hydrogen fuel and low-carbon CHP are potential pathways toward achieving at least 85% emissions reductions for industrial process heat by 2035.[26]

Because hydrogen produces a 2100°C flame when burned in air, hydrogen combustion has promise as a low-carbon solution to high-temperature process

[22] NREL, Solar for Industrial Process Heat Analysis, n.d., https://www.nrel.gov/analysis/solar-industrial-process-heat.html.
[23] DOE, "Industrial Decarbonization Roadmap," 2022, https://www.energy.gov/eere/doe-industrial-decarbonization-roadmap.
[24] DOE, National Clean Hydrogen Strategy and Roadmap, 2022, https://www.hydrogen.energy.gov/pdfs/clean-hydrogen-strategy-roadmap.pdf.
[25] DOE, "Industrial Decarbonization Roadmap," 2022, https://www.energy.gov/eere/doe-industrial-decarbonization-roadmap.
[26] Industrial Heat Shot | Department of Energy. https://www.energy.gov/eere/industrial-heat-shot.

heat needs. Currently, most hydrogen is made by reforming natural gas, but clean production of hydrogen from renewables, nuclear power, or fossil fuels with carbon capture can reduce GHG emissions associated with hydrogen generation. Hydrogen blended or used in conjunction with incumbent fuels has the potential to act as a transitional strategy, reducing GHG emissions while mitigating potential technological risks to industrial sites. Initiatives such as DOE's HyBlend address technical barriers to adding hydrogen to natural gas sources.[27]

Low-carbon-input, flexible combined heat and power (CHP) also has potential to contribute to decarbonization of the industrial sector. In 2018, CHP and cogeneration provided 2,729 TBtu of onsite energy for U.S. manufacturing, but—by primarily taking fossil fuels as inputs—produced 145.2 million metric tons (MMT) CO_2e in accompanying emissions.[28]

Topic 2 Technology Focus: Topic 2 will focus on research, development, validation, and demonstration needed to accelerate the commercial readiness of hydrogen-fueled process heating technology and low-carbon-input, flexible CHP.

Fuel switching for industrial process heating equipment can require significant retrofit or, in some cases, completely new design. This is because of the lower volumetric calorific value of hydrogen, its higher flame speed and adiabatic flame temperature, and differences in the heating profiles and exhausts of hydrogen combustion. These differences yield unique combustion environments that must be accommodated to avoid issues such as flashback and high-temperature hydrogen attack, while ensuring appropriate and adequate heating process environments with new fuels. The issues are further exacerbated by the heterogeneity of industry and processes: broadly applicable solutions using hydrogen must be developed to address multiple industrial subsectors in a cost-effective way. Systems-level approaches are needed to realize the widespread use and adoption of hydrogen-based combustion technology.

One of the most significant issues facing hydrogen combustion end-use in the industrial sector is NO_x mitigation. Recent studies have found that burning

[27] DOE EERE Hydrogen and Fuel Cells Technologies Office, "HyBlend: Opportunities for Hydrogen Blending in Natural Gas Pipelines," n.d., https://www.energy.gov/eere/fuelcells/hyblend-opportunities-hydrogen-blending-natural-gas-pipelines.

[28] DOE, Manufacturing Energy and Carbon Footprint – Sector: All Manufacturing (NAICS 31-33), 2022, https://www.energy.gov/sites/default/files/2022-01/2018_mecs_all_manufacturing_energy_carbon_footprint.pdf.

hydrogen in industrial settings results in significantly higher NO_x emissions.[29] Given the higher adiabatic flame temperature of hydrogen, NO_x emissions from its combustion must be tightly controlled to avoid the harmful environmental and health effects of NO_x.

For onsite generation, CHP enables highly efficient use of fuels. "Flexible" CHP—CHP systems that allow the ratio of output heat to power to be modulated—can further provide support services to the grid. In industrial systems, these CHP systems can provide added value to facilities while allowing industrial users to meet unique operational needs. CHP systems installed at industrial sites can provide many of the same benefits as utility-owned peaking plants using distributed generation technologies.[30]

Applicants should develop and demonstrate new advances in hydrogen combustion and/or low-carbon-input CHP to accelerate the commercial readiness of low-carbon fuel utilization. While demonstrations in partnership with Industry Partners in specific subsectors are encouraged, applications must thoroughly address and justify the potential impacts of their technologies in multiple subsectors. Applications submitted under this topic must address at least one of the areas of interest below.

Topic 2 is focused on cross-sectoral impact and seeks applications pursuing advancements that will contribute to utilization of hydrogen or low-carbon-input flexible CHP across multiple industries. Thus, applications and concept papers must discuss the potential for cross-sectoral impact to justify the cross-sector nature of the proposed technology. Applicants are encouraged to assemble project teams that include advisers from multiple relevant industries. Applications focused on technologies or processes relevant to only a single subsector are not of interest for Topic 2.

For AOI 1, AOI 2, and AOI 3, this topic seeks both Tier 1 and Tier 2 applications. For Tier 1, applications should prove concepts in a relevant environment at TRL 3–5 at an appropriate scale to advance the technology toward commercialization. Applications must show potential for >85% reduction in carbon emissions. Applications must establish the potential to be cost-competitive with commercially available state-of-the-art technology. During the award performance period, carbon emissions, energy intensity, and cost must be validated via LCA and TEA.

[29] Cellek et al., "Investigations on performance and emission characteristics of an industrial low swirl burner while burning natural gas, methane, hydrogen-enriched natural gas and hydrogen as fuels," *International Journal of Hydrogen Energy* 43 (2018).

[30] DOE AMO, "Flexible Combined Heat and Power (CHP) Systems," 2018, https://www.energy.gov/sites/prod/files/2018/01/f47/Flexible CHP Comms_01.18.18_compliant.pdf.

For Tier 2, applications should validate concepts in a relevant environment or operational environment at TRL 5–7 at an appropriate scale to advance the technology toward commercialization. Applications must show potential for >85% reduction in carbon emissions and must establish the potential to be cost-competitive with commercially available state-of-the-art technology. During the award performance period, carbon emissions, energy intensity, and cost must be validated via LCA and TEA.

Area of Interest 1 – Mitigating H_2 Combustion Impacts on Material and Product Quality: This AOI seeks applications for innovative technologies that identify and mitigate potentially negative impacts of H_2 combustion on product and process quality. Potentially negative impacts of moving from conventional fuels to H_2 combustion include altered heat transfer, heating profiles, and exhaust gas (including water vapor and NO_x). Research channels for improvements include modeling and simulation to understand and mitigate effects on process environment, modifications to auxiliary components, and firebox modifications. Every application must include an experimental validation component.

EERE expects all applications to meet or exceed NO_x emissions targets (on par with that of natural-gas-based process heating). Each application must be able to accept variable fuel blends, including 0% hydrogen, 100% hydrogen, and ranges in between.

Area of Interest 2 – Developing H_2-Based Combustion Systems: This AOI seeks applications for innovative hydrogen combustion systems to enable safe and effective hydrogen-blended combustion for process heating. Potential integral system hardware could include, but is not limited to, furnace and burner designs, NO_x mitigation systems, fuel injectors and nozzles, and operational design technology (sensors and controls). This topic emphasizes systems-level design and implementations of H_2-based technology. While development of key components and hardware is encouraged, target technologies must be able to demonstrate that they can deliver the needed process heat within a system design in a relevant industrial environment.

All applications are expected to meet or exceed NO_x emissions targets (on par with those of natural-gas-based process heating). Each application must be able to accept variable fuel blends, including 0% hydrogen, 100% hydrogen, and ranges in between.

Area of Interest 3 – Low-Carbon-Input, Flexible CHP: This AOI seeks applications for R&D to enable industrial implementations of flexible CHP that utilize clean fuel sources such as H_2, biofuels, or renewable resources (e.g., solar thermal,

geothermal, or thermal energy storage). Applications should address the unique load balancing considerations presented by flexible CHP by presenting innovative prime movers and other CHP components to meet industrial needs. This AOI is limited to CHP onsite generation.

Not of interest in Topic 2: Applications focused on technologies or processes relevant to only a single subsector are not of interest for Topic 2. An example of cross-sectoral approaches for hydrogen combustion applications could be industries with similar high temperature heat needs and sensitivities to potential negative impacts of hydrogen combustion. DOE is not interested in funding applications in this topic focused on hydrogen production, storage, or transportation. Additionally, DOE is not interested in funding applications in this topic focused on carbon capture, utilization, and sequestration (CCUS), onsite electricity generation, or the production of fuels/chemicals from byproducts or wastes.

Topic 2 Candidate Metrics and Targets: Applications must show potential for >85% reduction in carbon emissions while achieving NO_x emissions targets. Applications will be evaluated based on potential to reduce carbon emissions annually within the industrial sector at the national level if broadly implemented. Technologies must also establish the potential to be scalable in terms of material availability and scaling operations to reach production capacity.

Applications must clearly explain how the proposed technology will meet the following metrics, including defining appropriate benchmarks or baselines:

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Enable GHG emissions reduction	% CO_2e reduction/heat delivered	85%	> 90%	*Applicant defined*
NO_x emissions	ppm	Equivalent to or better than natural gas		*Applicant defined*

Additional metrics and critical criteria that will lead to successfully meeting the goal above should also be identified. Relevant benchmarks/baselines, minimum targets, and stretch targets should be included for each metric. Examples of applicant-identified metrics include the following:

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Process improvements	Increased yield/heat delivered	30%	> 70%	*Applicant defined*
Reduce pollutant exposure	% pollutant change as measured by ton pollutant/heat delivered	*Applicant defined*	*Applicant defined*	*Applicant defined*

Project Safety Plan: Safe practices in the production, storage, distribution, and use of hydrogen are essential for the widespread acceptance of hydrogen and fuel cell technologies. Successful awardees with proposed hydrogen work must comply with the following requirements:

- The recipient is required to coordinate with the Hydrogen Safety Panel (HSP), a resource of the DOE Hydrogen and Fuel Cells Program, throughout the project life cycle. Examples of opportunities for HSP involvement include participation in post-award project kickoff meetings, project design and document reviews, risk assessments, and pre-startup reviews prior to beginning field demonstrations. To minimize project impacts, these engagements should be coordinated with regularly scheduled project activities rather than be unique efforts and should be based on discussions with the HSP.
- All awarded projects are required to submit safety plans. Guidance for the creation of the Safety Plan can be found at https://h2tools.org/sites/default/files/Safety_Planning_for_Hydrogen_and_Fuel_Cell_Projects.pdf. The Safety Plan should cover the full scope of the project, including work by the prime recipient as well as any subrecipients, and should be completed before the relevant work discussed in the Safety Plan is started. The Safety Plan is due to DOE within 90 days after the award is signed unless alternative timing is approved due to project constraints. The Safety Plan should be included as a task in the Statement of Project Objectives. The HSP will review the Safety Plan and provide feedback to the recipient (through DOE) within approximately 30 days of receipt. The recipient will then have 30 days to respond to the HSP's feedback (e.g., either by incorporating comments into the Plan or by providing rationale for not incorporating comments) and submit a revised Safety Plan to DOE.

DOE may request HSP involvement in site visits or via teleconferences. If a safety-focused site visit/teleconference is requested, the HSP will provide a written site visit report to the recipient for review and comment and may conduct a follow-up interview with the recipient and project team. All such HSP reports are also provided to DOE.

Topic Area 3: Exploratory Cross-Sector R&D

Emerging efficiency and decarbonization concepts in the industrial sector can provide enhanced facility value and significantly increase efficiency. This topic encompasses two subtopics: (a) Enabling Flexible Industrial Energy Use and (b) Enhanced Thermal Conductivity Materials.

Subtopic 3a: Enabling Flexible Industrial Energy Use

Subtopic 3a Background and Opportunity: A key challenge limiting adoption of technologies powered by renewable resources (e.g., wind and solar energy) is the intermittent nature of those resources. Supporting technologies must be developed that enable industry to remain resilient and economically competitive as renewable and variable resources are integrated into industrial energy usage.

The ability to accommodate and respond to variability in energy inputs, whether via flexible processes or auxiliary systems such as energy storage, is a key component to realizing emissions reductions in a resilient and reliable industrial sector. The Energy Storage Grand Challenge's Energy Storage for Manufacturing and Industrial Decarbonization workshop identified energy storage systems as potential technologies to increase renewable energy usage in industry.[31] The National Renewable Energy Laboratory's Electrification Futures Studies similarly found that demand-side flexibility can contribute to emissions reductions by enabling high renewable penetration and electrification.[32] In the event of an outage, flexible systems have the potential to shift energy demand to avoid loss of production, reduced product quality, potential damage to equipment, and potentially lengthy waits to recover full production capabilities.[33]

[31] DOE Office of Scientific and Technical Information, *Energy Storage for Manufacturing and Industrial Decarbonization (Energy StorM)*, Technical Report SAND2022-12303, 2022, https://www.osti.gov/servlets/purl/1887337.

[32] NREL, "Flexible Loads and Renewable Energy Work Together in a Highly Electrified Future," 2021, https://www.nrel.gov/news/program/2021/flexible-loads-and-renewable-energy-work-together-in-a-highly-electrified-future.html.

[33] Heffron et al., "Industrial demand-side flexibility: A key element of a just energy transition and industrial development," *Applied Energy* 269 (2020).

Moreover, flexible industrial energy use has the potential to enhance facility value by enabling grid-interactive industry. By participating in demand response programs, industrial customers may be able to benefit from lower wholesale market prices and reduce costly peaker loads, while providing ancillary services to the grid. Industrial customers constitute the largest demand-side contribution to peak load reduction potential with an estimated 47% of the total across all retail programs.[34] Grid-interactive industry also capitalizes on the enormous amounts of energy used in the industrial sector to provide energy capacity for grid stabilization in the face of a changing grid mix.

Subtopic 3a Technology Focus: Topic 3a focuses on developing and demonstrating technologies that will enhance industrial resilience and increase the flexibility of industrial energy usage. Many manufacturing facilities that currently participate in peak shaving programs often limit their flexible capabilities to less-critical, lower energy-intensity, and/or time-flexible process loads such as HVAC. There is a significant opportunity to address load flexibility in more energy-intensive processes such as pumps, compressed air, and materials processing equipment.[35] Demonstration of systems that can operate flexibly while maintaining process, production, and quality metrics are needed. While thermal energy storage can provide valuable load shifting, innovations addressing cost-effective implementation in industrial settings is needed. Industrial thermal storage systems need innovations in efficient transport and deployment of heat, high R-value insulation, minimal customization for all temperature ranges, and pilot demonstrations and proof-of-concept systems.[36]

While demonstrations in partnership with Industry Partners in specific subsectors are encouraged, applications should thoroughly address and justify the potential impacts of their technology in multiple subsectors. Applications submitted under this subtopic must address at least one of the AOIs below.

Subtopic 3a is focused on cross-sectoral impact and seeks applications pursuing advancements that will contribute to industrial load flexibility or thermal energy storage across multiple industries. Thus, applications and concept papers must discuss the potential for cross-sectoral impact to justify the cross-sector nature of the proposed technology. Applicants are encouraged to assemble project teams that include advisers from multiple relevant industries. Applications

[34] Federal Energy Regulatory Commission. "2022 Assessment of Demand Response and Advanced Metering." 2022. https://www.ferc.gov/media/2022-assessment-demand-response-and-advanced-metering.
[35] DOE. Quadrennial Technology Review – Chapter 6: Innovating Clean Energy Technologies in Advanced Manufacturing, 2015, https://www.energy.gov/sites/prod/files/2017/03/f34/qtr-2015-chapter6.pdf.
[36] DOE Office of Scientific and Technical Information, *Energy Storage for Manufacturing and Industrial Decarbonization (Energy StorM)*, Technical Report SAND2022-12303, 2022, https://www.osti.gov/servlets/purl/1887337.

focused on technologies or processes relevant to only a single subsector are not of interest for subtopic 3a.

For AOI 1 and AOI 2, this subtopic seeks both Tier 1 and Tier 2 applications. For Tier 1, applications should prove concepts in a relevant environment at TRL 3–5 at an appropriate scale to advance the technology toward commercialization. Applications must establish the potential to be cost-competitive with commercially available state-of-the-art technology. During the award performance period, carbon emissions, energy intensity, and cost must be validated via LCA and TEA.

For Tier 2, applications should validate concepts in a relevant environment or operational environment at TRL 5–7 at an appropriate scale to advance the technology toward commercialization. Applications must establish the potential to be cost-competitive with commercially available state-of-the-art technology. During the award performance period, carbon emissions, energy intensity, and cost must be validated via LCA and TEA.

Area of Interest 1 – Industrial Load Flexibility: This AOI seeks applications for innovative technologies that would allow core unit operations that typically have fixed energy input levels to operate flexibly. These technologies are sometimes referred to as "virtual batteries" and capitalize on the enormous amounts of energy used in the industrial sector to increase resilience and provide value-added ancillary services. Technologies to realize industrial load flexibility can include, but are not limited to, dynamic heat management, power electronics to enable grid interactivity, distributed sensing and control systems, and novel electrification and processing methods that can maintain system balance with variable inputs. Applications must demonstrate an increased capability for flexibility in energy usage compared to the state of the art. Applications addressing non-interruptible core unit operations and processes are encouraged.

AOI 1 Candidate Metrics and Targets: Analyses of enabled penetration of intermittent low-carbon energy sources must be included with a comparison of the current commercially available state-of-the-art technology if broadly implemented at the national level. Applications will be evaluated based on potential to increase use of intermittent low-carbon energy sources and decrease facility downtime annually within the industrial sector at the national level if broadly implemented. Technologies must also establish the potential to be scalable in terms of material availability and scaling operations to reach production capacity.

Additional metrics and critical criteria that will lead to successfully meeting the goals of the project should also be identified. Relevant benchmarks/baselines,

minimum targets, and stretch targets should be included for each metric. Examples of applicant-identified metrics are in the table below.

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Increased flexibility	% energy usage around baseline	+/- 35%	+/- 70%	*Applicant defined*
Reduced downtime	% decrease in hours plant is off-line	50%	100%	*Non-flexible baseline or state-of-the-art flexible system for same product/process output*
Increased productivity	% increase in production per unit time	10%	> 70%	*Non-flexible baseline or state-of-the-art flexible system for same product/process output*
Cost savings	$/kg product	Cost analysis should be conducted in relation to the incumbent non-flexible system.		

Area of Interest 2 – Thermal Energy Storage Systems: This AOI seeks applications to develop and integrate thermal energy storage systems for providing industrial process heat. Research advances are required in multiple thermal energy storage system components, including potentially new storage materials and mechanisms, efficient transportation and deployment of stored heat, and technologies that improve operational lifetime, as well as demonstrations that show the capabilities and long-term benefits of thermal energy storage. Given the cross-sector opportunity for thermal energy storage, applications must include detailed subsystem design for integration into industrial processes. Applications must also detail the integration constraints of their systems and show the systems' ability to be integrated into multiple

industrial subsectors. Applications that focus primarily on power generation from thermal storage are not of interest.

AOI 2 Candidate Metrics and Targets: Applications will be evaluated based on the potential to reduce carbon emissions annually within the industrial sector at the national level if broadly implemented. Technologies must also establish the potential to be scalable in terms of material availability and scaling operations to reach production capacity.

Additional metrics and critical criteria that will lead to successfully meeting the goals of the project should also be identified. Relevant benchmarks/baselines, minimum targets, and stretch targets should be included for each metric. Examples of applicant-identified metrics are provided in the table below.

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Increased flexibility	% energy usage around baseline	+/- 35%	+/- 70%	*Applicant defined*
Round trip efficiency	energy delivered/ energy input	≥ 70%	≥ 90%	*Applicant defined*
Exergetic efficiency of the storage system	exergy used in industrial process/exergy input	≥ 50%	≥ 70%	*Applicant defined*
Thermal cycles	Charge-Discharge cycles	1,000	10,000	*Applicant defined*
Thermal Capacity	MW·h	5	50	*Applicant defined*
Payback period	years	8	3	*Applicant defined*
Discharge time	hours	10	48	*Applicant defined*
Cost	$/kW·h	Cost analysis should indicate parity with other readily available energy sources.		

Not of interest in Subtopic 3a: Applications focused on technologies or processes relevant to only a single subsector are not of interest for Subtopic 3a. Additionally, DOE is not interested in funding applications in this topic focused on carbon capture, utilization, and sequestration (CCUS), onsite electricity generation, or the production of fuels/chemicals from byproducts or wastes.

Subtopic 3b: Enhanced Thermal Conductivity Materials

Subtopic 3b Background and Opportunity: Thermally conductive materials are needed in industrial and energy technology applications critical for electrification and decarbonization. The performance and efficiency of thermal processing equipment, including heat pumps and associated heat exchangers, determine their performance and utility in process heating and thermal energy storage applications (see Topic 1 and Subtopic 3a AOI 2). Broadly speaking, heat exchangers are critical to efficient thermal energy exchange in numerous industrial applications with valuable applications in electricity generation, heat transport, thermal management, and waste heat recovery. While heat exchangers depend critically on their design and manufacturing [37] they also are dependent on the thermal properties of component materials and their operating temperatures. Materials for better thermal dissipation have become critical for energy efficiency in any application with a compact footprint—especially retrofits to convert from fossil to electric operation. Thus, given the acceleration of electrification in industry, there is also a need for accelerated materials and manufacturing RD&D and scale-up in these areas.

Subtopic 3b Technology Focus: This subtopic will accelerate manufacturing R&D on innovative materials and systems to reduce energy use of electrified equipment and processes. It seeks new, cost-effective materials with thermal conductivity (and hence system efficiency) enhanced above that of today's commercially available conductors (by at least 10 watts per meter-Kelvin (W/m-K)). Technical challenges include lowering costs of manufacturing and fabrication, especially for high thermal conductivity materials (e.g., > 300 W/m-K). Moderate conductivity (< 300 W/m-K) materials such as polymers, amorphous carbon, silica, and others are already cost-effective and have other desirable properties but need conductivity improvements to accelerate wide-spread adoption. Proposals sought should include descriptions of innovative materials compositions and processing methods that enable enhanced thermal conductivity. Proposals sought should include characterization and/or theory,

[37] ARPA-E HITEMMP, 2018, https://arpa-e.energy.gov/technologies/programs/hitemmp. HITEMMP projects target heat exchangers capable of operating for tens of thousands of hours in temperatures and pressures exceeding 800°C and 80 bar (1,160 psi) respectively. This new class of hardware, designed and manufactured using novel techniques, topologies, and materials, would enable far greater exchanger efficiency, thus boosting the performance of many important industrial processes.

modeling, and simulation to improve fabrication of enhanced thermal conductivity materials. The proposed thermal conductivity enhancement (of 10 W/m-K or greater) should be above a documented baseline such as those in the table below.

Element or alloy[38]	**W/m-K @25°C**
In-plane graphite	~4300[39]
Isotopically purified graphene	~3500
Diamond*	2200 (3320 syn)
Silver	428
Carbon nanotube fibers	> 350
Doped silicon	130–148
Phosphor bronze	110
Alumina	36
Boron	25
Silica quartz mineral	1.4–3
Ice (0°C, 32°F)*	2.18
Amorphous carbon	1.7
Polyethylene low density (PEL)	0.33
Polytetrafluoroethylene (PTFE)	0.25

** insulator*

Applications submitted under this subtopic must address the AOI below. This subtopic seeks Tier 1 applications only.

Area of Interest 1 – Thermal Conductors with Moderate to High Electrical Conductivity: This AOI focuses on increasing the thermal conductivity of conductors that also have moderate to high electrical conductivity (e.g., metals, graphene, carbon nanotubes). It is intended to complement innovations resulting from the DOE AMMTO CABLE Prize[40] and the Enhanced Conductivity

[38] Except where otherwise noted, Table references are from Table 6 of Topic 9b in US DOE SBIR FY22 Topic Descriptions (https://science.osti.gov/-/media/sbir/pdf/TechnicalTopics/FY22-Phase-I-Release-2-Combined-TopicsV512012021.pdf).

[39] Machida et al., "Phonon hydrodynamics and ultrahigh–room temperature thermal conductivity in thin graphite," *Science* 367, 309–312 (2020).

[40] American-Made Challenges, CABLE Conductor Manufacturing Prize, https://herox.com/cable

Metal-based Systems subtopic of the AMMTO FY22 Multi-Topic FOA,[41] which emphasize electrical conductivity. Today, most thermal conductors in widespread industrial and commercial use for heat exchangers and in heat pumps are metal.[42] This subtopic solicits innovative R&D proposals that also include some characterization or theory, modeling, and simulation to improve the fabrication of enhanced-thermal-conductivity metals and non-metals. Improved thermal conductivity can target many applications, including unique anisotropic application (directional optimization) for tunable materials that can function as thermal diodes.

Directional conductivity enhancement is of particular interest because most applications—from the largest industrial to the smallest microelectronics heat exchangers—prefer heat transfer in a particular direction. No minimum *baseline* (e.g., in conductivity (W/m-K), temperature (K), or load (W)) is required—it must be appropriate for the application being targeted and its other non-conductivity related (e.g., strength, corrosion-resistance, weight, footprint) material requirements. Applicants should address how their particular target should address their intended application. At a minimum, however, the *enhancement* in thermal conductivity should be above the range of 10 W/m-K. Non-metals can include, but are not limited to, polymers and carbonaceous materials, including bulk nanocarbons such as carbon nanotube fibers. The application should clearly describe the connection between experimental data and theoretical modeling. This subtopic is about bridging the gap between theory and the fabrication of these enhanced-thermal-conductivity materials. Note that while enhanced electrical conductivity also is of interest for this AOI, there is no minimum electrical conductivity requirement.

Examples of technical challenges to be addressed include:

- Lower energy and carbon emissions associated with mechanical, physical processing, or chemical refining
- Simulation and modeling of manufacturing scale-up from micro- (e.g., 10 grams) to commercial- (kilograms) to industrial-scale (tons)
- Simulation and modeling of order of magnitude cost-per-kg reductions (for both materials and processing) for high thermal conductivity (>300 W/m-K) materials, which are generally more costly than moderate thermal conductivity materials.

[41] DOE, "Department of Energy Announces $52 Million to Fund Applied Research and Development for Materials and Technologies to Drive Innovation in Clean Manufacturing," Jan. 4, 2023, https://www.energy.gov/eere/amo/articles/department-energy-announces-52-million-fund-applied-research-and-development.

[42] DOE AMO, Thermal Process Intensification: Transforming the Way Industry Uses Thermal Process Energy, 2022, https://doi.org/10.2172/1871912.

Not of interest in Subtopic 3b: DOE is not interested in funding applications in this subtopic focused on solely empirical theoretical models. Subtopic 3b will not accept Tier 2 applications.

Subtopic 3b Candidate Metrics and Targets: Competitive applications should have the potential to enhance thermal conductivity at least 10 W/m-K, compared to current technology, and also significantly reduce CO_2e emissions (e.g., % MMT annually if broadly implemented). Applications that target higher thermal conductivity materials (> 300 W/m-K), which are normally more expensive, must show significantly reduced cost. Applicants must clearly explain how the proposed technology will meet the following metrics:

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Increased end use energy efficiency and lower emissions	Thermal conductivity improvement W/m-K @25°C	10	30	*Applicant defined*
For applications targeting high thermal conductivity materials, only (> 300 W/m-K), dramatically reduced cost	Factor cost reduction ($/kg) for composition and fabrication	10X	30X	*Applicant defined*

Topic Area 4: Decarbonizing Chemicals

Topic 4 Background and Opportunity: The chemicals sector consumes the most energy and emits the most carbon within U.S. manufacturing, accounting for an estimated 8,169 trillion British thermal units (TBtu) of primary energy consumption in 2018 (including both feedstock and fuel use) and an associated 332 MMT of CO_2e GHG emissions (including both process and energy-related emissions).[43] The scale of both the entire industry and individual facilities presents a significant opportunity for decarbonization and reduction of global GHG emissions.

The chemicals industry is also a major contributor to the U.S. economy, supporting over 25% of the U.S. gross domestic product and exporting $153

[43] DOE AMO, Manufacturing Energy and Carbon Footprints (2018) – Chemicals Sector, 2021, https://www.energy.gov/sites/default/files/2021-12/2018_mecs_chemicals_energy_carbon_footprint_0.pdf.

billion of U.S. goods.[44] The chemicals industry converts raw materials into more than 70,000 different products,[45] which are used to make a wide variety of consumer goods that are essential inputs to other sectors of the U.S economy, including agriculture, manufacturing, pharmaceuticals, and construction.

Reducing GHG emissions and energy input is a key principle of the broader national objective towards sustainable chemistry, aiming to design and use chemicals with lower impacts on human and environmental health.[46] Broadly, sustainable chemistry can be defined as the design, development, and use of chemicals and materials that have lower energy consumption and emissions, are less toxic to human health and the environment, have reduced natural resource impacts, and are designed for reduced waste and increased recycling capability across the product lifecycle.[47] Decarbonization of the chemicals sector offers opportunities to incorporate aspects of sustainable chemistry throughout manufacturing operations, as an important contribution to the Biden Administration's Environmental and Energy Justice goals.[48]

The breadth of the chemicals sector underscores the difficulty of decarbonizing an industry with an extensive value chain and deep sectoral interconnections. Process heating alone accounted for over 70 MMT CO_2e in the chemical industry in 2018.[49] Improvements in process heating can be achieved through more efficient heating or reduced heat requirements with advanced unit operations, including advanced catalysts, advanced reactor concepts, and advanced separations.

Decarbonization of the chemicals sector will require dynamic and multi-faceted approaches for innovations that leverage the pillars of decarbonization including energy efficiency improvements; electrification of processes; and low-carbon fuels, feedstocks, and energy sources.

Topic 4 Technology Focus: Topic 4 will focus on the development, validation, and demonstration needed to accelerate the commercial readiness of emerging low-carbon unit operations to decarbonize the full supply chain of the chemicals

[44] American Chemistry Council, Data & Industry Statistics, 2021.
[45] Ibid.
[46] U.S. Government Accountability Office, Chemical Innovation, 2018, https://www.gao.gov/assets/gao-18-307.pdf.
[47] DOE AMO, Sustainable Chemistry in Manufacturing Processes Roundtable, 2020, https://www.energy.gov/eere/amo/articles/sustainable-chemistry-manufacturing-processes-roundtable.
[48] Executive Order 14008, Tackling the Climate Crisis at Home and Abroad, 2021, https://www.federalregister.gov/documents/2021/02/01/2021-02177/tackling-the-climate-crisis-at-home-and-abroad.
[49] DOE AMO, Manufacturing Energy and Carbon Footprints, Chemicals Sector (2018), 2021, https://www.energy.gov/sites/default/files/2021-12/2018_mecs_chemicals_energy_carbon_footprint_0.pdf.

sector. Technologies of interest include the potential to significantly reduce (>85%) carbon emissions and increase energy efficiency for high-volume chemical manufacturing, as are technologies that consider sustainable chemistry practices, as defined in Topic 4 Background and Opportunity.

Applications should address the production of high-volume, energy-intensive, high-carbon emissions chemicals, including petrochemicals (NAICS[50] 325110), basic organic chemicals (NAICS 325519), nitrogenous fertilizers (NAICS 325311), basic inorganic chemicals (NAICS 325180), and plastics materials and resins (NAICS 325211). Applications must aim to produce chemical product(s) with a current U.S. production volume >1 MMT or justify the ability for the technology to have broader decarbonization potential within the chemicals sector.

Applications including technologies that produce chemical(s) via alternative feedstocks, including CO_2, carbon monoxide, biobased feedstocks, recovered plastics, and renewable natural gas are strongly encouraged. Applications must consider heterogeneity and variability in feedstock quality through use of realistic feedstocks. Applications must justify that the proposed alternative feedstock can be scalable to meet demand of targeted chemical products.

This topic seeks applications for innovative unit operations with preference for technologies addressing challenges specific to the chemicals sector. Chemical specific technologies include advanced separations, reactor systems, and catalysts.

Advanced separations capable of replacing thermal-based evaporators and distillation processes are of interest. Examples include, but are not limited to, reactions driven by non-equilibrium processes, membranes, or processes that are driven by electrochemical or other novel separation technologies. Separation technologies must be robust and durable in realistic operational environments, including longevity and stability in corrosive or acidic environments of chemical manufacturing processes. Applications focused on hard-to-separate chemical products (e.g., olefins/paraffins, liquid–liquid extractions) are encouraged.

Other areas of interest include advanced reactors capable of improving reaction performance while reducing carbon emissions through reactor systems for thermal catalytic, non-catalytic oxidation, electrochemical, and non-contact energy transfer for precision heating (e.g., microwave and plasma) or other novel reactor technologies. Applications must consider the optimization or

[50] North American Industrial Classification System (NAICS). Used by federal statistical agencies in classifying business establishments for the purpose of collecting, analyzing, and publishing statistical data related to the U.S. business economy. Details on specific codes and references are available at https://www.census.gov/naics/.

design of the reactor system, including heat transfer and catalysts, when applicable. Applications must improve the conversion, selectivity, and stability of the reactor system and components compared to the current state of the art.

Additionally, this topic is significantly interested in technologies that are capable of manufacturing high-volume, energy-intensive, high-carbon emissions chemicals from waste CO_2. Applications focused on CO_2 utilization should address critical scale-up challenges including energy efficiency of thermal and electrochemical reactors, mass- and heat- transfer limitations, component stability, etc.

Applications focused on dynamic catalyst science[51] must apply data analytics and modeling with transient characterization techniques for realistic industrial reactions with advanced *operando* spectroscopic methods that have time resolution on the scale of 10^{-3} seconds. Applications must inform industrial catalyst formulation, process conditions, or catalyst performance through structural characterization, microkinetic data, or transport phenomena.

This topic seeks both Tier 1 and Tier 2 applications. For Tier 1, applications should prove concepts in a relevant environment at TRL 3–5 at an appropriate scale to advance the technology toward commercialization—for example, 1/100 of the current commercial-scale process—and achieve a continuous operation by the end of the project. Applications must show potential for >85% reduction in carbon emissions of the unit operation, and it is encouraged that proposals include an energy intensity reduction of >30%. Applications must establish the potential to be cost-competitive with commercially available state-of-the-art technology. During the award performance period, carbon emissions, energy intensity, and cost must be validated via LCA and TEA.

For Tier 2, applications should validate concepts in a relevant environment or operational environment at TRL 5–7 at an appropriate scale to advance the technology toward commercialization—for example, scaling to 1/50 of the current commercial scale process for a continuous operation. Applications must show potential for >85% reduction in carbon emissions of the unit operation, and it is encouraged that proposals include energy intensity reduction of >30%. Applications must establish the potential to be cost-competitive with commercially available state-of-the-art technology. During the award performance period, carbon emissions, energy intensity, and cost must be validated via LCA and TEA.[52]

[51] DOE AMO, 2020 Dynamic Catalyst Science Roundtable, 2020, https://www.energy.gov/eere/amo/events/dynamic-catalyst-science-roundtable.

[52] For processes using CO_2 as an alternative feedstock, LCA advice can be found in The National Energy Technology Laboratory CO2U LCA Guidance Toolkit: https://www.netl.doe.gov/LCA/CO2U.

Additionally, implementation of sustainable chemistry processes in chemicals manufacturing can positively influence communities near chemicals production facilities by improving local air quality and reducing risk of exposure to harmful chemicals. Applications are encouraged to discuss impacts of their technologies as related to principles of sustainable chemistry processes within the scope of work and the Community Benefits Plan.

Not of interest in Topic 4: DOE is not interested in funding applications in this topic focused on the production of alternative feedstocks, including projects exclusively focused on the capture of carbon dioxide.

Topic 4 Candidate Metrics and Targets: Applications must show potential for >85% reduction in carbon emissions of the unit operation, and it is encouraged that proposals also include energy intensity reduction >30%. Applications will be evaluated based on potential to reduce carbon emissions annually within the chemicals sector at the national level if broadly implemented. Technologies must also establish the potential to be scalable in terms of material availability and scaling operations to reach production capacity.

Applications must clearly explain how the proposed technology will meet the metrics in the table below, including defining appropriate benchmarks or baselines.

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Reduce carbon intensity	% carbon intensity change as measured by ton CO_2e/kg product	> 85%	> 100%	*Applicant Defined*
Reduce energy consumption	Btu/kg product	*Applicant Defined*	*Applicant Defined*	*Applicant Defined*

Additional metrics and critical criteria that will lead to successfully meeting the goal above should also be identified. Relevant benchmarks/baselines, minimum targets, and stretch targets should be included for each metric; these can also include co-benefits, such as a reduction in criteria air pollutants. Examples of applicant-identified metrics are provided in the table below.

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Process improvements	Increased yield/per physical unit input	30%	> 70%	*Applicant Defined*
Reduce cost	Unit (product mass or part basis) cost vs. state of the art	Cost parity	> 50%	*Applicant Defined*
Increase component lifetime (e.g., catalyst stability)	Number of cycles or time before regeneration or replacement	30%	> 50%	*Applicant Defined*
Reduce criteria air pollutant emissions	% pollutant change as measured by ton pollutant/ton product	*Applicant Defined*	*Applicant Defined*	*Applicant Defined*

Topic Area 5: Decarbonizing Iron and Steel

Topic 5 Background and Opportunity: Steel is a vital material across economic sectors, with uses in transportation, homes, commercial buildings, and industrial equipment, as well as many other applications used in everyday life. Total U.S. steel mill shipments were around 95 million net tons of steel in 2018, with an import market share of finished steel estimated at 23% of total consumption.[53] To produce these products, the U.S. steel industry consumed over 1 quadrillion Btu (quad) of energy and accounted for an estimated 71 MMT of GHG emissions in the same year, excluding off-site electricity and steam generation losses.[54] While significant, US GHG emissions per ton of steel are relatively low, globally, due to the high proportion of electric arc furnace (EAF)-based domestic steel production. Key industry operations include integrated steelmaking, EAF

[53] American Iron and Steel Institute, "AISI Releases 2018 Annual Statistical Report," 2019, https://www.steel.org/2019/07/aisi-releases-2018-annual-statistical-report-2/.

[54] DOE AMO, 2018 Manufacturing Energy and Carbon Footprints – Iron and Steel Sector, 2021, https://www.energy.gov/sites/default/files/2021-12/2018_mecs_iron_steel_energy_carbon_footprint.pdf.

steelmaking, direct reduced iron production, and downstream steel mill operations.

Steelmaking remains a relatively energy-intensive process, with considerable GHG emissions. There is no single solution for the decarbonization of the steel industry. Possible pathways to a decarbonized steel industry include approaches such as alternative iron and steelmaking, hydrogen injection into the blast furnace, utilizing clean electricity sources, increased use of scrap, and integrating hydrogen use into existing fossil fuel processes. Use of hydrogen in steelmaking must overcome challenges to ensure product quality and operational sustainability. Other offices within EERE and across DOE are investing in technology development to provide an infrastructure capable of supplying clean hydrogen and renewable electricity to help enable the industry to decarbonize its operations.

Topic 5 Technology Focus: Applicants under this topic should develop and achieve advances in technologies leading to commercial readiness of low-carbon or net-zero-carbon process technologies for the iron and steel industry. During the award performance period, an assessment of carbon emissions, energy intensity, and cost must be validated via LCA and TEA. Applications submitted under this topic must address at least one of the AOIs stated below. All AOIs for Topic 5 seek both Tier 1 and Tier 2 applications.

Area of Interest 1 – Innovative Manufacturing Technologies to Enable Decarbonization: This AOI seeks applications for innovative technologies that enable decarbonization in ore-based or scrap-based iron and steelmaking operations. Innovative technologies may include, but are not limited to, the following: new ironmaking or steelmaking technologies (up to 400 kg/day scale); low-carbon reduction of iron; feedstock flexibility such as blast furnace (BF) alternative injection processes, coke substitution, EAF variable metallic feedstock processing; continuous operating EAF; and heat recovery. This AOI covers areas inclusive of:

1. Ore-based routes, from beneficiation, reduction, BF, basic oxygen furnace (BOF), and refining
2. Scrap-based route, from scrap and metallics use through EAF and refining operations.

Area of Interest 2 – Electrification of Existing Manufacturing Processes: This AOI seeks applications for technologies that convert existing iron and steelmaking thermal processes to utilize electricity. Possible applications include reheat and annealing furnaces, finishing operations, combustion applications, vessel preheaters, etc. Applications must describe how the proposed technology will

withstand the harsh environment associated with iron and steelmaking operations while maintaining or improving operations.

Area of Interest 3 – Overcoming Challenges Associated with Utilizing Hydrogen in Steelmaking: This AOI seeks applications for innovative technologies that overcome the challenges (operational and product quality) associated with the use of hydrogen in steelmaking operations. Innovative technologies may include, but are not limited to, the following: utilizing hydrogen-based direct reduced iron in an EAF, refractory modifications, and maintaining steel quality in furnaces utilizing hydrogen.

Area of Interest 4 – Addressing Scrap Contaminants in Recycling: This AOI seeks applications for technologies that minimize or eliminate tramp elements from entering the steelmaking process. Possible applications include scrap sorting technologies to separate tramp elements such as copper and tin.

Not of interest in Topic 5: DOE is not interested in funding applications in this topic focused on CCUS, onsite electricity generation, production of fuels/chemicals from byproducts or wastes, or GHG emissions reductions solely from purchased electricity. This topic is focused on addressing GHG emissions from steel production—not from use of steel—and is not interested in applications focused on GHG emissions reductions in processes outside of the steel industry that use steel as a feedstock (e.g., metal forming processes).

Topic 5 Candidate Metrics and Targets: Compared to current technology, the novel technology proposed should have the potential to significantly reduce CO_2 emissions within the iron and steel sector at the national level if broadly implemented. Applicants must clearly explain how the proposed technology will meet the following metric:

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Reduce carbon intensity of iron and steel industry manufacturing	% carbon intensity change as measured by ton CO_2e/kg product (product must be identified such as hot metal, crude steel, finished steel, etc.)	40%	100%	*Applicant Defined (see note*)*

** Note: The U.S. BF-BOF route has CO_2 emissions of approximately 1.88 tons CO_2 per ton of crude steel. The scrap-based U.S. EAF route has CO_2 emissions of approximately 0.56 tons CO_2 per ton of crude steel using 2019 electricity emissions intensity of 0.381 kg CO_2/kilowatt-hour (kWh). The use of*

CO_2-free electricity would reduce the baseline steel scrap EAF route emissions to approximately 0.28 tons CO_2 per ton of crude steel.[55]

Additional metrics and critical criteria that will lead to successfully meeting the goal above should also be identified. Relevant benchmarks/baselines, minimum targets, and stretch targets should be included for each metric. Examples of applicant-identified metrics are provided in the table below.

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Reduce energy consumption	Btu/ton product	15%	30%	*Applicant Defined*
Increase throughput	Production rate per unit of time	15%	30%	*Applicant Defined*
Decrease operating cost	$/ton product	Cost parity	30%	*Applicant Defined*

Topic Area 6: Decarbonizing Food and Beverage Manufacturing

Topic 6 Background and Opportunity: The food and beverage industry is a critical component of the U.S. economy and includes all facilities involved in transforming raw agricultural goods into consumer food products, ranging from fresh and processed foods to beverages and packaged snacks. In 2018, the industry employed 1.7 million workers to produce and ship nearly $950 billion worth of products.[56] The industry accounted for an estimated 1,935 TBtu of energy (10% of total energy use for U.S. manufacturing) and 96 MMT CO_2e of GHG emissions (10% of total energy-related emissions for U.S. manufacturing) in 2018.[57] About two-thirds of energy consumed by the food and beverage industry is used in manufacturing processes,[58] while the remainder is used for non-process uses or lost in onsite steam and electricity generation and distribution. The food industry can reduce emissions by increasing the energy efficiency of

[55] A. Hasanbeigi, Steel Climate Impact – An International Benchmarking of Energy and CO_2 Intensities, Global Efficiency Intelligence, Florida, United States, 2022, https://www.globalefficiencyintel.com/steel-climate-impact-international-benchmarking-energy-co2-intensities.
[56] Annual Survey of Manufactures, 2018–2021 – Summary Statistics for Industry Groups and Industries. U.S. Census Bureau, December 2022, https://www.census.gov/data/tables/time-series/econ/asm/2018-2021-asm.html.
[57] DOE AMO, 2018 Manufacturing Energy and Carbon Footprints – Food and Beverage Sector, 2021, https://www.energy.gov/sites/default/files/2021-12/2018_mecs_food_beverage_energy_carbon_footprint.pdf.
[58] DOE Advanced Manufacturing & Industrial Decarbonization, Food & Beverage, https://www.energy.gov/eere/amo/food-beverage.

food production and processing technologies, adopting equipment and processes that utilize low-carbon energy sources, and reducing food waste.

Considerable opportunity remains for improving the energy efficiency of food and beverage processing operations, as indicated in DOE's energy bandwidth report for the industry.[59] The DOE Industrial Decarbonization Roadmap[60] also highlights opportunities to decarbonize the sector by electrifying processes and utilizing low-carbon fuels and energy sources. Furthermore, separate reports identify alternative thermal processing approaches for the food and beverage industry.[61,62]

Topic 6 Technology Focus: Within this topic, DOE seeks the development and demonstration of high-impact decarbonization solutions for a wide variety of food and beverage manufacturing operations. Possible solutions include, but are not limited to, innovative heating, cooling, drying, and refrigeration processes across a full spectrum of applications, ranging from industrial baking and ingredients manufacturing to product fermentation and livestock processing and rendering. The proposed technical solutions can be demonstrated at pilot scale or first-of-a-kind demonstration in relevant environments and operating conditions.

Applicants under this topic should develop and demonstrate new advances in processes to accelerate the commercial readiness of emerging low-carbon or net-zero-carbon process technologies for deep decarbonization of the food and beverage industry. Topic 6 seeks both Tier 1 and Tier 2 applications. Applications submitted under this topic must address the AOI listed below.

Area of Interest 1 – Low- and Zero-Carbon Solutions for Process Heating, Cooling and Refrigeration: This AOI seeks applications for innovative technologies that decarbonize existing operations within the food and beverage sector. Example thermal processes utilized within the industry include but are not limited to evaporation, pasteurization, dehydration, cooking, baking, drying, frying, chilling, and freezing. Technology approaches may include, but are not limited to, optimized low- and zero-carbon heating, cooling, and refrigeration systems, as well as systems utilizing low-carbon fuels and/or waste heat.

[59] DOE AMO, Bandwidth Study on Energy Use and Potential Energy Savings Opportunities in U.S. Food and Beverage Manufacturing, September 2017, https://www.energy.gov/sites/default/files/2019/05/f62/Food_and_beverage_bandwidth_study_2017.pdf.

[60] DOE, "Industrial Decarbonization Roadmap," 2022, https://www.energy.gov/eere/doe-industrial-decarbonization-roadmap.

[61] See Section 5.6. of DOE AMO, Thermal Process Intensification: Transforming the Way Industry Uses Thermal Process Energy, 2022, https://doi.org/10.2172/1871912.

[62] A. Thekdi, S. Nimbalkar, S. Sundaramoorthy, et al., Technology Assessment on Low-Temperature Waste Heat Recovery in Industry, Oak Ridge National Laboratory, ORNL/TM-2021/2150, September 2021, https://www.osti.gov/biblio/1819547.

Examples of technical challenges to be addressed for AOI 1 are listed below:

- Innovative drying and dehydration concepts for high-quality food and ingredient manufacturing that reduce carbon intensity of respective operations by at least 50% compared to conventional technologies
- Reduction of energy consumption through cost-effective capture of heat and water from moisture-laden exhausts for onsite reuse
- Decarbonization of beverage production processes (brewery, distillery, juicing, carbonating, etc.), including sanitizing, pasteurization, and bottling processes
- Novel concepts of waste heat recovery for energy-efficient thermal-driven cooling, cold rooms, and refrigeration services

Not of interest in Topic 6: DOE is not interested in funding applications in this topic focused on CCUS, onsite electricity generation, or the production of fuels/chemicals from byproducts or wastes. Because many electric alternatives for process heating, cooling, and refrigeration (e.g., heaters, chillers, heat pumps) are presently available off-the-shelf on the commercial market, they are not of primary interest for Topic 6.

Topic 6 Candidate Metrics and Targets: Compared to current technology, competitive applications should have the potential to reduce CO_2e emissions by at least 500,000 metric tons annually within the food and beverage sector at the national level if broadly implemented. Applicants must clearly explain how the proposed technology will meet the following metric:

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Reduce carbon intensity	% carbon intensity change as measured by ton CO_2e/kg product	50%	> 85%	*Applicant Defined*

Additional metrics and critical criteria that will lead to successfully meeting the goal above should also be identified. Relevant benchmarks/baselines, minimum targets, and stretch targets should be included for each metric. These can also incorporate co-benefits, such as a reduction in criteria air pollutants, for example. Examples of applicant-identified metrics are provided in the table below.

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Reduce energy consumption	Btu/kg product	10%	30%	*Applicant Defined*
Increase throughput	Production rate per unit of time	10%	30%	*Applicant Defined*
Decrease operating cost	$/kg product	10%	30%	*Applicant Defined*
Reduce criteria air pollutant emissions	% pollutant change as measured by ton pollutant/ton product	*Applicant Defined*	*Applicant Defined*	*Applicant Defined*

Topic Area 7: Decarbonizing Cement and Concrete

Topic 7 Background and Opportunity: The production of modern ordinary portland cement (OPC) involves pyroprocessing, the high-temperature calcination and sintering of a blended mixture comprising predominantly calcareous ($CaCO_3$-containing) raw materials and clay raw materials, with small amounts of other oxides. Pyroprocessing converts the mixture to clinker, which is ground and combined with other ingredients to make portland cement. Portland cement clinker typically contains a relatively high (65%–70%) lime (CaO) content. When cement is combined with aggregate, air, and water and allowed to set, a strong composite material—concrete—forms, which further cures with time to its full strength.

To meet market demands, over 86 MMT of cement was produced in 2018 in the United States for use as a necessary component of concrete.[63] The cement industry accounted for 296 TBtu of onsite energy use in 2018, with an estimated 61 MMT CO_2e of onsite GHG emissions.[64] The pyroprocessing step is responsible for the vast majority of CO_2 emissions from the cement industry, making it the most impactful area to target for emissions and energy reductions.

[63] U.S. Geological Survey, Mineral Commodity Summaries: Cement, January 2020, https://pubs.usgs.gov/periodicals/mcs2020/mcs2020-cement.pdf.
[64] DOE AMO, 2018 Manufacturing Energy and Carbon Footprints – Cement Sector, 2021, https://www.energy.gov/sites/default/files/2021-12/2018_mecs_cement_energy_carbon_footprint_0.pdf.

Pyroprocessing emissions can be divided into two categories: process emissions and energy-related emissions. Process emissions result from the high-temperature reaction occurring in the calciner (~900°C) as well as the sintering reaction in the rotary kiln (~1450°C), where each ton of portland cement produced is accompanied by around one-half ton of CO_2, accounting for over 60% of pyroprocessing CO_2 emissions. Energy-related emissions originate from the onsite combustion of fossil fuel (fuel mixes are about 60% petroleum coke or coal on average)[65] to provide the heat required for these processes.

Topic 7 Technology Focus: Applicants under this topic should develop and demonstrate advances to accelerate the commercial readiness of emerging low-carbon or net-zero-carbon technologies for the cement and concrete industry, to provide energy savings, carbon emissions reduction, and other benefits such as reduced complexity and improved process efficiency/optimization in the cement/concrete production sector.

This topic seeks both Tier 1 and Tier 2 applications. For Tier 2, applications should validate concepts in a relevant environment or operational environment at TRL 5–7 at an appropriate scale to advance the technology toward commercialization—for example, scaling to 1/50 of the current commercial scale process for a continuous operation.

Applications submitted under this topic must address at least one of the AOIs stated below. For all AOIs, new cement/concrete formulations must be tested and shown to comply with all applicable performance specifications (e.g., strength, heat of hydration, durability/resistance to attack) for general and special use of hydraulic cement given in ASTM C1157 or blended hydraulic cement in ASTM C595,[66] investigations should be made of the effects of the new formulations on the microstructural features and physical properties of both plain and reinforced concretes.

Area of Interest 1 – Sustainably Sourced SCMs: Clinker Substitutions (Blended Cements): This AOI seeks proposals for Tier 1 or Tier 2 projects for optimizing processing parameters, blended cement formulations, and concrete constituent proportioning to achieve scalable, cost-competitive concrete with good levels of performance (high compressive strength, acceptable setting time, low permeability, high rate of hydration, workability, etc.) while significantly lowering the carbon footprint. The proposed approaches must utilize sustainably sourced solids, including fillers (non-SCMs) and/or ingredients that have been

[65] U.S. Geological Survey, Mineral Commodity Summaries: Cement, January 2020, https://pubs.usgs.gov/periodicals/mcs2020/mcs2020-cement.pdf.

[66] "Standard Performance Specification for Hydraulic Cement." https://www.astm.org/standards/c1157; Standard Performance Specification for Blended Hydraulic Cement." https://www.astm.org/standards/c595.

shown to have the potential for serving to some degree as SCMs, at least with appropriate mechanical and/or chemical pre-treatments. Applicants should also explore scaling up clinker substitutions in concrete mixes by using fillers and SCM quantities in excess of conventional upper limits together with any necessary admixtures or other parameters/adjustments to achieve required performance properties. Areas of interest for clinker substitutions include, but not exclusively so, are circular waste management practices such as recovery and end-of-life interventions utilizing industrial siliceous waste materials as clinker substitutions. Examples include cement kiln dust, fine waste glass powder derived from waste glass, mining waste (e.g., Belterra clay), finely ground waste concrete powder derived from construction and demolition waste, or rubble, and EAF dust together with lime kiln dust.

Area of Interest 2 – Novel Decarbonized Production Processes for Portland Cement or Lime: This AOI seeks Tier 2 projects to address scale-up challenges with novel, net-low-carbon, carbon-neutral, zero-carbon, or carbon-negative production routes for (1) lime (CaO, a feedstock for OPC) that can be combined with other phases and water to directly produce calcium silicate hydrate (concrete), (2) modern OPC, or (3) a cement product that approximates the alite/belite ratio in OPC. The production routes may involve chemical-, electrochemical-, thermal-, or biological-based processes, or combinations thereof, and the valorization of side-products other than CO_2 emissions can be included as part of the proposed scope.

Area of Interest 3 – Novel, Low-Carbon Non-OPC Formulations: This AOI seeks applications for Tier 1 or Tier 2 projects on low-carbon technologies that have the potential to produce scalable quantities of cost-competitive calcium silicate-based or non-silicate-based binder phases other than modern OPC, which can be used to produce concrete with early and late strength gain characteristics, hardening, durability, and other performance properties comparable to OPC. Proposals sought include those addressing challenges related to raw material/feedstock supply chains, scalability, non-GHG emissions, or costs of either non-silicate-based cements (e.g., calcium sulfoaluminate, alkali-activated cements) or calcium silicate-based cement formulations. Formulations that can be produced at lower peak temperatures, require less limestone than OPC, and contain either (1) higher reactive belite proportions than found in OPC or (2) a low lime (CaO)/high silica (SiO_2) ratio are of interest. The addition of chemical, mineral, or superplasticizer admixtures may be necessary to achieve the desired finished concrete qualities, particularly with an acceptable rate of strength development.

Area of Interest 4 – CO_2 Mineralization: This AOI seeks proposals for Tier 1 or Tier 2 projects for optimizing products and processing parameters of ex situ CO_2

mineralization in concrete to achieve scalable, cost-competitive products with good levels of performance (high compressive strength, acceptable setting time, low permeability, high rate of hydration, workability, etc.) while significantly lowering the overall product/process embodied carbon. The proposed process technology should be capable of utilizing CO_2 previously captured from industrial sources (e.g., cement kiln flues) or direct air capture – a life cycle assessment should clearly show the impact of CO_2 source on embodied carbon. The mineralization CO_2 could be added at different stages of the clinker, cement, and concrete life cycle, including during mixing (this has limited mineralization potential); in fresh waste concrete that can subsequently be utilized as an SCM; for hardening; or for recycled concrete to be used as aggregate in fresh concrete.

Not of Interest in Topic 7: DOE is not interested in funding applications in this topic primarily focused on the utilization of low-carbon fuels or the electrification of existing processes.

Topic 7 Candidate Metrics and Targets: Compared to current technology, the novel technology proposed should have the potential to reduce CO_2 emissions by at least 2 MMT annually within the cement and concrete sector at the national level if broadly implemented. Applicants must clearly explain how the proposed technology will meet the following metric:

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Reduce carbon intensity	% carbon intensity change as measured by ton CO_2e/kg product	50%	80%	*Applicant Defined*

Additional metrics and critical criteria that will lead to successfully meeting the goal above should also be identified. Relevant benchmarks/baselines, minimum targets, and stretch targets should be included for each metric. Examples of applicant-identified metrics are provided in the table below.

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Clinker content	Clinker-to-cement ratio	≤ 0.80 by 2050	none	*ASTM C595 cement types: IL, IS, IP, and IT*

Technical performance (e.g., strength, heat of hydration, sulfate resistance, etc.)	Standard performance specifications for hydraulic and blended cements	As given in ASTM C595 or C1157	none	*ASTM C595 and ASTM C1157*
Economic impacts of decarbonized raw materials, products, or processes	Cost	Cost competitive /minimal green premium	Cost parity	*OPC-centric baseline*

Topic Area 8: Decarbonizing Forest Products

Topic 8 Background and Opportunity: The forest products industry is a key component of the U.S. economy. It produces nearly $300 billion worth of essential products annually (e.g., pulp, paper, packaging, plywood, lumber) and employs approximately 950,000 people nationwide. The industry is the third-largest consumer of energy in the U.S. manufacturing sector, accounting for 2,883 Tbtu of energy use (15% of total energy use for U.S. manufacturing).[67] Approximately 56% of energy demand is met from renewable energy sources through the efficient reuse of waste materials from the manufacturing process, such as bark, sawdust, and black liquor.[68] Pulp, paper, and various wood products are made mostly from recycled fiber or fiber from sustainably managed forests that are replanted to ensure a renewable supply, thereby reducing the environmental footprint of the industry. Yet despite producing more carbon-neutral bioenergy than any other industrial subsector, the forest products industry still consumes significant quantities of fossil fuel-based energy, resulting in approximately 80 MMT CO_2e of non-biogenic GHG emissions annually (8% of total energy-related emissions for U.S. manufacturing).[69]

[67] DOE AMO, 2018 Manufacturing Energy and Carbon Footprints – Forest Products Sector, 2021, https://www.energy.gov/sites/default/files/2021-12/2018_mecs_forest_products_energy_carbon_footprint_0.pdf.
[68] Based on analysis of EPA Greenhouse Gas Reporting Program (GHGRP) data.
[69] DOE AMO, 2018 Manufacturing Energy and Carbon Footprints – Forest Products Sector, 2021, https://www.energy.gov/sites/default/files/2021-12/2018_mecs_forest_products_energy_carbon_footprint_0.pdf.

As indicated in DOE's energy bandwidth report for the industry,[70] the major consumers of thermal energy within the forest products industry are liquor evaporation, pulping chemical preparation, wood cooking, bleaching, and drying. While production of recycled paper does not have the steps associated with the kraft pulping process, there is also a significant thermal energy use associated with heating the pulp slurry and drying paper.

A separate DOE report highlights thermal process intensification and alternative thermal processing approaches for the pulp and paper industry.[71]

Topic 8 Technology Focus: Applicants under this topic should develop and demonstrate new advances in processes and associated equipment to accelerate the commercial readiness of emerging low-carbon or net-zero-carbon process technologies for the energy-intensive paper and forest products manufacturing applications.

Applications submitted under this topic must address at least one of the AOIs stated below. All AOIs for Topic 8 seek both Tier 1 and Tier 2 applications. During the award performance period, an assessment of carbon emissions, energy intensity, and cost must be validated via LCA and TEA.

Area of Interest 1 – Innovative Paper-Forming and Novel Dewatering Technologies: This AOI seeks applications for innovative technologies that decarbonize existing thermal and non-thermal drying and dewatering processes within paper manufacturing, as a considerable portion of energy use in the paper industry is consumed in drying operations. Technology approaches could include, but are not limited to, innovative paper-forming and novel dewatering technologies, high-efficient and cost-effective systems increasing the dryness of products, and other relevant innovations.

Proposals sought include those addressing challenges related to:

- Increasing the solids content of the paper web exiting the press section
- Increasing the thermal efficiency of the traditional multi-cylinder paper machine dryer section
- Increasing energy efficiency and drying rate by utilizing alternate energy sources such as ultrasonic energy, radio frequency radiation, infrared radiation, and electrohydrodynamic effects

[70] DOE AMO, Bandwidth Study on Energy Use and Potential Energy Savings Opportunities in U.S. Pulp and Paper Manufacturing, June 2015, https://www.energy.gov/sites/default/files/2015/08/f26/pulp_and_paper_bandwidth_report.pdf.
[71] DOE AMO, Thermal Process Intensification: Transforming the Way Industry Uses Thermal Process Energy, 2022, https://doi.org/10.2172/1871912.

- Capturing energy lost from the drying process and reusing the recovered energy onsite

Area of Interest 2 – Innovative Fiber Preparation, Pulping, and Chemical Recovery Processes: This AOI seeks applications for innovative pulping and chemical recovery technologies to improve energy efficiency and decarbonize operations associated with the preparation of pulp fibers. Technology approaches could include, but are not limited to, catalytic pulping, novel solvent-based pulping, refining improvements, and other innovations.

Proposals sought include those addressing challenges related to:

- Developing lower-energy mechanical, physical, or chemical refining approaches to fiber development
- Reducing energy use and carbon emissions associated with recovery of pulping chemicals
- Reducing energy use in pulping by various means, including reducing the negative impact of the peeling reaction on polysaccharide yield, developing approaches to enable milder pulping conditions, developing catalysts for delignification reactions, and developing novel solvent-based pulping chemistries
- Reducing energy use and improving quality of recycled fiber

Not of interest in Topic 8: DOE is not interested in funding applications in this topic focused on CCUS, onsite electricity generation, or the production of fuels or chemicals from forest products industry byproducts or wastes.

Topic 8 Candidate Metrics and Targets: Compared to current technology, competitive applications should have the potential to reduce CO_2e emissions by at least 1 MMT annually within the paper and forest products sector at the national level if broadly implemented. Applicants must clearly explain how the proposed technology will meet the following metric:

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Reduce carbon intensity	% carbon intensity change as measured by ton CO_2e/kg product	50%	> 85%	*Applicant Defined*

Additional metrics and critical criteria that will lead to successfully meeting the goal above should also be identified. Relevant benchmarks/baselines, minimum targets, and stretch targets should be included for each metric; these can also include co-benefits, such as a reduction in criteria air pollutants. Examples of applicant-identified metrics are provided in the table below.

Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance
Reduce energy consumption	Btu/kg product	10%	30%	*Applicant Defined*
Increase throughput	Production rate per unit of time	10%	30%	*Applicant Defined*
Decrease operating cost	$/kg product	10%	30%	*Applicant Defined*
Reduce criteria air pollutant emissions	% pollutant change as measured by ton pollutant/ton product	*Applicant Defined*	*Applicant Defined*	*Applicant Defined*

C. Applications Specifically Not of Interest

The following types of applications will be deemed nonresponsive and will not be reviewed or considered (See Section III.D. of the FOA):

- Applications that fall outside the technical parameters specified in Section I.A. and I.B. of the FOA.
- Applications for proposed technologies that are not based on sound scientific principles (e.g., violates the laws of thermodynamics).
- Applications pertaining to geologic carbon sequestration after capture.
- In Topic 1, applications focused on: technologies or processes relevant to only a single subsector; CCUS; onsite electricity generation; or the production of fuels/chemicals from byproducts or wastes.
- In Topic 2, applications focused on: technologies or processes relevant to only a single subsector; hydrogen production, storage, or transportation; CCUS; onsite electricity generation; or the production of fuels/chemicals from byproducts or wastes.
- In Subtopic 3a, applications focused on: technologies or processes relevant to only a single subsector; CCUS; onsite electricity generation; or the production of fuels/chemicals from byproducts or wastes.

- In Subtopic 3b, Tier 2 applications or applications focused on solely empirical theoretical models.
- In Topic 4, applications focused on production of alternative feedstocks, including projects exclusively focused on the capture of carbon dioxide.
- In Topic 5, applications focused on: CCUS; onsite electricity generation; production of fuels/chemicals from byproducts or wastes; GHG emissions reductions solely from purchased electricity; or GHG emissions reductions in processes using steel as a feedstock (e.g., metal forming processes).
- In Topic 6, applications focused on: CCUS; onsite electricity generation; production of fuels/chemicals from byproducts or wastes; or electric solutions (e.g., heaters, chillers, heat pumps).
- In Topic 7, applications primarily focused on: utilization of low-carbon fuels or the electrification of existing processes.
- In Topic 8, applications focused on: CCUS; onsite electricity generation; or production of fuels/chemicals from forest products industry byproducts or wastes.

D. Community Benefits Plan

DOE is committed to investing in research and development (R&D) innovations that deliver benefits to the American public and leads to commercialization of technologies and products that foster sustainable, resilient, and equitable access to clean energy. Further, DOE is committed to supporting the development of more diverse, equitable, inclusive, and accessible workplaces to help maintain the nation's leadership in science and technology.

To support the goal of building a clean and equitable energy economy, projects funded under this FOA are expected to (1) advance diversity, equity, inclusion and accessibility (DEIA); (2) contribute to energy equity; and (3) invest in America's workforce. To ensure these objectives are met, applications must include a Community Benefits Plan that addresses the three objectives stated above. See Section IV.D.xv and Appendix H for the more information on the Community Benefits Plan content requirements.

E. Authorizing Statutes

The programmatic authorizing statute is §6003 of the Energy Act of 2020, as codified at 42 U.S.C. § 17113 et seq.

Awards made under this announcement will fall under the purview of 2 Code of Federal Regulation (CFR) Part 200 as amended by 2 CFR Part 910.

II. Award Information

A. Award Overview

i. Estimated Funding

EERE expects to make a total of approximately $155,700,000 of federal funding available for new awards under this FOA, subject to the availability of appropriated funds. EERE anticipates making approximately 37-62 awards under this FOA. EERE may issue one, multiple, or no awards. Individual awards may vary between up to $750,000 and up to $10,000,000.

EERE may issue awards in one, multiple, or none of the following topic areas:

Topic Area Number	Topic Area Title	Anticipated Number of Awards	Anticipated Minimum Award Size for Any One Individual Award (Fed Share)	Anticipated Maximum Award Size for Any One Individual Award (Fed Share)	Approximate Total Federal Funding Available for All Awards	Anticipated Period of Performance (months)
1	Decarbonizing Industrial Heat	6-10	$1 M	$6 M	$19.4 M	24-36
2	Low-Carbon Fuels Utilization R&D	3-6	$1 M	$5 M	$13.2 M	24-36
3a	Enabling Flexible Industrial Energy Use	3-5	$1 M	$5 M	$9.8 M	24-36
3b	Enhanced Thermal Conductivity Materials	3-4	$0.75 M	$1.5 M	$4 M	24-36
4	Decarbonizing Chemicals	5-9	$1 M	$10 M	$27.9 M	24-36
5	Decarbonizing Iron and Steel	7-10	$1 M	$10 M	$34.7 M	24-36
6	Decarbonizing Food and Beverage Products	3-5	$1 M	$8 M	$13.2 M	24-36
7	Decarbonizing Cement and Concrete	4-8	$1 M	$10 M	$21.5 M	24-36
8	Decarbonizing Forest Products	3-5	$1 M	$8 M	$12 M	24-36

EERE may establish more than one budget period for each award and fund only the initial budget period(s). Funding for all budget periods, including the initial budget period, is not guaranteed.

ii. Period of Performance

EERE anticipates making awards that will run from 24 months up to 36 months in length, comprised of two or more budget periods. Project continuation will be contingent upon several elements, including satisfactory performance and Go/No-Go decision review. For a complete list, see Section VI.B.xiii.

iii. New Applications Only

EERE will accept only new applications under this FOA. EERE will not consider applications for renewals of existing EERE-funded awards through this FOA.

B. EERE Funding Agreements

Through cooperative agreements and other similar agreements, EERE provides financial and other support to projects that have the potential to realize the FOA objectives. EERE does not use such agreements to acquire property or services for the direct benefit or use of the United States government.

i. Cooperative Agreements

EERE generally uses cooperative agreements to provide financial and other support to prime recipients.

Through cooperative agreements, EERE provides financial or other support to accomplish a public purpose of support or stimulation authorized by federal statute. Under cooperative agreements, the government and prime recipients share responsibility for the direction of projects.

EERE has substantial involvement in all projects funded via cooperative agreement. See Section VI.B.ix of the FOA for more information on what substantial involvement may involve.

ii. Funding Agreements with Federally Funded Research and Development Center (FFRDCs)

In most cases, FFRDCs are funded independently of the remainder of the project team. The FFRDC then executes an agreement with any non-FFRDC project team members to arrange work structure, project execution, and any other matters. Regardless of these arrangements, the entity that applied as the prime recipient for the project will remain the prime recipient for the project.

III. Eligibility Information

To be considered for substantive evaluation, an applicant's submission must meet the criteria set forth below. If the application does not meet these eligibility requirements, it will be considered ineligible and removed from further evaluation.

A. Eligible Applicants

i. Domestic Entities

The following types of domestic entities are eligible to participate as a prime recipient or subrecipient of this FOA:

1. Institutions of higher education;
2. For-profit entities; and
3. Non-profit entities.

To qualify as a domestic entity, the entity must be organized, chartered or incorporated (or otherwise formed) under the laws of a particular state or territory of the United States; have majority domestic ownership and control; and have a physical place of business in the United States.

State, local, and tribal government entities are eligible to participate as a subrecipient.

DOE/NNSA FFRDCs are eligible to apply for funding as a prime recipient or subrecipient.

Non-DOE/NNSA FFRDCs are eligible to apply for funding as a prime recipient or subrecipient.

Federal agencies and instrumentalities (other than DOE and Non-DOE/NNSA FFRDCs) are eligible to participate as a subrecipient, but are not eligible to apply as a prime recipient.

Entities banned from doing business with the United States government such as entities debarred, suspended, or otherwise excluded from or ineligible for participating in Federal programs are not eligible.

Nonprofit organizations described in section 501(c)(4) of the Internal Revenue Code of 1986 that engaged in lobbying activities after December 31, 1995, are **not** eligible to apply for funding.

ii. Foreign Entities

In limited circumstances, DOE may approve a waiver to allow a foreign entity to participate as a prime recipient or subrecipient. A foreign entity may submit a Full Application to this FOA, but the Full Application must be accompanied by an explicit written waiver request. Likewise, if the applicant seeks to include a

foreign entity as a subrecipient, the applicant must submit a separate explicit written waiver request in the Full Application for each proposed foreign subrecipient.

Appendix C lists the information that must be included in a foreign entity waiver request. The applicant does not have the right to appeal DOE's decision concerning a waiver request.

iii. Incorporated Consortia

Domestic incorporated consortia are eligible to apply as a prime recipient or subrecipient. For consortia incorporated (or otherwise formed) under the laws of a state or territory of the United States, please refer to "Domestic Entities" above. For consortia incorporated (or otherwise formed) in a foreign country, please refer to the requirements in "Foreign Entities" above.

Each consortium must have an internal governance structure and a written set of internal rules. Upon request, the consortium must provide a written description of its internal governance structure and its internal rules to the Grants Officer.

If the consortium includes foreign members, the applicant must submit a separate explicit written waiver request in the Full Application for each foreign member. See Appendix C.

iv. Unincorporated Consortia

Unincorporated Consortia must designate one member of the consortium to serve as the prime recipient/consortium representative. The prime recipient/consortium representative must qualify as a domestic entity.

Upon request, unincorporated consortia must provide the Grants Officer with a collaboration agreement, commonly referred to as the articles of collaboration, which sets out the rights and responsibilities of each consortium member. This agreement binds the individual consortium members together and should include the consortium's:

- Management structure;
- Method of making payments to consortium members;
- Means of ensuring and overseeing members' efforts on the project;
- Provisions for members' cost sharing contributions; and
- Provisions for ownership and rights in intellectual property developed previously or under the agreement.

If the consortium includes foreign members, the applicant must submit a separate explicit written waiver request in the Full Application for each foreign member. See Appendix C

B. Cost Sharing

For Tier 1 project applications, the cost share must be at least 20% of the total allowable costs (i.e., the sum of the government share, including FFRDC costs if applicable, and the recipient share of allowable costs equals the total allowable cost of the project) for research and development projects.

Tier 2 project applications should be organized into at least one of the three distinct phases and must include activities in Phase 2 or Phase 3: research and development (Phase 1); design and testing (Phase 2); and installation and demonstration (Phase 3). The cost share for Phase 1 and Phase 2 must be at least 20% of the total allowable costs. For Phase 3, the demonstration phase, the cost share must be at least 50% of total allowable costs. Applications must clearly identify what work and which costs are associated with each phase.

The cost share must come from non-federal sources unless otherwise allowed by law. (See 2 CFR 200.306 and 2 CFR 910.130 for the applicable cost sharing requirements.)

To assist applicants in calculating proper cost share amounts, EERE has included a cost share information sheet and sample cost share calculation as Appendices A and B to this FOA.

i. Legal Responsibility

Although the cost share requirement applies to the project as a whole, including work performed by members of the project team other than the prime recipient, the prime recipient is legally responsible for paying the entire cost share. If the funding agreement is terminated prior to the end of the project period, the prime recipient is required to contribute at least the cost share percentage of total expenditures incurred through the date of termination.

The prime recipient is solely responsible for managing cost share contributions by the project team and enforcing cost share obligation assumed by project team members in subawards or related agreements.

ii. Cost Share Allocation

Each project team is free to determine how best to allocate the cost share requirement among the team members. The amount contributed by individual

project team members may vary, as long as the cost share requirement for the project as a whole is met.

iii. Cost Share Types and Allowability

Every cost share contribution must be allowable under the applicable federal cost principles, as described in Section IV.J.i. of the FOA. In addition, cost share must be verifiable upon submission of the Full Application.

Project teams may provide cost share in the form of cash or in-kind contributions. Cost share may be provided by the prime recipient, subrecipients, or third parties (entities that do not have a role in performing the scope of work). Vendors/contractors may not provide cost share. Any partial donation of goods or services is considered a discount and is not allowable.

Cash contributions include, but are not limited to: personnel costs, fringe costs, supply and equipment costs, indirect costs and other direct costs.

In-kind contributions are those where a value of the contribution can be readily determined, verified and justified but where no actual cash is transacted in securing the good or service comprising the contribution. Allowable in-kind contributions include, but are not limited to: the donation of volunteer time or the donation of space or use of equipment.

Project teams may use funding or property received from state or local governments to meet the cost share requirement, so long as the funding was not provided to the state or local government by the federal government.

The prime recipient may not use the following sources to meet its cost share obligations including, but not limited to:

- Revenues or royalties from the prospective operation of an activity beyond the project period;
- Proceeds from the prospective sale of an asset of an activity;
- Federal funding or property (e.g., federal grants, equipment owned by the federal government); or
- Expenditures that were reimbursed under a separate federal program.

Project teams may not use the same cash or in-kind contributions to meet cost share requirements for more than one project or program.

Cost share contributions must be specified in the project budget, verifiable from the prime recipient's records, and necessary and reasonable for proper and efficient accomplishment of the project. As all sources of cost share are

considered part of total project cost, the cost share dollars will be scrutinized under the same federal regulations as federal dollars to the project. Every cost share contribution must be reviewed and approved in advance by the Grants Officer and incorporated into the project budget before the expenditures are incurred.

Applicants are encouraged to refer to 2 CFR 200.306 as amended by 2 CFR 910.130 for additional cost sharing requirements.

iv. Cost Share Contributions by FFRDCs

Because FFRDCs are funded by the federal government, costs incurred by FFRDCs generally may not be used to meet the cost share requirement. FFRDCs may contribute cost share only if the contributions are paid directly from the contractor's Management Fee or another non-federal source.

v. Cost Share Verification

Applicants are required to provide written assurance of their proposed cost share contributions in their Full Applications.

Upon selection for award negotiations, applicants are required to provide additional information and documentation regarding their cost share contributions. Please refer to Appendix A of the FOA.

vi. Cost Share Payment

DOE requires prime recipients to contribute the cost share amount incrementally over the life of the award. Specifically, the prime recipient's cost share for each billing period must always reflect the overall cost share ratio negotiated by the parties (i.e., the total amount of cost sharing on each invoice when considered cumulatively with previous invoices must reflect, at a minimum, the cost sharing percentage negotiated). As FFRDC funding will be provided directly to the FFRDC(s) by DOE, prime recipients will be required to provide project cost share at a percentage commensurate with the FFRDC costs, on a budget period basis, resulting in a higher interim invoicing cost share ratio than the total award ratio.

In limited circumstances, and where it is in the government's interest, the Grants Officer may approve a request by the prime recipient to meet its cost share requirements on a less frequent basis, such as monthly or quarterly. Regardless of the interval requested, the prime recipient must be up-to-date on cost share at each interval. Such requests must be sent to the Grants Officer during award negotiations and include the following information: (1) a detailed justification for the request; (2) a proposed schedule of payments, including amounts and dates; (3) a written commitment to meet that schedule; and (4) such evidence as

necessary to demonstrate that the prime recipient has complied with its cost share obligations to date. The Grants Officer must approve all such requests before they go into effect.

C. Compliance Criteria

All applicant submissions must:

- comply with the applicable content and form requirements listed in Section IV of the FOA;
- include all required documents;
- be successfully uploaded in EERE Exchange https://eere-Exchange.energy.gov, including clicking the "Submit" button; and
- be submitted by the deadline stated in the FOA.

EERE will not review or consider submissions submitted through means other than EERE eXCHANGE, submissions submitted after the applicable deadline, or incomplete submissions.

Applicants are strongly encouraged to submit their Concept Papers, Full Applications, and Replies to Reviewer Comments at least 48 hours in advance of the submission deadline. Under normal conditions (i.e., at least 48 hours in advance of the submission deadline), applicants should allow at least 1 hour to submit a Concept Paper, Full Application, or Reply to Reviewer Comments. Once the Concept Paper, Full Application, or Reply to Reviewer Comments is submitted in EERE Exchange, applicants may revise or update that submission until the expiration of the applicable deadline. If changes are made to any of these documents, the applicant must resubmit the Concept Paper, Full Application, or Reply to Reviewer Comments before the applicable deadline. DOE will not extend the submission deadline for applicants that fail to submit required information by the applicable deadline due to server/connection congestion.

D. Responsiveness Criteria

All "Applications Specifically Not of Interest," as described in Section I.C. of the FOA, are deemed nonresponsive and are not reviewed or considered.

E. Other Eligibility Requirements

i. Requirements for DOE/National Nuclear Security Agency (NNSA) Federally Funded Research and Development Centers (FFRDC) Listed as the applicant

A DOE/NNSA FFRDC is eligible to apply for funding under this FOA if its cognizant Contracting Officer provides written authorization and this authorization is submitted with the application.

The following wording is acceptable for the authorization:

> Authorization is granted for the Laboratory to participate in the proposed project. The work proposed for the laboratory is consistent with or complementary to the missions of the laboratory, and will not adversely impact execution of the DOE assigned programs at the laboratory.

If a DOE/NNSA FFRDC is selected for award negotiation, the proposed work will be authorized under the DOE work authorization process and performed under the laboratory's Management and Operating (M&O) contract.

ii. Requirements for DOE/NNSA and non-DOE/NNSA Federally Funded Research and Development Centers Included as a Subrecipient

DOE/NNSA and non-DOE/NNSA FFRDCs may be proposed as a subrecipient on another entity's application subject to the following guidelines:

a. Authorization for non-DOE/NNSA FFRDCs
The federal agency sponsoring the FFRDC must authorize in writing the use of the FFRDC on the proposed project and this authorization must be submitted with the application. The use of a FFRDC must be consistent with its authority under its award.

b. Authorization for DOE/NNSA FFRDCs
The cognizant Contracting Officer for the FFRDC must authorize in writing the use of the FFRDC on the proposed project and this authorization must be submitted with the application. The following wording is acceptable for this authorization:

> Authorization is granted for the Laboratory to participate in the proposed project. The work proposed for the laboratory is consistent with or complementary to the missions of the

laboratory, and will not adversely impact execution of the DOE assigned programs at the laboratory.

c. Funding, Cost Share and Subaward with FFRDCs
The value of and funding for the FFRDC portion of the work will not normally be included in the award. DOE/NNSA FFRDCs participating as a subrecipient on a project will be funded directly through the DOE field work proposal (WP) process. Non-DOE/NNSA FFRDCs participating as a subrecipient will be funded through an interagency agreement with the sponsoring agency.

Although the FFRDC portion of the work is excluded from the award, the applicant's cost share requirement will be based on the total cost of the project, including the applicant's, the subrecipient's, and the FFRDC's portions of the project.

Unless instructed otherwise by the DOE CO for the DOE award, all FFRDCs are required to enter into a Cooperative Research and Development Agreement[72] (CRADA) or, if the role of the DOE/NNSA FFRDC is limited to technical assistance and intellectual property is not anticipated to be generated from the DOE/NNSA FFRDC's work, a Technical Assistance Agreement (TAA), with at least the prime recipient before any project work begins. Any questions regarding the use of a CRADA or TAA should be directed to the cognizant DOE field intellectual property (IP) counsel.

The CRADA or TAA is used to ensure accountability for project work and provide the appropriate management of intellectual property (IP), e.g., data protection and background IP. The CRADA or TAA must be agreed upon by all parties and submitted to DOE or other sponsoring agency, when applicable, for approval, or submitted to DOE for notice under the Master Scope of Work process, when applicable, using any DOE or other sponsoring agency approved CRADA or TAA template without substantive changes by the time the award is made to the prime recipient.

d. Responsibility
The prime recipient will be the responsible authority regarding the settlement and satisfaction of all contractual and administrative issues including, but not limited to disputes and claims arising out of any agreement between the prime recipient and the FFRDC.

[72] A cooperative research and development agreement is a contractual agreement between a national laboratory contractor and a private company or university to work together on research and development. For more information, see https://www.energy.gov/gc/downloads/doe-cooperative-research-and-development-agreements

e. Limit on FFRDC Effort
The scope of work to be performed by the FFRDC may not be more significant than the scope of work to be performed by the applicant.

F. Limitation on Number of Concept Papers and Full Applications Eligible for Review

An entity may only submit one Concept Paper and one Full Application for each topic area of this FOA. If an entity submits more than one Concept Paper and one Full Application to the same topic area, EERE will request a determination from the applicant's authorizing representative as to which application should be reviewed. Any other submissions received listing the same entity as the applicant for the same topic area will not be eligible for further consideration. This limitation does not prohibit an applicant from collaborating on other applications (e.g., as a potential subrecipient or partner) so long as the entity is only listed as the applicant on one Concept Paper and one Full Application for each topic area of this FOA.

G. Questions Regarding Eligibility

EERE will not make eligibility determinations for potential applicants prior to the date on which applications to this FOA must be submitted. The decision whether to submit an application in response to this FOA lies solely with the applicant.

IV. Application and Submission Information

A. Application Process

The application process will include two phases: a Concept Paper phase and a Full Application phase. **Only applicants who have submitted an eligible Concept Paper will be eligible to submit a Full Application**.

All submissions must conform to the following form and content requirements, including maximum page lengths.

- Each must be submitted in Adobe PDF format unless stated otherwise;
- Each must be written in English;
- All pages must be formatted to fit on 8.5 x 11 inch paper with margins not less than one inch on every side. Use Calibri typeface, a black font color, and a font size of 12 point or larger (except in figures or tables, which may be 10 point font). A symbol font may be used to insert Greek letters or special characters, but the font size requirement still applies. References must be included as footnotes or endnotes in a font size of 10

or larger. Footnotes and endnotes are counted toward the maximum page requirement;

- A **control number** will be issued when an applicant begins the EERE eXCHANGE application process. The control number must be included with all application documents. Specifically, the control number must be prominently displayed on the upper right corner of the header of every page and included in the file name (i.e., *Control Number_Applicant Name_Full Application*);
- Page numbers must be included in the footer of every page; and
- Each submission must not exceed the specified maximum page limit, including cover page, charts, graphs, maps, and photographs when printed using the formatting requirements set forth above and single spaced. If applicants exceed the maximum page lengths indicated below, EERE will review only the authorized number of pages and disregard any additional pages.

i. Additional Information on EERE eXCHANGE

EERE eXCHANGE is designed to enforce the deadlines specified in this FOA. The "Apply" and "Submit" buttons will automatically disable at the defined submission deadlines. Should applicants experience problems with EERE eXCHANGE, the following information may be helpful.

Applicants that experience issues with submission PRIOR to the FOA deadline: In the event that an applicant experiences technical difficulties with a submission, the applicant should contact the EERE eXCHANGE helpdesk for assistance (EERE-eXCHANGESupport@hq.doe.gov). The EERE eXCHANGE helpdesk and/or the EERE eXCHANGE system administrators will assist applicants in resolving issues.

B. Application Forms

The application forms and instructions are available at EERE Funding Application and Management Forms and on EERE eXCHANGE. To access these materials, go to https://eere-eXCHANGE.energy.gov and select the appropriate funding opportunity number.

Note: The maximum file size that can be uploaded to the EERE eXCHANGE website is 50MB. Files in excess of 50MB cannot be uploaded, and hence cannot be submitted for review. If a file exceeds 50MB but is still within the maximum page limit specified in the FOA, it must be broken into parts and denoted to that effect. For example:
TechnicalVolume_Part_1
TechnicalVolume_Part_2

EERE will not accept late submissions that resulted from technical difficulties due to uploading files that exceed 50MB

C. Content and Form of the Concept Paper

To be eligible to submit a Full Application, applicants must submit a Concept Paper by the specified due date and time.

i. Concept Paper Content Requirements

Each Concept Paper must be limited to a single concept or technology. The Concept Paper must conform to the following content requirements:

Section	Page Limit	Description
Cover Page	1 page maximum	The cover page should include the project title, the specific announcement Topic Area and Area(s) of Interest (AOIs) being addressed, both the technical and business points of contact, names of all team member organizations, and any statements regarding confidentiality.
Technology Description	4 pages maximum	Applicants are required to describe succinctly: • The proposed technology, including its basic operating principles and how it is unique and innovative; • The scale of the proposed work, including, as appropriate, mass flow, energy flow, heat flux, reactor volume, and other quantitative measures; • The proposed technology's target level of performance (applicants should provide technical data or other support to show how the proposed target could be met); • The current state-of-the-art in the relevant field and application, including key shortcomings, limitations, and challenges; • How the proposed technology will overcome the shortcomings, limitations, and challenges in the relevant field and application; • The potential impact that the proposed project would have on the relevant field and application; • The key technical risks/issues associated with the proposed technology development plan; and • The impact that EERE funding would have on the proposed project.
Addendum	1 page maximum	Applicants are required to describe succinctly the qualifications, experience, and capabilities of the proposed Project Team, including:

		• Whether the Principal Investigator (PI) and Project Team have the skill and expertise needed to successfully execute the project plan; • Whether the applicant has prior experience which demonstrates an ability to perform tasks of similar risk and complexity; • Whether the applicant has worked together with its teaming partners on prior projects or programs; and • Whether the applicant has adequate access to equipment and facilities necessary to accomplish the effort and/or clearly explain how it intends to obtain access to the necessary equipment and facilities. • Applicants may provide graphs, charts, or other data to supplement their Technology Description.

EERE makes an independent assessment of each Concept Paper based on the criteria in Section V.A.i. of the FOA. EERE will encourage a subset of applicants to submit Full Applications. Other applicants will be discouraged from submitting a Full Application.

D. Content and Form of the Full Application

Applicants must complete the following application forms found at EERE Funding Application and Management Forms and on the EERE eXCHANGE website at https://eere-eXCHANGE.energy.gov/, in accordance with the instructions.

Applicants will have approximately 30 days from receipt of the Concept Paper Encourage/Discourage notification on EERE eXCHANGE to prepare and submit a Full Application. Regardless of the date the applicant receives the Encourage/Discourage notification, the submission deadline for the Full Application remains the date and time stated on the FOA cover page.

All Full Application documents must be marked with the Control Number issued to the applicant.

i. Full Application Content Requirements

Each Full Application shall be limited to a single concept. Full Applications must conform to the following requirements and must not exceed the stated page limits:

Component	File Format	Page Limit	File Name
Technical Volume	PDF	25	ControlNumber_LeadOrganization_Technical Volume
Resumes	PDF	3 pages each	ControlNumber_LeadOrganization_Resumes
Letters of Commitment	PDF	1 page each	ControlNumber_LeadOrganization_LOCs
Statement of Project Objectives	MS Word	15	ControlNumber_LeadOrganization_SOPO
SF-424: Application for Federal Assistance	PDF	n/a	ControlNumber_LeadOrganization_App424
Budget Justification Workbook	MS Excel	n/a	ControlNumber_LeadOrganization_Budget_Justification
Summary/Abstract for Public Release	PDF	1	ControlNumber_LeadOrganization_Summary
Summary Slide	MS Powerpoint	1	ControlNumber_LeadOrganization_Slide
Subrecipient Budget Justification	MS Excel	n/a	ControlNumber_LeadOrganization_Subrecipient_Budget_Justification
DOE Work Proposal for FFRDC, if applicable (see DOE O 412.1A, Attachment 2)	PDF	n/a	ControlNumber_LeadOrganization_WP
Authorization from cognizant Contracting Officer for FFRDC	PDF	n/a	ControlNumber_LeadOrganization_FFRDCAuth
SF-LLL Disclosure of Lobbying Activities	PDF	n/a	ControlNumber_LeadOrganization_SF-LLL
Foreign Entity Waiver Requests and Foreign Work Waiver Requests	PDF	n/a	ControlNumber_LeadOrganization_Waiver
Community Benefits Plan	PDF	5	ControlNumber_LeadOrganization_CBP
Current and Pending Support	PDF	n/a	ControlNumber_LeadOrganization_CPS
Transparency of Foreign Connections	PDF	n/a	ControlNumber_LeadOrganization_TFC
Potentially Duplicative Funding Notice	PDF	n/a	ControlNumber_LeadOrganization_PDFN

Note: The maximum file size that can be uploaded to the EERE eXCHANGE website is 50MB. See Section IV.B.
EERE provides detailed guidance on the content and form of each component below.

ii. Technical Volume

The Technical Volume must conform to the following content and form requirements. This volume must address the technical review criteria as discussed in Section V.A. of the FOA.

Save the Technical Volume in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_TechnicalVolume".
Applicants must provide sufficient citations and references to the primary research literature to justify the claims and approaches made in the Technical Volume. However, EERE and reviewers are under no obligation to review cited sources.

The Technical Volume to the Full Application may not be more than 25 pages, including the cover page, table of contents, and all citations, charts, graphs, maps, photos, or other graphics, and must include all of the information in the table below. The applicant should consider the weighting of each of the evaluation criteria (see Section V.A.ii. of the FOA) when preparing the Technical Volume.

The Technical Volume should clearly describe and expand upon information provided in the Concept Paper.

Technical Volume Content Requirements	
SECTION/PAGE LIMIT	**DESCRIPTION**
Cover Page	The cover page should include the project title, the specific FOA Topic Area and AOI(s) being addressed, both the technical and business points of contact, names of all team member organizations, names of project managers, senior/key personnel and their organizations, the project location (s) and any statements regarding confidentiality.
Project Overview (Approximately 10% of the Technical Volume)	The Project Overview should contain the following information: • Background: The applicant should discuss the background of their organization, including the history, successes, and current research and development status (i.e., the technical baseline) relevant to the technical topic being addressed in the Full Application. • Project Goal: The applicant should explicitly identify the targeted improvements to the baseline technology and the critical success factors in achieving that goal. • DOE Impact: The applicant should discuss the impact that DOE funding would have on the proposed project. Applicants should specifically explain how DOE funding, relative to prior, current, or anticipated funding from other public and private sources, is necessary to achieve the project objectives.
Technical Description, Innovation, and Impact (Approximately 30% of the Technical Volume)	The Technical Description should contain the following information: • Relevance and Outcomes: The applicant should provide a detailed description of the technology, including the scientific and other principles and objectives that will be pursued during the project. This section should describe the relevance of the proposed project

	to the goals and objectives of the FOA, including the potential to meet specific DOE technical targets or other relevant performance targets. The applicant should clearly specify the expected outcomes of the project. • Feasibility: The applicant should demonstrate the technical feasibility of the proposed technology and capability of achieving the anticipated performance targets, including a description of previous work done and prior results. • Innovation and Impacts: The applicant should describe the current state-of-the-art in the applicable field, the specific innovation of the proposed technology, the advantages of proposed technology over current and emerging technologies, and the overall impact on advancing the state-of-the-art/technical baseline if the project is successful.
Workplan and Market Transformation Plan (Approximately 40% of the Technical Volume)	The Workplan should include a summary of the Project Objectives, Technical Scope, Work Breakdown Structure (WBS), Milestones, Go/No-Go Decision Points, and Project Schedule. A detailed SOPO is separately requested. The Workplan should contain the following information: • Project Objectives: The applicant should provide a clear and concise (high-level) statement of the goals and objectives of the project as well as the expected outcomes. • Technical Scope Summary: The applicant should provide a summary description of the overall work scope and approach to achieve the objective(s). The overall work scope is to be divided by performance periods that are separated by discrete, approximately annual decision points (see below for more information on Go/No-Go decision points). The applicant should describe the specific expected end result of each performance period. • WBS and Task Description Summary: The Workplan should describe the work to be accomplished and how the applicant will achieve the milestones, will accomplish the final project goal(s), and will produce all deliverables. The Workplan is to be structured with a hierarchy of performance period (approximately annual), task and subtasks, which is typical of a standard WBS for any project. The Workplan shall contain a concise description of the specific activities to be conducted over the life of the project. The description shall be a full explanation and disclosure of the project being proposed (i.e., a statement such as “we will then complete a proprietary process” is unacceptable). It is the applicant’s responsibility to prepare an adequately detailed task plan to describe the proposed project and the plan for addressing the objectives of this FOA. The summary provided should be consistent with the SOPO. The SOPO will contain a more detailed description of the WBS and tasks.

	• Milestone Summary: The applicant should provide a summary of appropriate milestones throughout the project to demonstrate success. A milestone may be either a progress measure (which can be activity based) or a SMART technical milestone. SMART milestones should be Specific, Measurable, Achievable, Relevant, and Timely, and must demonstrate a technical achievement rather than simply completing a task. Unless otherwise specified in the FOA, the minimum requirement is that each project must have at least one milestone per quarter for the duration of the project with at least one SMART technical milestone per year (depending on the project, more milestones may be necessary to comprehensively demonstrate progress). The applicant should also provide the means by which the milestone will be verified. The summary provided should be consistent with the Milestone Summary Table in the SOPO. • Go/No-Go Decision Points: The applicant should provide a summary of project-wide Go/No-Go decision points at appropriate points in the Workplan. A Go/No-Go decision point is a risk management tool and a project management best practice to ensure that, for the current phase or period of performance, technical success is definitively achieved and potential for success in future phases or periods of performance is evaluated, prior to actually beginning the execution of future phases. At a minimum, each project must have at least one project-wide Go/No-Go decision point for each budget period (12 to 18-month period) of the project. See Section VI.B.xiii. The applicant should also provide the specific technical criteria to be used to evaluate the project at the Go/No-Go decision point. The summary provided should be consistent with the SOPO. Go/No-Go decision points are considered "SMART" and can fulfill the requirement for an annual SMART milestone. • End of Project Goal: The applicant should provide a summary of the end of project goal(s). At a minimum, each project must have one SMART end of project goal. The summary provided should be consistent with the SOPO. • Project Schedule (Gantt Chart or similar): The applicant should provide a schedule for the entire project, including task and subtask durations, milestones, and Go/No-Go decision points. • Buy America Requirements for Infrastructure Projects: Within the first 2 pages of the Workplan, include a short statement on whether the project will involve the construction, alteration, and/or repair of infrastructure in the United States. See Appendix D for applicable definitions and other information to inform this statement. • Project Management: The applicant should discuss the team's proposed management plan, including the following:

	○ The overall approach to and organization for managing the work ○ The roles of each project team member ○ Any critical handoffs/interdependencies among project team members ○ The technical and management aspects of the management plan, including systems and practices, such as financial and project management practices ○ The approach to project risk management ○ A description of how project changes will be handled ○ If applicable, the approach to Quality Assurance/Control ○ How communications will be maintained among project team members • Market Transformation Plan: The applicant should provide a market transformation plan, including the following: ○ Identification of target market, competitors, and distribution channels for proposed technology along with known or perceived barriers to market penetration, including a mitigation plan ○ Identification of a product development and/or service plan, commercialization timeline, financing, product marketing, legal/regulatory considerations including intellectual property, infrastructure requirements, data dissemination, and product distribution.
Technical Qualifications and Resources (Approximately 20% of the Technical Volume)	The Technical Qualifications and Resources should contain the following information: • Describe the project team's unique qualifications and expertise, including those of key subrecipients. • Describe the project team's existing equipment and facilities that will facilitate the successful completion of the proposed project; include a justification of any new equipment or facilities requested as part of the project. • This section should also include relevant, previous work efforts, demonstrated innovations, and how these enable the applicant to achieve the project objectives. • Describe the time commitment of the key team members to support the project. • Describe the technical services to be provided by DOE/NNSA FFRDCs, if applicable.

	• For multi-organizational or multi-investigator projects, describe succinctly:
	  ○ The roles and the work to be performed by each PI and senior/key personnel;
	  ○ Business agreements between the applicant and each PI and senior/key personnel;
	  ○ How the various efforts will be integrated and managed;
	  ○ Process for making decisions on scientific/technical direction;
	  ○ Publication arrangements;
	  ○ Intellectual Property issues; and
	  ○ Communication plans

iii. Resumes

A resume provides information that can be used by reviewers to evaluate the individual's skills, experience, and potential for leadership within the scientific community. Applicants must submit a resume (limited to three pages) for each Principal Investigator or Lead Project Manager and Senior/Key Personnel that include the following:

- Contact Information;
- Education and training: Provide institution, major/area, degree, and year for undergraduate, graduate, and postdoctoral training;
- Research and Professional Experience: Beginning with the current position, list professional/academic positions in chronological order with a brief description. List all current academic, professional, or institutional appointments, foreign or domestic, at the applicant institution or elsewhere, whether or not remuneration is received, and, whether full-time, part-time, or voluntary;
- Awards and honors;
- A list of up to 10 publications most closely related to the proposed project. For each publication, identify the names of all authors (in the same sequence in which they appear in the publication), the article title, book or journal title, volume number, page numbers, year of publication, and website address if available electronically. Patents, copyrights, and software systems developed may be provided in addition to or substituted for publications. An abbreviated style such as the Physical Review Letters (PRL) convention for citations (list only the first author) may be used for publications with more than 10 authors;
- Synergistic Activities: List up to five professional and scholarly activities related to the proposed effort; and

- There should be no lapses in time over the past ten years or since age 18, which ever time period is shorter.

As an alternative to a resume, it is acceptable to use the biographical sketch format approved by the National Science Foundation (NSF). The biographical sketch format may be generated by the Science Experts Network Curriculum Vita (SciENcv), a cooperative venture maintained at https://www.ncbi.nlm.nih.gov/sciencv/, and is also available at https://nsf.gov/bfa/dias/policy/nsfapprovedformats/biosketch.pdf. The use of a format required by another agency is intended to reduce the administrative burden to researchers by promoting the use of common formats.

Save the resumes in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_Resumes".

iv. Letters of Commitment

Submit letters of commitment from all subrecipient and third-party cost share providers. If applicable, the letter must state that the third party is committed to providing a specific minimum dollar amount or value of in-kind contributions allocated to cost sharing. The following information for each third party contributing to cost sharing should be identified: (1) the name of the organization; (2) the proposed dollar amount to be provided; and (3) the proposed cost sharing type – (cash or in-kind contributions). Each letter must not exceed 1 page.

Save the letters of commitment in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_LOCs".

Letters of support or endorsement for the project from entities that do not have a substantive role in the project are not accepted.

v. Statement of Project Objectives (SOPO)

Applicants must complete a SOPO. A SOPO template is available at: EERE Funding Application and Management Forms and on EERE eXCHANGE at https://eere-eXCHANGE.energy.gov/ under this FOA posting. The SOPO, including the Milestone Table, must not exceed 15 pages when printed using standard 8.5 x 11 paper with 1" margins (top, bottom, left, and right) with font not smaller than 12 point (except in figures or tables, which may be 10 point font).

Save the SOPO in a single Microsoft Word file using the following convention for the title "ControlNumber_LeadOrganization_SOPO".

vi. SF-424: Application for Federal Assistance

Applicants must complete the SF-424 Application for Federal Assistance. This form is available at EERE Funding Application and Management Forms and on EERE eXCHANGE at https://eere-eXCHANGE.energy.gov/ under this FOA posting. Complete all required fields in accordance with the instructions on the form. The list of certifications and assurances in Field 21 can be found at http://energy.gov/management/office-management/operational-management/financial-assistance/financial-assistance-forms, under Certifications and Assurances. Note: The dates and dollar amounts on the SF-424 are for the complete project period and not just the first project year, first phase or other subset of the project period.

Save the SF-424 in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_424".

vii. Budget Justification Workbook

Applicants must complete the Budget Justification Workbook which is available at: EERE Funding Application and Management Forms and on EERE eXCHANGE https://eere-eXCHANGE.energy.gov/ under this FOA posting. Applicants must complete each tab of the Budget Justification Workbook for the project as a whole, including all work to be performed by the prime recipient and its subrecipients and contractors. Applicants should include costs associated with required annual audits and incurred cost proposals in their proposed budget documents. The "Instructions and Summary" included with the Budget Justification Workbook will auto-populate as the applicant enters information into the Workbook. Applicants must carefully read the "Instructions and Summary" tab provided within the Budget Justification Workbook.

Save the Budget Justification Workbook in a single Microsoft Excel file using the following convention for the title "ControlNumber_LeadOrganization_Budget_Justification".

viii. Summary for Public Release

Applicants must submit a one-page summary of their project that is suitable for dissemination to the public. It should be a self-contained document that identifies the name of the applicant, the project director/principal investigator(s), the project title, the objectives of the project, a description of the project, including methods to be employed, the potential impact of the project (e.g., benefits, outcomes), and major participants (for collaborative projects). This document must not include any proprietary or sensitive business information as DOE may make it available to the public after selections are made. The project summary must not exceed 1 page when printed using

standard 8.5 x 11 paper with 1" margins (top, bottom, left, and right) with font not smaller than 12 point.

Save the Summary for Public Release in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_Summary".

ix. Summary Slide

Applicants must provide a single slide summarizing the proposed project. This slide is used during the evaluation process.

The Summary Slide template requires the following information:

- A technology summary;
- A description of the technology's impact;
- Proposed project goals;
- Any key graphics (illustrations, charts and/or tables);
- The project's key idea/takeaway;
- Project title, prime recipient, Principal Investigator, and senior/key personnel information; and
- Requested EERE funds and proposed applicant cost share.

Save the Summary Slide in a single Microsoft Powerpoint file using the following convention for the title "ControlNumber_LeadOrganization_Slide".

x. Subrecipient Budget Justification (if applicable)

Applicants must provide a separate budget justification for each subrecipient that is expected to perform work estimated to be more than $250,000 or 25 percent of the total work effort (whichever is less). The budget justification must include the same justification information described in the "Budget Justification" section above.

Save each subrecipient budget justification in a Microsoft Excel file using the following convention for the title "ControlNumber_LeadOrganization_Subrecipient_Budget_Justification".

xi. Budget for DOE/NNSA FFRDC (if applicable)

If a DOE/NNSA FFRDC contractor is to perform a portion of the work, the applicant must provide a DOE WP in accordance with the requirements in DOE Order 412.1A, Work Authorization System, Attachment 2, available at: https://www.directives.doe.gov/directives-documents/400-series/0412.1-BOrder-a-chg1-AdmChg

Save the WP in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_WP".

xii. Authorization for non-DOE/NNSA or DOE/NNSA FFRDCs (if applicable)

The federal agency sponsoring the FFRDC must authorize in writing the use of the FFRDC on the proposed project and this authorization must be submitted with the application. The use of a FFRDC must be consistent with the contractor's authority under its award.

Save the Authorization in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_FFRDCAuth".

xiii. SF-LLL: Disclosure of Lobbying Activities (required)

Recipients and subrecipients may not use any federal funds to influence or attempt to influence, directly or indirectly, congressional action on any legislative or appropriation matters.

Recipients and subrecipients are required to complete and submit SF-LLL, "Disclosure of Lobbying Activities" (https://www.grants.gov/web/grants/forms/sf-424-individual-family.html) to ensure that non-federal funds have not been paid and will not be paid to any person for influencing or attempting to influence any of the following in connection with the application:

- An officer or employee of any federal agency;
- A Member of Congress;
- An officer or employee of Congress; or
- An employee of a Member of Congress.

Save the SF-LLL in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_SF-LLL".

xiv. Waiver Requests (if applicable)

Foreign Entity Participation:

For projects selected under this FOA, all recipients and subrecipients must qualify as domestic entities. See Section III. To request a waiver of this requirement, the applicant must submit an explicit waiver request in the Full Application. Appendix C lists the information that must be included in a waiver request.

Foreign Work Waiver Request

As set forth in Section IV.K.iii., all work for projects selected under this FOA must be performed in the United States. To request a waiver of this requirement, the applicant must submit an explicit waiver request in the Full Application. Appendix C lists the information that must be included in a foreign work waiver request.

Save the Waivers in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_Waiver".

xv. Community Benefits Plan

The Community Benefits Plan must set forth the applicant's approach to ensuring the Federal investments advance the following three objectives: (1) advance diversity, equity, inclusion and accessibility (DEIA); (2) contribute to energy equity; and (3) invest in America's workforce. The below sections set forth the content requirements for the Community Benefits Plan, which addresses each of the foregoing objectives. Applicants must address all three sections.

The applicant's Community Benefits Plan must include at least one Specific, Measurable, Assignable, Relevant, and Timely (SMART) milestone per budget period to measure progress on the proposed actions. The Community Benefits Plan will be evaluated as part of the technical review process. If EERE selects a project, EERE will incorporate the Community Benefits Plan into the award and the recipient must implement its Community Benefits Plan as part of carrying out its project. During the life of the EERE award, EERE will evaluate the recipient's progress, including as part of the Go/No-Go review process.

The plan should be specific to the proposed project and not a restatement of an organizational policies. Applicants should describe the future implications or a milestone-based plan for identifying future implications of their research on energy equity, including, but not limited to, benefits for the U.S. workforce. These impacts may be uncertain, occur over a long period of time, and/or have many factors within and outside the specific proposed research. Applicants are encouraged to describe the influencing factors and the most likely workforce and energy equity implications of the proposed research if the research is successful. While some guidance and example activities are provided in Appendix H, applicants are encouraged to leverage promising practices and develop a plan that is tailored for their project.

The Community Benefits Plan must not exceed five pages. It must be submitted in PDF format using the following convention name for the title:

"ControlNumber_LeadOrganization_CBP." This Plan must address the technical review criterion titled, "Community Benefits Plan." See Section V.A.ii of the FOA. The applicant's Community Benefits Plan must address the following three sections:

i. **Diversity, Equity, Inclusion, and Accessibility:**
To build a clean and equitable energy economy, it is important that there are opportunities for people of all racial, ethnic, socioeconomic and geographic backgrounds, sexual orientation, gender identity, persons with disabilities, and those re-entering the workforce from incarceration. This section of the plan must demonstrate how DEIA is incorporated in the technical project objectives. The plan must identify the specific action the applicant would undertake that integrated into the research goals and project teams. Submitting an institutional DEIA plan without specific integration into the project will be deemed insufficient.

ii. **Energy Equity:**
This section must articulate the applicant's consideration of long-term equity implications of the research. It must identify how the specific project integrates equity considerations into the project design to support equitable outcomes should the innovation be successful. Like cost reductions and commercialization plans, the Community Benefits Plan requires description of the equity implications of the innovation if successful.

iii. **Workforce Implications:**
This section must articulate the applicant's consideration of long-term workforce impacts and opportunities of the research. It must identify how the project is designed and executed to include an understanding of the future workforce needs should the resulting innovation be successful.

See Appendix H for more guidance.

xvi. Current and Pending Support

Current and pending support is intended to allow the identification of potential duplication, overcommitment, potential conflicts of interest or commitment, and all other sources of support. As part of the application, the principal investigator, or lead project manager and all senior/key personnel at the applicant and subrecipient level must provide a list of all sponsored activities, awards, and appointments, whether paid or unpaid; provided as a gift with terms or conditions or provided as a gift without terms or conditions; full-time, part-time, or voluntary; faculty, visiting, adjunct, or honorary; cash or in-kind; foreign or domestic; governmental or private-sector; directly supporting the individual's research or indirectly supporting the individual by supporting students, research

staff, space, equipment, or other research expenses. All connections with foreign government-sponsored talent recruitment programs must be identified in current and pending support.

For every activity, list the following items:

- The sponsor of the activity or the source of funding;
- The award or other identifying number;
- The title of the award or activity. If the title of the award or activity is not descriptive, add a brief description of the research being performed that would identify any overlaps or synergies with the proposed research;
- The total cost or value of the award or activity, including direct and indirect costs and cost share. For pending proposals, provide the total amount of requested funding;
- The award period (start date – end date); and
- The person-months of effort per year being dedicated to the award or activity.

To identify overlap, duplication of effort, or synergistic efforts, append a description of the other award or activity to the current and pending support.

Details of any obligations, contractual or otherwise, to any program, entity, or organization sponsored by a foreign government must be provided on request to either the applicant institution or DOE. Supporting documents of any identified source of support must be provided to DOE on request, including certified translations of any document.

PIs and senior/key personnel must provide a separate disclosure statement listing the required information above regarding current and pending support. Each individual must sign and date their respective disclosure statement and include the following certification statement:

> I, [Full Name and Title], certify to the best of my knowledge and belief that the information contained in this Current and Pending Support Disclosure Statement is true, complete and accurate. I understand that any false, fictitious, or fraudulent information, misrepresentations, half-truths, or omissions of any material fact, may subject me to criminal, civil or administrative penalties for fraud, false statements, false claims or otherwise. (18 U.S.C. §§ 1001 and 287, and 31 U.S.C. §§ 3729-3733 and 3801-3812). I further understand and agree that (1) the statements and representations made herein are material to DOE's funding decision, and (2) I have a responsibility to update the disclosures during the period of performance of the award should

circumstances change which impact the responses provided above.

The information may be provided in the format approved by the National Science Foundation (NSF), which may be generated by the Science Experts Network Curriculum Vita (SciENcv), a cooperative venture maintained at https://www.ncbi.nlm.nih.gov/sciencv/, and is also available at https://www.nsf.gov/bfa/dias/policy/nsfapprovedformats/cps.pdf. The use of a format required by another agency is intended to reduce the administrative burden to researchers by promoting the use of common formats. If the NSF format is used, the individual must still include a signature, date, and a certification statement using the language included in the paragraph above.

Save the Current and Pending Support in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_CPS".

Definitions:

Current and pending support – (a) All resources made available, or expected to be made available, to an individual in support of the individual's RD&D efforts, regardless of (i) whether the source is foreign or domestic; (ii) whether the resource is made available through the entity applying for an award or directly to the individual; or (iii) whether the resource has monetary value; and (b) includes in-kind contributions requiring a commitment of time and directly supporting the individual's RD&D efforts, such as the provision of office or laboratory space, equipment, supplies, employees, or students. This term has the same meaning as the term Other Support as applied to researchers in NSPM-33: For researchers, Other Support includes all resources made available to a researcher in support of and/or related to all of their professional RD&D efforts, including resources provided directly to the individual or through the organization, and regardless of whether or not they have monetary value (e.g., even if the support received is only in-kind, such as office/laboratory space, equipment, supplies, or employees). This includes resource and/or financial support from all foreign and domestic entities, including but not limited to, gifts provided with terms or conditions, financial support for laboratory personnel, and participation of student and visiting researchers supported by other sources of funding.

Foreign Government-Sponsored Talent Recruitment Program – An effort directly or indirectly organized, managed, or funded by a foreign government, or a foreign government instrumentality or entity, to recruit science and technology professionals or students (regardless of citizenship or national origin, or 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 relocate physically to the foreign state for the above purpose. Some programs allow for or encourage continued employment at United States 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 United States 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.

Senior/key personnel – an individual who contributes in a substantive, meaningful way to the scientific development or execution of a research, development and demonstration (RD&D) project proposed to be carried out with DOE award.[73]

xvii. Transparency of Foreign Connections

Applicants must identify the following as they relate to the proposed recipient and subrecipients:

1. Entity name, website address and mailing address;
2. The identity of all owners, principal investigators, project managers, and senior/key personnel who are a party to any *Foreign Government-Sponsored Talent Recruitment Program* of a foreign country of risk (i.e., China, Iran, North Korea, and Russia);
3. The existence of any joint venture or subsidiary that is based in, funded by, or has a foreign affiliation with any foreign country of risk, including the People's Republic of China;
4. Any current or pending contractual or financial obligation or other agreement specific to a business arrangement, or joint venture-like arrangement with an enterprise owned by a foreign state or any foreign entity;
5. Percentage, if any, that the proposed recipient or subrecipient has foreign ownership or control;

[73] Typically, these individuals have doctoral or other professional degrees, although individuals at the masters or baccalaureate level may be considered senior/key personnel if their involvement meets this definition. Consultants, graduate students, and those with a postdoctoral role also may be considered senior/key personnel if they meet this definition.

6. Percentage, if any, that the proposed recipient or subrecipient is wholly or partially owned by an entity in a foreign country of risk;
7. The percentage, if any, of venture capital or institutional investment by an entity that has a general partner or individual holding a leadership role in such entity who has a foreign affiliation with any foreign country of risk;
8. Any technology licensing or intellectual property sales to a foreign country of risk, during the 5-year period preceding submission of the proposal;
9. Any foreign business entity, offshore entity, or entity outside the United States related to the proposed recipient or subrecipient;
10. Complete list of all directors (and board observers), including their full name, citizenship and shareholder affiliation, date of appointment, duration of term, as well as a description of observer rights as applicable;
11. Complete capitalization table for your entity, including all equity interests (including LLC and partnership interests, as well as derivative securities). Include both the number of shares issued to each equity holder, as well as the percentage of that series and all equity on a fully diluted basis. Identify the principal place of incorporation (or organization) for each equity holder. If the equity holder is a natural person, identify the citizenship(s). If the recipient or subrecipient is a publicly traded company, provide the above information for shareholders with an interest greater than five percent;
12. A summary table identifying all rounds of financing, the purchase dates, the investors for each round, and all the associated governance and information rights obtained by investors during each round of financing; and
13. An organization chart to illustrate the relationship between your entity and the immediate parent, ultimate parent, and any intermediate parent, as well as any subsidiary or affiliates. Identify where each entity is incorporated.

DOE reserves the right to request additional or clarifying information based on the information submitted.

Save the Transparency of Foreign Connections information in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_TFC."

xviii. Potentially Duplicative Funding Notice

If the applicant or project team member has other active awards of federal funds, the applicant must determine whether the activities of those awards potentially overlap with the activities set forth in its application to this FOA. If there is a potential overlap, the applicant must notify DOE in writing of the potential overlap and state how it will ensure any project funds (i.e., recipient cost share and federal funds) will not be used for identical cost items under multiple awards. Likewise, for projects that receive funding under this FOA, if a recipient or project team member receives any other award of federal funds for

activities that potentially overlap with the activities funded under the DOE award, the recipient must promptly notify DOE in writing of the potential overlap and state whether project funds from any of those other federal awards have been, are being, or are to be used (in whole or in part) for one or more of the identical cost items under the DOE award. If there are identical cost items, the recipient must promptly notify the DOE Contracting Officer in writing of the potential duplication and eliminate any inappropriate duplication of funding. Save the Potentially Duplicative Funding Notice in a single PDF file using the following convention for the title "PDFN.pdf."

E. Content and Form of Replies to Reviewer Comments

EERE will provide applicants with reviewer comments following the evaluation of all eligible Full Applications. Applicants will have a brief opportunity to review the comments and to prepare a short Reply to Reviewer Comments (Reply). The Reply must not exceed three (3) pages. If a Reply is more than three (3) pages in length, EERE will only review the first three (3) pages and disregard any additional pages. Applicants may use the Reply to respond to one or more comments or to supplement their Full Application. The Reply may include text, graphs, charts, or data.

EERE will post the Reviewer Comments in EERE eXCHANGE. The expected submission deadline is on the cover page of the FOA; however, it is the applicant's responsibility to monitor EERE eXCHANGE in the event that the expected date changes. The deadline will not be extended for applicants who are unable to timely submit their Reply due to failure to check EERE eXCHANGE or relying on the expected date alone. Applicants should anticipate having approximately three (3) business days to submit a Reply.

Applicants are not required to submit a Reply. EERE will review and consider each eligible Full Application, even if no Reply is submitted or if the Reply is found to be ineligible.

F. Post Selection Information Requests

If selected for award negotiations, EERE reserves the right to require that selected applicants provide additional or clarifying information regarding the application submissions, the project, the project team, the award requirements, and any other matters related to anticipated award. The following is a non-exhaustive list of examples of information that may be requested:

- Personnel proposed to work on the project and collaborating organizations (See Section VI.B.xviii. Participants and Collaborating Organizations);

- Current and Pending Support (See Sections IV.D.xvi and VI.B.xix. Current and Pending Support);
- Indirect cost information;
- Other budget information;
- Letters of Commitment from third parties contributing to cost share, if applicable;
- Name and phone number of the Designated Responsible Employee for complying with national policies prohibiting discrimination (See 10 CFR 1040.5);
- Information for the DOE Office of Civil Rights to process assurance reviews under 10 CFR 1040;
- Representation of Limited Rights Data and Restricted Software, if applicable; and Environmental Questionnaire.

G. Unique Entity Identifier (UEI) and System for Award Management (SAM)

Each applicant (unless the applicant is an individual or federal awarding agency that is excepted from those requirements under 2 CFR 25.110(b) or (c), or has an exception approved by the federal awarding agency under 2 CFR 25.110(d)) is required to: (1) Be registered in the SAM at https://www.sam.gov/ before submitting its application; (2) provide a valid UEI in its application; and (3) continue to maintain an active SAM registration with current information at all times during which it has an active federal award or an application or plan under consideration by a federal awarding agency. DOE may not make a federal award to an applicant until the applicant has complied with all applicable UEI and SAM requirements and, if an applicant has not fully complied with the requirements by the time DOE is ready to make a federal award, the DOE will determine that the applicant is not qualified to receive a federal award and use that determination as a basis for making a federal award to another applicant.

NOTE: Due to the high demand of UEI requests and SAM registrations, entity legal business name and address validations are taking longer than expected to process. Entities should start the UEI and SAM registration process as soon as possible. If entities have technical difficulties with the UEI validation or SAM registration process they should utilize the HELP feature on SAM.gov. SAM.gov will work entity service tickets in the order in which they are received and asks that entities not create multiple service tickets for the same request or technical issue. Additional entity validation resources can be found here: GSAFSD Tier 0 Knowledge Base - Validating your Entity.

H. Submission Dates and Times

All required submissions must be submitted in EERE eXCHANGE no later than 5 p.m. Eastern Time on the dates provided on the cover page of this FOA.

I. Intergovernmental Review

This FOA is not subject to Executive Order 12372 – Intergovernmental Review of Federal Programs.

J. Funding Restrictions

i. Allowable Costs

All expenditures must be allowable, allocable, and reasonable in accordance with the applicable federal cost principles. Pursuant to 2 CFR 910.352, the cost principles in the Federal Acquisition Regulations (48 CFR 31.2) apply to for-profit entities. The cost principles contained in 2 CFR Part 200, Subpart E apply to all entities other than for-profits.

ii. Pre-Award Costs

Applicants selected for award negotiations (selectee) must request prior written approval to charge pre-award costs. Pre-award costs are those incurred prior to the effective date of the federal award directly pursuant to the negotiation and in anticipation of the federal award where such costs are necessary for efficient and timely performance of the scope of work. Such costs are allowable only to the extent that they would have been allowable if incurred after the date of the federal award and **only** with the written approval of the federal awarding agency, through the Grants Officer assigned to the award.

Pre-award costs cannot be incurred prior to the Selection Official signing the Selection Statement and Analysis.

Pre-award expenditures are made at the selectee's risk. EERE is not obligated to reimburse costs: (1) in the absence of appropriations; (2) if an award is not made; or (3) if an award is made for a lesser amount than the selectee anticipated.

1. **National Environmental Policy Act (NEPA) Requirements Related to Pre-Award Costs**
   EERE's decision whether and how to distribute federal funds under this FOA is subject to NEPA. Applicants should carefully consider and should seek legal counsel or other expert advice before taking any action related to the proposed project that would have an adverse effect on the environment or

limit the choice of reasonable alternatives prior to EERE completing the NEPA review process.

EERE does not guarantee or assume any obligation to reimburse pre-award costs incurred prior to receiving written authorization from the Grants Officer. If the applicant elects to undertake activities that DOE determines may have an adverse effect on the environment or limit the choice of reasonable alternatives prior to receiving such written authorization from the Grants Officer, the applicant is doing so at risk of not receiving federal funding for their project and such costs may not be recognized as allowable cost share. Nothing contained in the pre-award cost reimbursement regulations or any pre-award costs approval letter from the Grants Officer override these NEPA requirements to obtain the written authorization from the Grants Officer prior to taking any action that may have an adverse effect on the environment or limit the choice of reasonable alternatives. Likewise, if an application is selected for negotiation of award, and the prime recipient elects to undertake activities that are not authorized for federal funding by the Grants Officer in advance of EERE completing a NEPA review, the prime recipient is doing so at risk of not receiving federal funding and such costs may not be recognized as allowable cost share.

iii. Performance of Work in the United States (Foreign Work Waiver)

1. Requirement

   All work performed under awards issued under this FOA must be performed in the United States. The prime recipient must flow down this requirement to its subrecipients.

2. Failure to Comply

   If the prime recipient fails to comply with the Performance of Work in the United States requirement, DOE may deny reimbursement for the work conducted outside the United States and such costs may not be recognized as allowable recipient cost share. The prime recipient is responsible should any work under this award be performed outside the United States, absent a waiver, regardless of whether the work is performed by the prime recipient, subrecipients, contractors or other project partners.

3. Waiver

   To seek a foreign work waiver, the applicant must submit a written waiver request to DOE. Appendix C lists the information that must be included in a request for a foreign work waiver.

Save the waiver request(s) in a single PDF file. The applicant does not have the right to appeal DOE's decision concerning a waiver request.

iv. Construction

Recipients are required to obtain written authorization from the Grants Officer before incurring any major construction costs.

v. Foreign Travel

If international travel is proposed for your project, please note that your organization must comply with the International Air Transportation Fair Competitive Practices Act of 1974 (49 USC 40118), commonly referred to as the "Fly America Act," and implementing regulations at 41 CFR 301-10.131 through 301-10.143. The law and regulations require air transport of people or property to, from, between, or within a country other than the United States, the cost of which is supported under this award, to be performed by or under a cost-sharing arrangement with a U.S. flag carrier, if service is available. Foreign travel costs are allowable only with the written prior approval of the Grants Officer assigned to the award.

vi. Equipment and Supplies

Property disposition will be required at the end of a project if the current fair market value of property exceeds $5,000. For-profit entity disposition requirements are set forth at 2 CFR 910.360. Property disposition requirements for other non-federal entities are set forth in 2 CFR 200.310 – 200.316.

vii. Buy America Requirements for Infrastructure Projects

Pursuant to the Build America Buy America Act, subtitle IX of BIL (Buy America, or "BABA"), federally assisted projects which involve infrastructure work, undertaken by applicable recipient types, require that:

All iron, steel, and manufactured products used in the infrastructure work are produced in the United States; and
All construction materials used in the infrastructure work are manufactured in the United States.

Whether a given project must apply this requirement is project-specific and dependent on several factors, such as the recipient's entity type, whether the work involves "infrastructure," as that term is defined in Section 70914 of of the Bipartisan Infrastructure Law, and whether the infrastructure in question is publicly owned or serves a public function.

Applicants are strongly encouraged to consult Appendix D of this FOA to determine whether their project may have to apply this requirement, both to

make an early determination as to the need of a waiver, as well as to determine what impact, if any, this requirement may have on the proposed project's budget.

Please note that, based on implementation guidance from the Office of Management and Budget (OMB) issued on April 18, 2022, the Buy America requirements of the BIL do not apply to DOE projects in which the prime recipient is a for-profit entity; the requirements only apply to projects whose prime recipient is a "non-Federal entity," e.g., a State, local government, Indian tribe, Institution of Higher Education, or nonprofit organization. Subawards should conform to the terms of the prime award from which they flow; in other words, for-profit prime recipients are not required to flow down these Buy America requirements to subrecipients, even if those subrecipients are non-Federal entities as defined above. Conversely, prime recipients which are non-Federal entities must flow the Buy America requirements down to all subrecipients, even if those subrecipients are for-profit entities. Finally, for all applicants—both non-Federal entities and for-profit entities—DOE is including a Program Policy Factor that the Selection Official may consider in determining which Full Applications to select for award negotiations that considers whether the applicant has made a commitment to procure U.S. iron, steel, manufactured products, and construction materials in its project.

The Cooperative Agreement between DOE and the awardee will require each recipient: (1) to fulfill the commitments made in its application regarding the procurement of U.S.-produced products and (2) to fulfill the commitments made in its application regarding the procurement of other key component metals and manufactured products domestically that are deemed available in sufficient and reasonably available quantities or of a satisfactory quality at the time of award negotiation. Applicants may seek waivers of these requirements in very limited circumstances and for good cause shown. Further details on requesting a waiver can be found in Appendix D and the terms and conditions of the applicant's award.

Applicants are strongly encouraged to consult Appendix D for more information.

viii. Lobbying

Recipients and subrecipients may not use any federal funds to influence or attempt to influence, directly or indirectly, congressional action on any legislative or appropriation matters.

Recipients and subrecipients are required to complete and submit SF-LLL, "Disclosure of Lobbying Activities" (https://www.grants.gov/web/grants/forms/sf-424-individual-family.html) to

ensure that non-federal funds have not been paid and will not be paid to any person for influencing or attempting to influence any of the following in connection with the application:

- An officer or employee of any federal agency;
- A Member of Congress;
- An officer or employee of Congress; or
- An employee of a Member of Congress.

ix. Risk Assessment

Pursuant to 2 CFR 200.206, DOE will conduct an additional review of the risk posed by applications submitted under this FOA. Such risk assessment will consider:

1. Financial stability;
2. Quality of management systems and ability to meet the management standards prescribed in 2 CFR 200 as amended and adopted by 2 CFR 910;
3. History of performance;
4. Audit reports and findings; and
5. The applicant's ability to effectively implement statutory, regulatory, or other requirements imposed on non-federal entities.

DOE may make use of other publicly available information and the history of an applicant's performance under DOE or other federal agency awards.

Depending on the severity of the findings and whether the findings were resolved, DOE may elect not to fund the applicant.

In addition to this review, DOE must comply with the guidelines on government-wide suspension and debarment in 2 CFR 180, and must require non-federal entities to comply with these provisions. These provisions restrict federal awards, subawards and contracts with certain parties that are debarred, suspended or otherwise excluded from or ineligible for participation in federal programs or activities.

Further, as DOE invests in critical infrastructure and funds critical and emerging technology areas, DOE also considers possible vectors of undue foreign influence in evaluating risk. If high risks are identified and cannot be sufficiently mitigated, DOE may elect to not fund the applicant.

x. Invoice Review and Approval

DOE employs a risk-based approach to determine the level of supporting documentation required for approving invoice payments. Recipients may be required to provide some or all of the following items with their requests for reimbursement:

- Summary of costs by cost categories
- Timesheets or person
- Invoices/receipts for all travel, equipment, supplies, contractual, and other costs;
- UCC filing proof for equipment acquired with project funds by for-profit recipients and subrecipients;
- Explanation of cost share for invoicing period;
- Analogous information for some subrecipients; and
- Other items as required by DOE.

xi. Foreign Collaboration Considerations

a. Consideration of new collaborations with foreign entities and governments. The recipient will be required to provide DOE with advanced written notification of any potential collaboration with foreign entities or governments in connection with its DOE-funded award scope. The recipient will then be required to await further guidance from DOE prior to contacting the proposed foreign entity or government regarding the potential collaboration or negotiating the terms of any potential agreement.

b. Existing collaborations with foreign entities and governments. The recipient will be required to provide DOE with a written list of all existing foreign collaborations in which it has entered in connection with its DOE-funded award scope.

c. Description of collaborations that should be reported: In general, a collaboration will involve some provision of a thing of value to, or from, the recipient. A thing of value includes but may not be limited to all resources made available to, or from, the recipient in support of and/or related to the DOE award, regardless of whether or not they have monetary value. Things of value also may include in-kind contributions (such as office/laboratory space, data, equipment, supplies, employees, students). In-kind contributions not intended for direct use on the DOE award but resulting in provision of a thing of value from or to the DOE award must also be reported. Collaborations do not include routine workshops, conferences, use of the recipient's services and facilities by foreign investigators resulting from its standard published process for evaluating requests for access, or the routine use of foreign facilities by awardee staff in accordance with the recipient's standard policies and procedures.

xii. Prohibition Related to Foreign Government-Sponsored Talent Recruitment Programs

a. Prohibition

Persons participating in a Foreign Government-Sponsored Talent Recruitment Program of a Foreign Country of Risk are prohibited from participating in projects selected for federal funding under this FOA. Should an award result from this FOA, the recipient must exercise ongoing due diligence to reasonably ensure that no individuals participating on the DOE-funded project are participating in a Foreign Government-Sponsored Talent Recruitment Program of a Foreign Country of Risk. Consequences for violations of this prohibition will be determined according to applicable law, regulations, and policy. Further, the recipient must notify DOE within five (5) business days upon learning that an individual on the project team is or is believed to be participating in a foreign government talent recruitment program of a foreign country of risk. DOE may modify and add requirements related to this prohibition to the extent required by law.

b. Definitions

1. **Foreign Government-Sponsored Talent Recruitment Program.** An effort directly or indirectly organized, managed, or funded by a foreign government, or a foreign government instrumentality or entity, to recruit science and technology professionals or students (regardless of citizenship or national origin, or 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 relocate physically to the foreign state for the above purpose. Some programs allow for or encourage continued employment at United States 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.

2. **Foreign Country of Risk.** DOE has designated the following countries as foreign countries of risk: Iran, North Korea, Russia, and China. This list is subject to change.

V. Application Review Information

A. Technical Review Criteria

i. Concept Papers

Concept Papers are evaluated based on consideration of the following factors. All sub-criteria are of equal weight.

Concept Paper Criterion: Overall FOA Responsiveness and Viability of the Project (Weight: 100%)
This criterion involves consideration of the following factors:

- The applicant clearly describes the proposed technology, describes how the technology is unique and innovative, and how the technology will advance the current state-of-the-art;
- The applicant has identified risks and challenges, including possible mitigation strategies, and has shown the impact that EERE funding and the proposed project would have on the relevant field and application;
- The applicant has the qualifications, experience, capabilities and other resources necessary to complete the proposed project; and
- The proposed work, if successfully accomplished, would clearly meet the objectives as stated in the FOA.

ii. Full Applications

Applications will be evaluated against the merit review criteria shown below. All sub-criteria are of equal weight.

Criterion 1: Technical Merit, Innovation, and Impact (45%)
This criterion involves consideration of the following factors:

Technical Merit and Innovation

- Extent to which the proposed technology or process is innovative;
- Degree to which the current state of the technology and the proposed advancement are clearly described;
- Extent to which the application specifically and convincingly demonstrates how the applicant will move the state-of-the-art to the proposed advancement; and

- Sufficiency of technical detail in the application to assess whether the proposed work is scientifically meritorious and revolutionary, including relevant data, calculations and discussion of prior work in the literature with analyses that support the viability of the proposed work.

Impact of Technology Advancement

- How the project supports the topic area objectives and target specifications and metrics; and
- The potential impact of the project on advancing the state-of-the-art, achieving emissions reduction and energy efficiency improvements in the industrial sector, and providing any co-benefits.

Criterion 2: Project Research and Market Transformation Plan (25%)
This criterion involves consideration of the following factors:

Research Approach, Workplan and SOPO

- Degree to which the approach and critical path have been clearly described and thoughtfully considered; and
- Degree to which the task descriptions are clear, detailed, timely, and reasonable, resulting in a high likelihood that the proposed Workplan and SOPO will succeed in meeting the project goals.

Identification of Technical Risks

- Discussion and demonstrated understanding of the key technical risk areas involved in the proposed work and the quality of the mitigation strategies to address them.

Baseline, Metrics, and Deliverables

- The level of clarity in the definition of the baseline, metrics, and milestones; and
- Relative to a clearly defined experimental baseline, the strength of the quantifiable metrics, milestones, and a mid-point deliverables defined in the application, such that meaningful interim progress will be made.

Market Transformation Plan

- Identification of target market, competitors, and distribution channels for proposed technology along with known or perceived barriers to market penetration, including mitigation plan; and
- Comprehensiveness of market transformation plan including but not limited to product development and/or service plan, commercialization timeline, financing, product marketing, legal/regulatory considerations including intellectual property, infrastructure requirements, and product distribution.

Criterion 3: Team and Resources (15%)

This criterion involves consideration of the following factors:

- The capability of the Principal Investigator(s) and the proposed team to address all aspects of the proposed work with a high probability of success.
- The qualifications, relevant expertise, and time commitment of the individuals on the team;
- The sufficiency of the facilities to support the work;
- The degree to which the proposed consortia/team demonstrates the ability to facilitate and expedite further development and commercial deployment of the proposed technologies;
- The level of participation by project participants as evidenced by letter(s) of commitment, how well they are integrated into the Workplan, and the level of industrial participation; and
- The reasonableness of the budget and spend plan for the proposed project and objectives.

Criterion 4: Community Benefits Plan (15%)

The criterion involves consideration of the factors below. Each section of the plan is equally weighted, such that full credit can only be given for plans with technically meritorious approaches in all three areas.

Diversity, Equity, Inclusion, and Accessibility (DEIA)

- Clear articulation of the project's goals related to diversity, equity, inclusion, and accessibility. These are four different, but related, concepts that should not be conflated. That is, you can achieve diversity without equity; all four are necessary for top scores;
- Quality of the project's DEIA goals, as measured by the goals' depth, breadth, likelihood of success, inclusion of appropriate and relevant SMART milestones, and overall project integration;
- Commitment and ability to track progress towards meeting each of the diversity, equity, inclusion, and accessibility goals; and
- Extent of engagement of organizations that represent disadvantaged communities as a core element of their mission, including MSIs, Minority Business Entities, and non-profit or community-based organizations.

Energy Equity

- Clear workplan tasks, staffing, research, and timeline for engaging energy equity stakeholders and/or evaluating the possible near and long-term implications of the project for the benefit of the American public, including, but not limited to the public health and public prosperity benefits;

- Approach, methodology, and expertise articulated in the plan for addressing energy equity and justice issues associated with the technology innovation; and
- Likelihood that the plan will result in improved understanding of distributional public benefits and costs related to the innovation if successful.

Workforce Implications

- Clear and comprehensive workplan tasks, staffing, research, and timeline for engaging workforce stakeholders and/or evaluating the possible near and long-term implications of the project for the U.S. workforce;
- Approach to document the knowledge, skills, and abilities of the workforce required for successful commercial deployment of innovations resulting from this research; and
- Likelihood that the plan will result in improved understanding of the workforce implications related to the innovation if successful.

iii. Criteria for Replies to Reviewer Comments

DOE has not established separate criteria to evaluate Replies to Reviewer Comments. Instead, Replies to Reviewer Comments are attached to the original applications and evaluated as an extension of the Full Application.

B. Standards for Application Evaluation

Applications that are determined to be eligible will be evaluated in accordance with this FOA, by the standards set forth in EERE's Notice of Objective Merit Review Procedure (76 Fed. Reg. 17846, March 31, 2011) and the guidance provided in the "DOE Merit Review Guide for Financial Assistance," effective September 2020, which is available at: https://energy.gov/management/downloads/merit-review-guide-financial-assistance-and-unsolicited-proposals-current.

C. Other Selection Factors

i. Program Policy Factors

In addition to the above criteria, the Selection Official may consider the following program policy factors in determining which Full Applications to select for award negotiations:

- The degree to which the proposed project exhibits technological diversity when compared to the existing DOE project portfolio and other projects selected from the subject FOA;
- The degree to which the proposed project, including proposed cost share, optimizes the use of available EERE funding to achieve programmatic objectives;
- The level of industry involvement and demonstrated ability to accelerate commercialization and overcome key market barriers;
- The degree to which the proposed project is likely to lead to increased employment and manufacturing in the United States;
- The degree to which the proposed project will accelerate transformational technological advances in areas that industry by itself is not likely to undertake because of technical and financial uncertainty;
- The degree to which the proposed project provides funding to disadvantaged communities or seeks to address environmental injustices that disproportionately affect disadvantaged communities in accordance with Executive Order 14008;
- The extent the proposed project will lead to advancements that will support the just transition of energy workers and communities to clean energy;
- The degree to which the proposed project, or group of projects, represent a desired geographic distribution (considering past awards and current applications);
- The degree to which the proposed project incorporates applicant or team members from Minority Serving Institutions (e.g. Historically Black Colleges and Universities (HBCUs)/Other Minority Institutions (OMIs)); and partnerships with Minority Business Enterprises, Minority Owned Businesses, Woman Owned Businesses, Veteran Owned Businesses, or tribal nations;
- The degree to which the proposed project, when compared to the existing DOE project portfolio and other projects to be selected from the subject FOA, contributes to the total portfolio meeting the goals reflected in the Community Benefits Plan criteria; and
- The degree to which the proposed project will employ procurement of U.S. iron, steel, manufactured products, and construction materials.

D. Evaluation and Selection Process

i. Overview

The evaluation process consists of multiple phases; each includes an initial eligibility review and a thorough technical review. Rigorous technical reviews of eligible submissions are conducted by reviewers that are experts in the subject matter of the FOA. Ultimately, the Selection Official considers the recommendations of the reviewers, along with other considerations such as program policy factors, in determining which applications to select.

ii. Pre-Selection Interviews

As part of the evaluation and selection process, EERE may invite one or more applicants to participate in Pre-Selection Interviews. Pre-Selection Interviews are distinct from and more formal than pre-selection clarifications (See Section V.D.iii. of the FOA). The invited applicant(s) will meet with EERE representatives to provide clarification on the contents of the Full Applications and to provide EERE an opportunity to ask questions regarding the proposed project. The information provided by applicants to EERE through Pre-Selection Interviews contributes to EERE's selection decisions.

EERE will arrange to meet with the invited applicants in person at EERE's offices or a mutually agreed upon location. EERE may also arrange site visits at certain applicants' facilities. In the alternative, EERE may invite certain applicants to participate in a one-on-one conference with EERE via webinar, videoconference, or conference call.

EERE will not reimburse applicants for travel and other expenses relating to the Pre-Selection Interviews, nor will these costs be eligible for reimbursement as pre-award costs.

Participation in Pre-Selection Interviews with EERE does not signify that applicants have been selected for award negotiations.

iii. Pre-Selection Clarification

EERE may determine that pre-selection clarifications are necessary from one or more applicants. Pre-selection clarifications are distinct from and less formal than pre-selection interviews. These pre-selection clarifications will solely be for the purposes of clarifying the application. The pre-selection clarifications may occur before, during or after the merit review evaluation process. Information provided by an applicant that is not necessary to address the pre-selection clarification question will not be reviewed or considered. Typically, a pre-selection clarification will be carried out through either written responses to EERE's written clarification questions or video or conference calls with EERE representatives.

The information provided by applicants to EERE through pre-selection clarifications is incorporated in their applications and contributes to the merit review evaluation and EERE's selection decisions. If EERE contacts an applicant for pre-selection clarification purposes, it does not signify that the applicant has been selected for negotiation of award or that the applicant is among the top ranked applications.

EERE will not reimburse applicants for expenses relating to the pre-selection clarifications, nor will these costs be eligible for reimbursement as pre-award costs.

iv. Recipient Integrity and Performance Matters

DOE, prior to making a federal award with a total amount of federal share greater than the simplified acquisition threshold, is required to review and consider any responsibility and qualification information about the applicant that is in the entity information domain in SAM.gov (see 41 U.S.C. 2313).

The applicant, at its option, may review information in the entity information domain SAM.gov and comment on any information about itself that a federal awarding agency previously entered and is currently in the entity information domain in SAM.gov.

DOE will consider any written comments by the applicant, in addition to the other information in the entity information domain in SAM.gov, in making a judgment about the applicant's integrity, business ethics, and record of performance under federal awards when completing the review of risk posed by applicants as described in 2 CFR 200.206.

v. Selection

The Selection Official may consider the technical merit, the Federal Consensus Board's recommendations, program policy factors, and the amount of funds available in arriving at selections for this FOA.

E. Anticipated Notice of Selection and Award Negotiation Dates

EERE anticipates notifying applicants selected for negotiation of award and negotiating awards by the dates provided on the cover page of this FOA.

VI. Award Administration Information

A. Award Notices

i. Ineligible Submissions

Ineligible Concept Papers and Full Applications will not be further reviewed or considered for award. The Grants Officer will send a notification letter by email to the technical and administrative points of contact designated by the applicant in EERE eXCHANGE. The notification letter will state the basis upon which the

Concept Paper or the Full Application is ineligible and not considered for further review.

ii. Concept Paper Notifications

EERE will notify applicants of its determination to encourage or discourage the submission of a Full Application. EERE will post these notifications to EERE eXCHANGE. EERE may include general comments provided from reviewers on an applicant's Concept Paper in the encourage/discourage notifications. Applicants may submit a Full Application even if they receive a notification discouraging them from doing so. By discouraging the submission of a Full Application, EERE intends to convey its lack of programmatic interest in the proposed project. Such assessments do not necessarily reflect judgments on the merits of the proposed project. The purpose of the Concept Paper phase is to save applicants the considerable time and expense of preparing a Full Application that is unlikely to be selected for award negotiations.

iii. Full Application Notifications

EERE will notify applicants of its determination via a notification letter by email to the technical and administrative points of contact designated by the applicant in EERE eXCHANGE. The notification letter will inform the applicant whether or not its Full Application was selected for award negotiations. Alternatively, EERE may notify one or more applicants that a final selection determination on particular Full Applications will be made at a later date, subject to the availability of funds or other factors.

iv. Successful Applicants

Receipt of a notification letter selecting a Full Application for award negotiations does not authorize the applicant to commence performance of the project. If an application is selected for award negotiations, it is not a commitment by EERE to issue an award. Applicants do not receive an award until award negotiations are complete and the Grants Officer executes the funding agreement, accessible by the prime recipient in FedConnect.

The award negotiation process will take approximately 60 days. Applicants must designate a primary and a backup point-of-contact in EERE eXCHANGE with whom EERE will communicate to conduct award negotiations. The applicant must be responsive during award negotiations (i.e., provide requested documentation) and meet the negotiation deadlines. If the applicant fails to do so or if award negotiations are otherwise unsuccessful, EERE will cancel the award negotiations and rescind the Selection. EERE reserves the right to terminate award negotiations at any time for any reason.

Please refer to Section IV.J.ii. of the FOA for guidance on pre-award costs.

v. Alternate Selection Determinations

In some instances, an applicant may receive a notification that its application was not selected for award and EERE designated the application to be an alternate. As an alternate, EERE may consider the Full Application for federal funding in the future. A notification letter stating the Full Application is designated as an alternate does not authorize the applicant to commence performance of the project. EERE may ultimately determine to select or not select the Full Application for award negotiations.

vi. Unsuccessful Applicants

EERE shall promptly notify in writing each applicant whose application has not been selected for award or whose application cannot be funded because of the unavailability of appropriated funds.

B. Administrative and National Policy Requirements

i. Registration Requirements

There are several one-time actions before submitting an application in response to this FOA, and it is vital that applicants address these items as soon as possible. Some may take several weeks, and failure to complete them could interfere with an applicant's ability to apply to this FOA, or to meet the negotiation deadlines and receive an award if the application is selected. These requirements are as follows:

1. **EERE Funding Opportunity Exchange (eXCHANGE)**
   Register and create an account on EERE eXCHANGE at https://eere-eXCHANGE.energy.gov. This account will allow the user to apply to any open EERE FOAs that are currently in EERE eXCHANGE.

   To access EERE eXCHANGE, potential applicants are required to have a Login.gov account. As part of the eXCHANGE registration process, new users will be directed to create an account in Login.gov. Please note that the email address associated with Login.gov must match the email address associated with the eXCHANGE account. For more information, refer to the eXCHANGE Multi-Factor Authentication (MFA) Quick Guide in the Manuals section of eXCHANGE.

   It is recommended that each organization or business unit, whether acting as a team or a single entity, use only one account as the contact point for each submission. Applicants should also designate backup points of contact so they may be easily contacted if deemed necessary. **This step is required to**

apply to this FOA. The eXCHANGE registration does not have a delay; however, **the remaining registration requirements below could take several weeks to process and are necessary for a potential applicant to receive an award under this FOA.**

2. **System for Award Management**
   Register with the SAM at https://www.sam.gov. Designating an Electronic Business Point of Contact (EBiz POC) and obtaining a special password called a Marketing Partner ID Number (MPIN) are important steps in SAM registration. Please update your SAM registration annually.

3. **FedConnect**
   Register in FedConnect at https://www.fedconnect.net. To create an organization account, your organization's SAM MPIN is required. For more information about the SAM MPIN or other registration requirements, review the FedConnect Ready, Set, Go! Guide at https://www.fedconnect.net/FedConnect/Marketing/Documents/FedConnect_Ready_Set_Go.pdf.

4. **Grants.gov**
   Register in Grants.gov (http://www.grants.gov) to receive automatic updates when Amendments to this FOA are posted. However, please note that Concept Papers and Full Applications will not be accepted through Grants.gov.

5. **Electronic Authorization of Applications and Award Documents**
   Submission of an application and supplemental information under this FOA through electronic systems used by the DOE, including EERE eXCHANGE and FedConnect.net, constitutes the authorized representative's approval and electronic signature.

ii. Award Administrative Requirements

The administrative requirements for DOE grants and cooperative agreements are contained in 2 CFR Part 200 as amended by 2 CFR Part 910.

iii. Foreign National Participation

All applicants selected for an award under this FOA and project participants (including subrecipients and contractors) who anticipate involving foreign nationals in the performance of an award, may be required to provide DOE with specific information about each foreign national to satisfy requirements for foreign national participation. A "foreign national" is defined as any person who is not a United States citizen by birth or naturalization. The volume and type of information collected may depend on various factors associated with the award.

DOE concurrence may be required before a foreign national can participate in the performance of any work under an award.

DOE may elect to deny foreign national's participation in the award. Likewise, DOE may elect to deny a foreign national's access to a DOE sites, information, technologies, equipment, programs, or personnel.

iv. Subaward and Executive Reporting

Additional administrative requirements necessary for DOE grants and cooperative agreements to comply with the Federal Funding and Transparency Act of 2006 (FFATA) are contained in 2 CFR Part 170. Prime recipients must register with the new FFATA Subaward Reporting System database and report the required data on their first tier subrecipients. Prime recipients must report the executive compensation for their own executives as part of their registration profile in SAM.

v. National Policy Requirements

The National Policy Assurances that are incorporated as a term and condition of award are located at: http://www.nsf.gov/awards/managing/rtc.jsp.

vi. Environmental Review in Accordance with National Environmental Policy Act (NEPA)

EERE's decision whether and how to distribute federal funds under this FOA is subject to NEPA (42 U.S.C. 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 https://www.energy.gov/nepa.

While NEPA compliance is a federal agency responsibility and the ultimate decisions remain with the federal agency, all recipients selected for an award will be required to assist in the timely and effective completion of the NEPA process in the manner most pertinent to their proposed project. If DOE determines certain records must be prepared to complete the NEPA review process (e.g., biological evaluations or environmental assessments), the recipient may be required to prepare the records and the costs to prepare the necessary records may be included as part of the project costs.

vii. Applicant Representations and Certifications

1. **Lobbying Restrictions**

By accepting funds under this award, the prime recipient agrees that none of the funds obligated on the award shall be expended, directly or indirectly, to influence Congressional action on any legislation or appropriation matters pending before Congress, other than to communicate to Members of Congress as described in 18 U.S.C. § 1913. This restriction is in addition to those prescribed elsewhere in statute and regulation.

2. **Corporate Felony Conviction and Federal Tax Liability Representations**
In submitting an application in response to this FOA, the applicant represents that:

   a. It is **not** a corporation that has been convicted of a felony criminal violation under any federal law within the preceding 24 months; and

   b. It is **not** a corporation that has any unpaid federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability.

   For purposes of these representations the following definitions apply:

   A Corporation includes any entity that has filed articles of incorporation in any of the 50 states, the District of Columbia, or the various territories of the United States [but not foreign corporations]. It includes both for-profit and non-profit organizations.

3. **Nondisclosure and Confidentiality Agreements Representations**
In submitting an application in response to this FOA the applicant represents that:

   a. It **does not and will not** require its employees or contractors to sign internal nondisclosure or confidentiality agreements or statements prohibiting or otherwise restricting its employees or contactors from lawfully reporting waste, fraud, or abuse to a designated investigative or law enforcement representative of a federal department or agency authorized to receive such information.

   b. It **does not and will not** use any federal funds to implement or enforce any nondisclosure and/or confidentiality policy, form, or agreement it uses unless it contains the following provisions:

(1) *''These provisions are consistent with and do not supersede, conflict with, or otherwise alter the employee obligations, rights, or liabilities created by existing statute or Executive order relating to (1) classified information, (2) communications to Congress, (3) the reporting to an Inspector General of a violation of any law, rule, or regulation, or mismanagement, a gross waste of funds, an abuse of authority, or a substantial and specific danger to public health or safety, or (4) any other whistleblower protection. The definitions, requirements, obligations, rights, sanctions, and liabilities created by controlling Executive orders and statutory provisions are incorporated into this agreement and are controlling.''*

(2) The limitation above shall not contravene requirements applicable to Standard Form 312 Classified Information Nondisclosure Agreement (https://fas.org/sgp/othergov/sf312.pdf), Form 4414 Sensitive Compartmented Information Disclosure Agreement (https://fas.org/sgp/othergov/intel/sf4414.pdf), or any other form issued by a federal department or agency governing the nondisclosure of classified information.

(3) Notwithstanding the provision listed in paragraph (a), a nondisclosure or confidentiality policy form or agreement that is to be executed by a person connected with the conduct of an intelligence or intelligence-related activity, other than an employee or officer of the United States government, may contain provisions appropriate to the particular activity for which such document is to be used. Such form or agreement shall, at a minimum, require that the person will not disclose any classified information received in the course of such activity unless specifically authorized to do so by the United States government. Such nondisclosure or confidentiality forms shall also make it clear that they do not bar disclosures to Congress, or to an authorized official of an executive agency or the Department of Justice, that are essential to reporting a substantial violation of law.

viii. Statement of Federal Stewardship

EERE will exercise normal federal stewardship in overseeing the project activities performed under EERE awards. Stewardship Activities include, but are not limited to, conducting site visits; reviewing performance and financial reports; providing assistance and/or temporary intervention in unusual circumstances to correct deficiencies that develop during the project; assuring compliance with terms and conditions; and reviewing technical performance after project completion to ensure that the project objectives have been accomplished.

ix. Statement of Substantial Involvement

EERE has substantial involvement in work performed under awards made as a result of this FOA. EERE does not limit its involvement to the administrative requirements of the award. Instead, EERE has substantial involvement in the direction and redirection of the technical aspects of the project as a whole. Substantial involvement includes, but is not limited to, the following:

1. EERE shares responsibility with the recipient for the management, control, direction, and performance of the project.
2. EERE may intervene in the conduct or performance of work under this award for programmatic reasons. Intervention includes the interruption or modification of the conduct or performance of project activities.
3. EERE may redirect or discontinue funding the project based on the outcome of EERE's evaluation of the project at the Go/No-Go decision point(s).
4. EERE participates in major project decision-making processes.

x. Subject Invention Utilization Reporting

In order to ensure that prime recipients and subrecipients holding title to subject inventions are taking the appropriate steps to commercialize subject inventions, EERE may require that each prime recipient holding title to a subject invention submit annual reports for ten (10) years from the date the subject invention was disclosed to EERE on the utilization of the subject invention and efforts made by prime recipient or their licensees or assignees to stimulate such utilization. The reports must include information regarding the status of development, date of first commercial sale or use, gross royalties received by the prime recipient, and such other data and information as EERE may specify.

xi. Intellectual Property Provisions

The standard DOE financial assistance intellectual property provisions applicable to the various types of recipients are located at http://energy.gov/gc/standard-intellectual-property-ip-provisions-financial-assistance-awards.

xii. Reporting

Reporting requirements are identified on the Federal Assistance Reporting Checklist, attached to the award agreement.

Additional reporting requirements apply for some projects. As described in Section I.B, awardees under Topic 2 (Low-Carbon Fuels Utilization R&D) AOIs 1 and 2 (Mitigating H_2 Combustion Impacts on Material and Product Quality; Developing H_2-Based Combustion Systems) will be required to comply with

Project Safety Plan requirements, including submission of a Project Safety Plan within 90 days of award signing.

xiii. Go/No-Go Review

Each project selected under this FOA will be subject to a periodic project evaluation referred to as a Go/No-Go Review. A Go/No-Go Review is a risk management tool and a project management best practice to ensure that, for the current phase or period of performance, technical success is definitively achieved and potential for success in future phases or periods of performance is evaluated, prior to actually beginning the execution of future phases. At the Go/No-Go decision points, DOE will evaluate project performance, project schedule adherence, meeting milestone objectives, compliance with reporting requirements, and overall contribution to the EERE program goals and objectives. Federal funding beyond the Go/No-Go decision point (continuation funding) is contingent upon (1) availability of federal funds appropriated by Congress for the purpose of this program; (2) the availability of future-year budget authority; (3) recipient's technical progress compared to the Milestone Summary Table stated in Attachment 1 of the award; (4) recipient's submittal of required reports; (5) recipient's compliance with the terms and conditions of the award; (6) DOE's Go/No-Go decision; (7) the recipient's submission of a continuation application; and (8) written approval of the continuation application by the Grants Officer.

As a result of the Go/No-Go Review, DOE may, at its discretion, authorize the following actions: (1) continue to fund the project, contingent upon the availability of funds appropriated by Congress for the purpose of this program and the availability of future-year budget authority; (2) recommend redirection of work under the project; (3) place a hold on federal funding for the project, pending further supporting data or funding; or (4) discontinue funding the project because of insufficient progress, change in strategic direction, or lack of funding.

The Go/No-Go decision is distinct from a non-compliance determination. In the event a recipient fails to comply with the requirements of an award, DOE may take appropriate action, including but not limited to, redirecting, suspending or terminating the award.

xiv. Conference Spending

The recipient shall not expend any funds on a conference not directly and programmatically related to the purpose for which the grant or cooperative agreement was awarded that would defray the cost to the United States government of a conference held by any Executive branch department, agency, board, commission, or office for which the cost to the United States government

would otherwise exceed $20,000, thereby circumventing the required notification by the head of any such Executive Branch department, agency, board, commission, or office to the Inspector General (or senior ethics official for any entity without an Inspector General), of the date, location, and number of employees attending such conference.

xv. Uniform Commercial Code (UCC) Financing Statements

Per 2 CFR 910.360 (Real Property and Equipment) when a piece of equipment is purchased by a for-profit recipient or subrecipient with federal funds, and when the federal share of the financial assistance agreement is more than $1,000,000, the recipient or subrecipient must:

Properly record, and consent to the Department's ability to properly record if the recipient fails to do so, UCC financing statement(s) for all equipment in excess of $5,000 purchased with project funds. These financing statement(s) must be approved in writing by the Grants Officer prior to the recording, and they shall provide notice that the recipient's title to all equipment (not real property) purchased with federal funds under the financial assistance agreement is conditional pursuant to the terms of this section, and that the government retains an undivided reversionary interest in the equipment. The UCC financing statement(s) must be filed before the Grants Officer may reimburse the recipient for the federal share of the equipment unless otherwise provided for in the relevant financial assistance agreement. The recipient shall further make any amendments to the financing statements or additional recordings, including appropriate continuation statements, as necessary or as the Grants Officer may direct.

xvi. Real Property and Equipment

Real property and equipment purchased with project funds (federal share and recipient cost share) are subject to the requirements at 2 CFR 200.310, 200.311, 200.313, and 200.316 (non-Federal entities, except for-profit entities) and 2 CFR 910.360 (for-profit entities). For projects selected for award under this FOA, the recipient may (1) take disposition action on the real property and equipment; or (2) continue to use the real property and equipment after the conclusion of the award period of performance with Grants Officer approval. The recipient's written Request for Continued Use must identify the property and include: a summary of how the property will be used (must align with the authorized project purposes); a proposed use period, (e.g., perpetuity, until fully depreciated, or a calendar date where the recipient expects to submit disposition instructions); acknowledgement that the recipient shall not sell or encumber the property or permit any encumbrance without prior written DOE approval; current fair market value of the property; and an Estimated Useful Life or depreciation schedule for equipment.

When the property is no longer needed for authorized project purposes, the recipient must request disposition instructions from DOE. For-profit entity disposition requirements are set forth at 2 CFR 910.360. Property disposition requirements for other non-federal entities are set forth in 2 CFR 200.310 – 200.316.

xvii. Implementation of Executive Order 13798, Promoting Free Speech and Religious Liberty

States, local governments, or other public entities may not condition sub-awards in a manner that would discriminate, or disadvantage sub-recipients based on their religious character.

xviii. Participants and Collaborating Organizations

If selected for award negotiations, the selected applicant must submit a list of personnel who are proposed to work on the project, both at the recipient and subrecipient level and a list of proposed collaborating organizations prior to award. Recipients will have an ongoing responsibility to notify DOE of changes to the personnel and collaborating organizations, and submit updated information during the life of the award.

xix. Current and Pending Support

If selected for award negotiations, within 30 days of the selection notice, the selectee must submit 1) current and pending support disclosures and resumes for any new PIs or senior/key personnel and 2) updated disclosures if there have been any changes to the current and pending support submitted with the application. Throughout the life of the award, the recipient has an ongoing responsibility to submit 1) current and pending support disclosure statements and resumes for any new PI and senior/key personnel, and 2) updated disclosures if there are changes to the current and pending support previously submitted to DOE. Also See. Section IV.E.xvii.

xx. U.S. Manufacturing Commitments

A primary objective of DOE's multi-billion dollar research, development and demonstration investments is to cultivate new research and development ecosystems, manufacturing capabilities, and supply chains for and by United States industry and labor. Therefore, in exchange for receiving taxpayer dollars to support an applicant's project, the applicant must agree to a U.S. Competitiveness Provision requiring that any products embodying any subject invention or produced through the use of any subject invention will be manufactured substantially in the United States unless the recipient can show to the satisfaction of DOE that it is not commercially feasible. Award terms,

including the specific U.S. Competitiveness Provision applicable to the various types of recipients and projects, are available at: https://www.energy.gov/gc/standard-intellectual-property-ip-provisions-financial-assistance-awards.

Please note that a subject invention is any invention conceived or first actually reduced to practice in performance of work under an award. An invention is any invention or discovery which is or may be patentable. The recipient includes any awardee, recipient, sub-awardee, or sub-recipient.

As noted in the U.S. Competitiveness Provision, if an entity cannot meet the requirements of the U.S. Competitiveness Provision, the entity may request a modification or waiver of the U.S. Competitiveness Provision. For example, the entity may propose modifying the language of the U.S. Competitiveness Provision in order to change the scope of the requirements or to provide more specifics on the application of the requirements for a particular technology. As another example, the entity may request that the U.S. Competitiveness Provision be waived in lieu of a net benefits statement or United States manufacturing plan. The statement or plan would contain specific and enforceable commitments that would be beneficial to the United States economy and competitiveness. Examples of such commitments could include manufacturing specific products in the U.S., making a specific investment in a new or existing United States manufacturing facility, keeping certain activities based in the United States or supporting a certain number of jobs in the United States related to the technology. DOE may, in its sole discretion, determine that the proposed modification or waiver promotes commercialization and provides substantial United States economic benefits, and grant the request. If granted, DOE will modify the award terms and conditions for the requesting entity accordingly.

More information and guidance on the waiver and modification request process can be found in the DOE Financial Assistance Letter on this topic, available at https://www.energy.gov/management/pf-2022-09-fal-2022-01-implementation-doe-determination-exceptional-circumstances-under. Additional information on DOE's Commitment to Domestic Manufacturing for DOE-funded R&D is available at https://www.energy.gov/gc/us-manufacturing.

The U.S. Competitiveness Provision is implemented by DOE pursuant to a Determination of Exceptional Circumstances (DEC) under the Bayh-Dole Act and DOE Patent Waivers. See Section VIII.J. Title to Subject Inventions of this FOA for more information on the DEC and DOE Patent Waivers.

xxi. Interim Conflict of Interest Policy for Financial Assistance

The DOE interim Conflict of Interest Policy for Financial Assistance (COI Policy)[74] is applicable to all non-Federal entities applying for, or that receive, DOE funding by means of a financial assistance award (e.g., a grant, cooperative agreement, or technology investment agreement) and, through the implementation of this policy by the entity, to each Investigator who is planning to participate in, or is participating in, the project funded wholly or in part under the DOE financial assistance award. The term "Investigator" means the PI and any other person, regardless of title or position, who is responsible for the purpose, design, conduct, or reporting of a project funded by DOE or proposed for funding by DOE. Recipients must flow down the requirements of the interim COI Policy to any subrecipient non-federal entities. Further, for DOE funded projects, the recipient must include all financial conflicts of interest (FCOI) (i.e., managed and unmanaged/ unmanageable) in their initial and ongoing FCOI reports.

It is understood that non-federal entities and individuals receiving DOE financial assistance awards will need sufficient time to come into full compliance with DOE's interim COI Policy. To provide some flexibility, DOE allows for a staggered implementation. Specifically, prior to award, applicants selected for award negotiations must: ensure all Investigators complete their significant financial disclosures; review the disclosures; determine whether a FCOI exists; develop and implement a management plan for FCOIs; and provide DOE with an initial FCOI report that includes all FCOIs (i.e., managed and unmanaged/ unmanageable). Recipients will have 180 days from the date of the award to come into full compliance with the other requirements set forth in DOE's interim COI Policy. Prior to award, the applicant must certify that it is, or will be within 180 days of the award, compliant with all requirements in the COI Policy.

xxii. Data Management Plan (DMP)

Each applicant whose Full Application is selected for award negotiations will be required to submit a DMP during the award negotiations phase. A DMP explains how, when appropriate, data generated in the course of the work performed under an EERE award will be shared and preserved in order to validate the results of the proposed work or how the results could be validated if the data is not shared or preserved. The DMP must provide a plan for making all research data displayed in publications resulting from the proposed work digitally accessible at the time of publications.

[74] DOE's interim COI Policy can be found at PF 2022-17 FAL 2022-02 Department of Energy Interim Conflict of Interest Policy Requirements for Financial Assistance.

xxiii. Fraud, Waste and Abuse

The mission of the DOE Office of Inspector General (OIG) is to strengthen the integrity, economy and efficiency of the Department's programs and operations including deterring and detecting fraud, waste, abuse and mismanagement. The OIG accomplishes this mission primarily through investigations, audits, and inspections of DOE activities to include grants, cooperative agreements, loans, and contracts.

The OIG maintains a Hotline for reporting allegations of fraud, waste, abuse, or mismanagement. To report such allegations, please visit https://www.energy.gov/ig/ig-hotline.

Additionally, recipients of DOE awards must be cognizant of the requirements of 2 CFR 200.113 Mandatory disclosures, which states:

> The non-Federal entity or applicant for a Federal award must disclose, in a timely manner, in writing to the Federal awarding agency or pass-through entity all violations of Federal criminal law involving fraud, bribery, or gratuity violations potentially affecting the Federal award. Non-Federal entities that have received a Federal award including the term and condition outlined in appendix XII of 2 CFR Part 200 are required to report certain civil, criminal, or administrative proceedings to SAM (currently FAPIIS). Failure to make required disclosures can result in any of the remedies described in 2 CFR 200.339. (See also 2 CFR part 180, 31 U.S.C. § 3321, and 41 U.S.C. § 2313.) [85 FR 49539, Aug. 13, 2020]

Applicants and subrecipients (if applicable) are encouraged to allocate sufficient costs in the project budget to cover the costs associated for personnel and data infrastructure needs to support performance management and program evaluation needs including but not limited to independent program and project audits to mitigate risks for fraud, waste, and abuse.

xxiv. Human Subjects Research

Research involving human subjects, biospecimens, or identifiable private information conducted with DOE funding is subject to the requirements of DOE Order 443.1C, Protection of Human Research Subjects, 45 CFR Part 46, Protection of Human Subjects (subpart A which is referred to as the "Common Rule"), and 10 CFR Part 745, Protection of Human Subjects. Additional information on the DOE Human Subjects Research Program can be found at: https://science.osti.gov/ber/human-subjects.

VII. Questions/Agency Contacts

Upon the issuance of a FOA, EERE personnel are prohibited from communicating (in writing or otherwise) with applicants regarding the FOA except through the established question and answer process as described below. Specifically, questions regarding the content of this FOA must be submitted to: IEDOMultiTopicFOA@ee.doe.gov. Questions must be submitted not later than 3 business days prior to the application due date and time. Please note, feedback on individual concepts will not be provided through Q&A.

All questions and answers related to this FOA will be posted on EERE eXCHANGE at: https://eere-exchange.energy.gov. **Please note that you must first select this specific FOA Number in order to view the questions and answers specific to this FOA**. EERE will attempt to respond to a question within 3 business days, unless a similar question and answer has already been posted on the website.

Questions related to the registration process and use of the EERE eXCHANGE website should be submitted to: EERE-eXCHANGESupport@hq.doe.gov.

VIII. Other Information

A. FOA Modifications

Amendments to this FOA will be posted on the EERE eXCHANGE website and the Grants.gov system. However, you will only receive an email when an amendment or a FOA is posted on these sites if you register for email notifications for this FOA in Grants.gov. EERE recommends that you register as soon after the release of the FOA as possible to ensure you receive timely notice of any amendments or other FOAs.

B. Government Right to Reject or Negotiate

EERE reserves the right, without qualification, to reject any or all applications received in response to this FOA and to select any application, in whole or in part, as a basis for negotiation and/or award.

C. Commitment of Public Funds

The Grants Officer is the only individual who can make awards or commit the government to the expenditure of public funds. A commitment by anyone other than the Grants Officer, either express or implied, is invalid.

D. Treatment of Application Information

Applicants should not include business sensitive (e.g., commercial or financial information that is privileged or confidential) trade secrets, proprietary, or otherwise confidential in their application unless such information is necessary

to convey an understanding of the proposed project or to comply with a requirement in the FOA. Applicants are advised to not include any critically sensitive proprietary detail.

If an application includes business sensitive, trade secrets, proprietary, or otherwise confidential information, 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, EERE will seek to limit disclosure of such information to its employees and to outside reviewers when necessary for merit 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.

If an applicant chooses to submit business sensitive, trade secrets, proprietary, or otherwise confidential information, the applicant must provide **two copies** of the submission (e.g, Concept Paper, Full Application). The first copy should be marked, "non-confidential" with the information believed to be confidential deleted. The second copy should be marked "confidential" and must clearly and conspicuously identify the business sensitive, trade secrets, proprietary, or otherwise confidential information and 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 cover sheet of the Full Application, and other applicant submission must be marked as follows and identify the specific pages containing business sensitive, trade secrets, proprietary, or otherwise confidential information:

> **Notice of Restriction on Disclosure and Use of Data:**
> Pages [list applicable pages] of this document may contain business sensitive, trade secrets, proprietary, or otherwise confidential information that is exempt from public disclosure. Such information shall be used or disclosed only for evaluation purposes or in accordance with a financial assistance agreement between the submitter and the government. The government may use or disclose any information that is not appropriately marked or otherwise restricted, regardless of source. [End of Notice]

In addition, (1) the header and footer of every page that contains business sensitive, trade secrets, proprietary, or otherwise confidential information must

be marked as follows: "Contains Business Sensitive, Trade Secrets, Proprietary, or Otherwise Confidential Information Exempt from Public Disclosure," and (2) every line or paragraph containing such information must be clearly marked with double brackets or highlighting. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

E. Evaluation and Administration by Non-Federal Personnel

In conducting the merit review evaluation, the Go/No-Go Reviews and Peer Reviews, the government may seek the advice of qualified non-federal personnel as reviewers. The government may also use non-federal personnel to conduct routine, nondiscretionary administrative activities, including EERE contractors. The applicant, by submitting its application, consents to the use of non-federal reviewers/administrators. Non-federal reviewers must sign conflict of interest (COI) and non-disclosure acknowledgements (NDA) prior to reviewing an application. Non-federal personnel conducting administrative activities must sign an NDA.

F. Notice Regarding Eligible/Ineligible Activities

Eligible activities under this FOA include those which describe and promote the understanding of scientific and technical aspects of specific energy technologies, but not those which encourage or support political activities such as the collection and dissemination of information related to potential, planned or pending legislation.

G. Notice of Right to Conduct a Review of Financial Capability

EERE reserves the right to conduct an independent third-party review of financial capability for applicants that are selected for negotiation of award (including personal credit information of principal(s) of a small business if there is insufficient information to determine financial capability of the organization).

H. Requirement for Full and Complete Disclosure

Applicants are required to make a full and complete disclosure of all information requested. Any failure to make a full and complete disclosure of the requested information may result in:

- The termination of award negotiations;
- The modification, suspension, and/or termination of a funding agreement;
- The initiation of debarment proceedings, debarment, and/or a declaration of ineligibility for receipt of federal contracts, subcontracts, and financial assistance and benefits; and
- Civil and/or criminal penalties.

I. Retention of Submissions

EERE expects to retain copies of all Full Applications and other submissions. No submissions will be returned. By applying to EERE for funding, applicants consent to EERE's retention of their submissions.

J. Title to Subject Inventions

Ownership of subject inventions is governed pursuant to the authorities listed below:

- Domestic Small Businesses, Educational Institutions, and Nonprofits: Under the Bayh-Dole Act (35 U.S.C. § 200 et seq.), domestic small businesses, educational institutions, and nonprofits may elect to retain title to their subject inventions;

- All other parties: The federal Non-Nuclear Energy Act of 1974, 42. U.S.C. 5908, provides that the government obtains title to new inventions unless a waiver is granted (see below);

- Class Patent Waiver: DOE has issued a class waiver that applies to this FOA. Under this class waiver, domestic large businesses may elect title to their subject inventions similar to the right provided to the domestic small businesses, educational institutions, and nonprofits by law. In order to avail itself of the class waiver, a domestic large business must agree that any products embodying or produced through the use of a subject invention first created or reduced to practice under this program will be substantially manufactured in the United States.

- Advance and Identified Waivers: For an applicant not covered by a Class Patent Waiver or the Bayh-Dole Act, the applicant may request a patent waiver that will cover subject inventions that may be invented under the award, in advance of or within 30 days after the effective date of the award. Even if an advance waiver is not requested or the request is denied, the recipient will have a continuing right under the award to request a waiver for identified inventions, i.e., individual subject inventions that are disclosed to EERE within the timeframes set forth in the award's intellectual property terms and conditions. Any patent waiver that may be granted is subject to certain terms and conditions in 10 CFR 784.

- DEC: On June 07, 2021, DOE approved a DETERMINATION OF EXCEPTIONAL CIRCUMSTANCES (DEC) UNDER THE BAYH-DOLE ACT TO FURTHER PROMOTE DOMESTIC MANUFACTURE OF DOE SCIENCE AND ENERGY TECHNOLOGIES. In

accordance with this DEC, all awards, including sub-awards, under this FOA shall include the U.S. Competitiveness Provision in accordance with Section VI.B.xx. U.S. Manufacturing Committments of this FOA. A copy of the DEC can be found at https://www.energy.gov/gc/determination-exceptional-circumstances-decs. Pursuant to 37 CFR § 401.4, any nonprofit organization or small business firm as defined by 35 U.S.C. 201 affected by any DEC has the right to appeal it by providing written notice to DOE within 30 working days from the time it receives a copy of the determination.

- DOE may issue and publish on the website above further DECs prior to the issuance of awards under this FOA. DOE may require additional submissions or requirements as authorized by any applicable DEC.

K. Government Rights in Subject Inventions

Where prime recipients and subrecipients retain title to subject inventions, the United States government retains certain rights.

Government Use License

The United States government retains a nonexclusive, nontransferable, irrevocable, paid-up license to practice or have practiced for or on behalf of the United States any subject invention throughout the world. This license extends to contractors doing work on behalf of the government.

March-In Rights

The United States government retains march-in rights with respect to all subject inventions. Through "march-in rights," the government may require a prime recipient or subrecipient who has elected to retain title to a subject invention (or their assignees or exclusive licensees), to grant a license for use of the invention to a third party. In addition, the government may grant licenses for use of the subject invention when a prime recipient, subrecipient, or their assignees and exclusive licensees refuse to do so.

DOE may exercise its march-in rights only if it determines that such action is necessary under any of the four following conditions:

- The owner or licensee has not taken or is not expected to take effective steps to achieve practical application of the invention within a reasonable time;
- The owner or licensee has not taken action to alleviate health or safety needs in a reasonably satisfied manner;
- The owner has not met public use requirements specified by federal statutes in a reasonably satisfied manner; or
- The U.S. manufacturing requirement has not been met.

Any determination that march-in rights are warranted must follow a fact-finding process in which the recipient has certain rights to present evidence and witnesses, confront witnesses and appear with counsel and appeal any adverse decision. To date, DOE has never exercised its march-in rights to any subject inventions.

L. Rights in Technical Data

Data rights differ based on whether data is first produced under an award or instead was developed at private expense outside the award.

"Limited Rights Data": The United States government will not normally require delivery of confidential or trade secret-type technical data developed solely at private expense prior to issuance of an award, except as necessary to monitor technical progress and evaluate the potential of proposed technologies to reach specific technical and cost metrics.

Government Rights in Technical Data Produced Under Awards: The United States government normally retains unlimited rights in technical data produced under government financial assistance awards, including the right to distribute to the public. However, pursuant to special statutory authority, certain categories of data generated under EERE awards may be protected from public disclosure for up to five years after the data is generated ("Protected Data"). For awards permitting Protected Data, the protected data must be marked as set forth in the award's intellectual property terms and conditions and a listing of unlimited rights data (i.e., non-protected data) must be inserted into the data clause in the award. In addition, invention disclosures may be protected from public disclosure for a reasonable time in order to allow for filing a patent application.

M. Copyright

The prime recipient and subrecipients may assert copyright in copyrightable works, such as software, first produced under the award without EERE approval. When copyright is asserted, the government retains a paid-up nonexclusive, irrevocable worldwide license to reproduce, prepare derivative works, distribute copies to the public, and to perform publicly and display publicly the copyrighted work. This license extends to contractors and others doing work on behalf of the government.

N. Export Control

The United States government regulates the transfer of information, commodities, technology, and software considered to be strategically important to the United States to protect national security, foreign policy, and economic

interests without imposing undue regulatory burdens on legitimate international trade. There is a network of federal agencies and regulations that govern exports that are collectively referred to as "Export Controls". All recipients and subrecipients are responsible for ensuring compliance with all applicable United States Export Control laws and regulations relating to any work performed under a resulting award.

The recipient must immediately report to DOE any export control violations related to the project funded under the DOE award, at the recipient or subrecipient level, and provide the corrective action(s) to prevent future violations.

O. Prohibition on Certain Telecommunications and Video Surveillance Services or Equipment

As set forth in 2 CFR 200.216, recipients and subrecipients are prohibited from obligating or expending project funds (federal funds and recipient cost share) to procure or obtain; extend or renew a contract to procure or obtain; or enter into a contract (or extend or renew a contract) to procure or obtain equipment, services, or systems that uses *covered telecommunications equipment or services* as a substantial or essential component of any system, or as critical technology as part of any system. As described in Section 889 of Public Law 115-232, *covered telecommunications equipment* is telecommunications equipment produced by Huawei Technologies Company or ZTE Corporation (or any subsidiary or affiliate of such entities).

See Public Law 115-232, Section 889, 2 CFR 200.216, and 2 CFR 200.471 for additional information.

P. Personally Identifiable Information (PII)

All information provided by the applicant must to the greatest extent possible exclude PII. The term "PII" refers to information which can be used to distinguish or trace an individual's identity, such as their name, social security number, biometric records, alone, or when combined with other personal or identifying information which is linked or linkable to a specific individual, such as date and place of birth, mother's maiden name. (See OMB Memorandum M-17-12 dated January 3, 2017)

By way of example, applicants must screen resumes to ensure that they do not contain PII such as personal addresses, personal landline/cell phone numbers, and personal emails. **Under no circumstances should Social Security Numbers (SSNs) be included in the application**. Federal agencies are prohibited from the collecting, using, and displaying unnecessary SSNs. (See, the Federal Information

Security Modernization Act of 2014 (Pub. L. No. 113-283, Dec 18, 2014; 44 U.S.C. § 3551).

Q. Annual Independent Audits

If a for-profit entity is a prime recipient and has expended $750,000 or more of DOE awards during the entity's fiscal year, an annual compliance audit performed by an independent auditor is required. For additional information, please refer to 2 CFR 910.501 and Subpart F.

If an educational institution, non-profit organization, or state/local government is a prime recipient or subrecipient and has expended $750,000 or more of federal awards during the non-federal entity's fiscal year, then a Single or Program-Specific Audit is required. For additional information, please refer to 2 CFR 200.501 and Subpart F.

Applicants and subrecipients (if applicable) should propose sufficient costs in the project budget to cover the costs associated with the audit. EERE will share in the cost of the audit at its applicable cost share ratio.

APPENDIX A – COST SHARE INFORMATION

Cost Sharing or Cost Matching

The terms "cost sharing" and "cost matching" are often used synonymously. Even the DOE Financial Assistance Regulations, 2 CFR 200.306, use both of the terms in the titles specific to regulations applicable to cost sharing. EERE almost always uses the term "cost sharing," as it conveys the concept that non-federal share is calculated as a percentage of the Total Project Cost. An exception is the State Energy Program Regulation, 10 CFR 420.12, State Matching Contribution. Here "cost matching" for the non-federal share is calculated as a percentage of the federal funds only, rather than the Total Project Cost.

How Cost Sharing Is Calculated

As stated above, cost sharing is calculated as a percentage of the Total Project Cost. FFRDC costs must be included in Total Project Costs. The following is an example of how to calculate cost sharing amounts for a project with $1,000,000 in federal funds with a minimum 20% non-federal cost sharing requirement:

(1) Formula: Federal share ($) divided by federal share (%) = Total Project Cost
Example: $1,000,000 divided by 80% = $1,250,000

(2) Formula: Total Project Cost ($) minus federal share ($) = Non-federal share ($)
Example: $1,250,000 minus $1,000,000 = $250,000

(3) Formula: Non-federal share ($) divided by Total Project Cost ($) = Non-federal share (%)
Example: $250,000 divided by $1,250,000 = 20%

What Qualifies For Cost Sharing

While it is not possible to explain what specifically qualifies for cost sharing in one or even a couple of sentences, in general, if a cost is allowable under the cost principles applicable to the organization incurring the cost and is eligible for reimbursement under an EERE grant or cooperative agreement, then it is allowable as cost share. Conversely, if the cost is not allowable under the cost principles and not eligible for reimbursement, then it is not allowable as cost share. In addition, costs may not be counted as cost share if they are paid by the federal government under another award unless authorized by federal statute to be used for cost sharing.

The rules associated with what is allowable as cost share are specific to the type of organization that is receiving funds under the grant or cooperative agreement, though are generally the same for all types of entities. The specific rules applicable to:

(4) FAR Part 31 for For-Profit entities, (48 CFR Part 31); and
(5) 2 CFR Part 200 Subpart E - Cost Principles for all other non-federal entities.

In addition to the regulations referenced above, other factors may also come into play such as timing of donations and length of the project period. For example, the value of ten years of donated maintenance on a project that has a project period of five years would not be fully allowable as cost share. Only the value for the five years of donated maintenance that corresponds to the project period is allowable and may be counted as cost share.

Additionally, EERE generally does not allow pre-award costs for either cost share or reimbursement when these costs precede the signing of the appropriation bill that funds the award. In the case of a competitive award, EERE generally does not allow pre-award costs prior to the signing of the Selection Statement by the EERE Selection Official.

General Cost Sharing Rules on a DOE Award

1. Cash Cost Share – encompasses all contributions to the project made by the recipient or subrecipient(s), for costs incurred and paid for during the project. This includes when an organization pays for personnel, supplies, equipment for their own company with organizational resources. If the item or service is reimbursed for, it is cash cost share. All cost share items must be necessary to the performance of the project.

2. In-Kind Cost Share – encompasses all contributions to the project made by the recipient or subrecipient(s) that do not involve a payment or reimbursement and represent donated items or services. In-Kind cost share items include volunteer personnel hours, donated existing equipment, donated existing supplies. The cash value and calculations thereof for all In-Kind cost share items must be justified and explained in the Cost Share section of the project Budget Justification. All cost share items must be necessary to the performance of the project. If questions exist, consult your DOE contact before filling out the In-Kind cost share section of the Budget Justification.

3. Funds from other federal sources MAY NOT be counted as cost share. This prohibition includes FFRDC subrecipients. Non-federal sources include any source not originally derived from federal funds. Cost sharing commitment letters from subrecipients must be provided with the original application.

4. Fee or profit, including foregone fee or profit, are not allowable as project costs (including cost share) under any resulting award. The project may only incur those costs that are allowable and allocable to the project (including cost share) as determined in accordance with the applicable cost principles prescribed in FAR Part 31 for For-Profit entities and 2 CFR Part 200 Subpart E - Cost Principles for all other non-federal entities.

As stated above, the rules associated with what is allowable cost share are generally the same for all types of organizations. Following are the rules found to be common, but again, the specifics are contained in the regulations and cost principles specific to the type of entity:

(A) Acceptable contributions. All contributions, including cash contributions and third party in-kind contributions, must be accepted as part of the prime recipient's cost sharing if such contributions meet all of the following criteria:

(1) They are verifiable from the recipient's records.

(2) They are not included as contributions for any other federally-assisted project or program.

(3) They are necessary and reasonable for the proper and efficient accomplishment of project or program objectives.

(4) They are allowable under the cost principles applicable to the type of entity incurring the cost as follows:

a. For-profit organizations. Allowability of costs incurred by for-profit organizations and those nonprofit organizations listed in Attachment C to OMB Circular A–122 is determined in accordance with the for-profit cost principles in 48 CFR Part 31 in the FAR, except that patent prosecution costs are not allowable unless specifically authorized in the award document. (v) Commercial Organizations. FAR Subpart 31.2—Contracts with Commercial Organizations; and

b. Other types of organizations. For all other non-federal entities, allowability of costs is determined in accordance with 2 CFR Part 200 Subpart E.

(5) They are not paid by the federal government under another award unless authorized by federal statute to be used for cost sharing or matching.

(6) They are provided for in the approved budget.

(B) Valuing and documenting contributions

(1) Valuing recipient's property or services of recipient's employees. Values are established in accordance with the applicable cost principles, which mean that amounts chargeable to the project are determined on the basis of costs incurred. For real property or equipment used on the project, the cost principles authorize depreciation or use charges. The full value of the item may be applied when the item will be consumed in

the performance of the award or fully depreciated by the end of the award. In cases where the full value of a donated capital asset is to be applied as cost sharing or matching, that full value must be the lesser or the following:

a. The certified value of the remaining life of the property recorded in the recipient's accounting records at the time of donation; or

b. The current fair market value. If there is sufficient justification, the Grants Officer may approve the use of the current fair market value of the donated property, even if it exceeds the certified value at the time of donation to the project. The Grants Officer may accept the use of any reasonable basis for determining the fair market value of the property.

(2) Valuing services of others' employees. If an employer other than the recipient furnishes the services of an employee, those services are valued at the employee's regular rate of pay, provided these services are for the same skill level for which the employee is normally paid.

(3) Valuing volunteer services. Volunteer services furnished by professional and technical personnel, consultants, and other skilled and unskilled labor may be counted as cost sharing or matching if the service is an integral and necessary part of an approved project or program. Rates for volunteer services must be consistent with those paid for similar work in the recipient's organization. In those markets in which the required skills are not found in the recipient organization, rates must be consistent with those paid for similar work in the labor market in which the recipient competes for the kind of services involved. In either case, paid fringe benefits that are reasonable, allowable, and allocable may be included in the valuation.

(4) Valuing property donated by third parties.

a. Donated supplies may include such items as office supplies or laboratory supplies. Value assessed to donated supplies included in the cost sharing or matching share must be reasonable and must not exceed the fair market value of the property at the time of the donation.

b. Normally only depreciation or use charges for equipment and buildings may be applied. However, the fair rental charges for land and the full value of equipment or other capital assets may be allowed, when they will be consumed in the performance of the award or fully depreciated by the end of the award, provided that the Grants Officer has approved the charges. When use charges are applied, values must be determined in accordance with the usual accounting policies of the recipient, with the following qualifications:

i. The value of donated space must not exceed the fair rental value of comparable space as established by an independent appraisal of comparable space and facilities in a privately-owned building in the same locality.

ii. The value of loaned equipment must not exceed its fair rental value.

(5) Documentation. The following requirements pertain to the recipient's supporting records for in-kind contributions from third parties:

a. Volunteer services must be documented and, to the extent feasible, supported by the same methods used by the recipient for its own employees.

b. The basis for determining the valuation for personal services and property must be documented.

APPENDIX B – SAMPLE COST SHARE CALCULATION FOR BLENDED COST SHARE PERCENTAGE

The following example shows the math for calculating required cost share for a project with $2,000,000 in federal funds with four tasks requiring different non-federal cost share percentages:

Task	Proposed Federal Share	Federal Share %	Recipient Share %
Task 1 (R&D)	$1,000,000	80%	20%
Task 2 (R&D)	$500,000	80%	20%
Task 3 (Demonstration)	$400,000	50%	50%
Task 4 (Outreach)	$100,000	100%	0%

Federal share ($) divided by federal share (%) = Task Cost

Each task must be calculated individually as follows:

Task 1
$1,000,000 divided by 80% = $1,250,000 (Task 1 Cost)
Task 1 Cost minus federal share = non-federal share
$1,250,000 - $1,000,000 = $250,000 (non-federal share)

Task 2
$500,000 divided 80% = $625,000 (Task 2 Cost)
Task 2 Cost minus federal share = non-federal share
$625,000 - $500,000 = $125,000 (non-federal share)

Task 3
$400,000 / 50% = $800,000 (Task 3 Cost)
Task 3 Cost minus federal share = non-federal share
$800,000 - $400,000 = $400,000 (non-federal share)

Task 4
Federal share = $100,000
Non-federal cost share is not mandated for outreach = $0 (non-federal share)

The calculation may then be completed as follows:

Tasks	$ Federal Share	% Federal Share	$ Non-Federal Share	% Non-Federal Share	Total Project Cost
Task 1	$1,000,000	80%	$250,000	20%	$1,250,000
Task 2	$500,000	80%	$125,000	20%	$625,000
Task 3	$400,000	50%	$400,000	50%	$800,000
Task 4	$100,000	100%	$0	0%	$100,000
Totals	$2,000,000		$775,000		$2,775,000

Blended Cost Share %
Non-federal share ($775,000) divided by Total Project Cost ($2,775,000) = 27.9% (non-federal)
Federal share ($2,000,000) divided by Total Project Cost ($2,775,000) = 72.1% (federal)

APPENDIX C – WAIVER REQUESTS FOR: 1. FOREIGN ENTITY PARTICIPATION; AND 2. FOREIGN WORK

1. Waiver for Foreign Entity Participation

Many of the technology areas DOE funds fall in the category of critical and emerging technologies (CETs). CETs are a subset of advanced technologies that are potentially significant to United States national and economy security.[75] For projects selected under this FOA, all recipients and subrecipients must be organized, chartered or incorporated (or otherwise formed) under the laws of a state or territory of the United States; have majority domestic ownership and control; and have a physical location for business operations in the United States. To request a waiver of this requirement, an applicant must submit an explicit waiver request in the Full Application.

Waiver Criteria

Foreign entities seeking to participate in a project funded under this FOA must demonstrate to the satisfaction of DOE that:

a. Its participation is in the best interest of the United States industry and United States economic development;
b. The project team has appropriate measures in place to control sensitive information and protect against unauthorized transfer of scientific and technical information;
c. Adequate protocols exist between the United States subsidiary and its foreign parent organization to comply with export control laws and any obligations to protect proprietary information from the foreign parent organization;
d. The work is conducted within the United States and the entity acknowledges and demonstrates that it has the intent and ability to comply with the U.S. Competitiveness Provision (see Section VI.B.xx.); and
e. The foreign entity will satisfy other conditions that may be deemed necessary by DOE to protect United States government interests.

Content for Waiver Request

A Foreign Entity waiver request must include the following:

a. Information about the entity: name, point of contact, and proposed type of involvement in the project;
b. Country of incorporation, the extent of the ownership/level control by foreign entities, whether the entity is state owned or controlled, a summary of the ownership breakdown of the foreign entity and the percentage of

[75] See, Critical and Emerging Technologies List Update (whitehouse.gov).

ownership/control by foreign entities, foreign shareholders, foreign state or foreign individuals;

c. The rationale for proposing a foreign entity participate (must address criteria above);
d. A description of the project's anticipated contributions to the United States economy;
    - How the project will benefit the United States, including manufacturing, contributions to employment in the United States and growth in new markets and jobs in the United States;
    - How the project will promote manufacturing of products and/or services in the United States;
e. A description of how the foreign entity's participation is essential to the project;
f. A description of the likelihood of Intellectual Property (IP) being created from the work and the treatment of any such IP; and
g. Countries where the work will be performed (Note: if any work is proposed to be conducted outside the United States, the applicant must also complete a separate request foreign work waiver).

DOE may also require:

- A risk assessment with respect to IP and data protection protocols that includes the export control risk based on the data protection protocols, the technology being developed and the foreign entity and country. These submissions could be prepared by the project lead (if not the prime recipient), but the prime recipient must make a representation to DOE as to whether it believes the data protection protocols are adequate and make a representation of the risk assessment – high, medium or low risk of data leakage to a foreign entity.
- Additional language can be added to any agreement or subagreement to protect IP, mitigate risk or other related purposes.

DOE may require additional information before considering the waiver request.

DOE's decision concerning a waiver request is not appealable.

2. Waiver for Performance of Work in the United States (Foreign Work Waiver)

As set forth in Section IV.K.iii., all work under this FOA must be performed in the United States. To seek a waiver of the Performance of Work in the United States requirement, the applicant must submit an explicit waiver request in the Full Application. A separate waiver request must be submitted for each entity proposing performance of work outside of the United States.

Overall, a waiver request must demonstrate to the satisfaction of DOE that it would further the purposes of this FOA and is otherwise in the economic interests of the United States to perform work outside of the United States. A request for a foreign work waiver must include the following:

1. The rationale for performing the work outside the United States ("foreign work");
2. A description of the work proposed to be performed outside the United States;
3. An explanation as to how the foreign work is essential to the project;
4. A description of the anticipated benefits to be realized by the proposed foreign work and the anticipated contributions to the United States economy;
5. The associated benefits to be realized and the contribution to the project from the foreign work;
6. How the foreign work will benefit United States, including manufacturing, contributions to employment in the United States and growth in new markets and jobs in the United States;
7. How the foreign work will promote manufacturing of products and/or services in the United States;
8. A description of the likelihood of Intellectual Property (IP) being created from the foreign work and the treatment of any such IP;
9. The total estimated cost (DOE and recipient cost share) of the proposed foreign work;
10. The countries in which the foreign work is proposed to be performed; and
11. The name of the entity that would perform the work proposed to be conducted outside the United States. (i.e., entity that seeks a waiver and the entity(ies) that will conduct the work).

DOE may also require:

- A risk assessment with respect to IP and data protection protocols that includes the export control risk based on the data protection protocols, the technology being developed and the foreign entity and country. These submissions could be prepared by the project lead (if not the prime recipient), but the prime recipient must make a representation to DOE as to whether it believes the data protection protocols are adequate and make a representation of the risk assessment – high, medium or low risk of data leakage to a foreign entity.
- Additional language be added to any agreement or subagreement to protect IP, mitigate risk or other related purposes.

DOE may require additional information before considering the waiver request.

DOE's decision concerning a waiver request is not appealable.

APPENDIX D – REQUIRED USE OF AMERICAN IRON, STEEL, MANUFACTURED PRODUCTS, AND CONSTRUCTION MATERIALS BUY AMERICA REQUIREMENTS FOR INFRASTRUCTURE PROJECTS

A. Definitions

For purposes of the Buy America requirements, based both on the statute and OMB Guidance Document dated April 18, 2022, the following definitions apply:

Construction materials includes an article, material, or supply—other than an item of primarily iron or steel; a manufactured product; cement and cementitious materials; aggregates such as stone, sand, or gravel; or aggregate binding agents or additives[76]—that is or consists primarily of:

- non-ferrous metals;
- plastic and polymer-based products (including polyvinylchloride, composite building materials, and polymers used in fiber optic cables);
- glass (including optic glass);
- lumber; or
- drywall.

Infrastructure includes, at a minimum, the structures, facilities, and equipment for, in the United States, roads, highways, and bridges; public transportation; dams, ports, harbors, and other maritime facilities; intercity passenger and freight railroads; freight and intermodal facilities; airports; water systems, including drinking water and wastewater systems; electrical transmission facilities and systems; utilities; broadband infrastructure; and buildings and real property. Infrastructure includes facilities that generate, transport, and distribute energy.

Moreover, according to the OMB guidance document:

> When determining if a program has infrastructure expenditures, Federal agencies should interpret the term "infrastructure" broadly and consider the definition provided above as illustrative and not exhaustive. When determining if a particular construction project of a type not listed in the definition above constitutes "infrastructure," agencies should consider whether the project will serve a public function, including whether the project is publicly owned and operated, privately operated on behalf of the public, or is a place of public accommodation, as opposed to a project that is privately owned and not open to the public. Projects with the former qualities have greater indicia of infrastructure, while projects with the latter quality have fewer. Projects consisting solely of the purchase, construction, or improvement of a private home for personal use, for example, would not constitute an infrastructure project.

[76] IL, § 70917(c)(1).

The Agency, not the applicant, will have the final say as to whether a given project includes infrastructure, as defined herein. Accordingly, in cases where the "public" nature of the infrastructure is unclear, but the other relevant criteria are met, DOE strongly recommends that applicants complete their full application with the assumption that Buy America requirements will apply to the proposed project.

Project means the construction, alteration, maintenance, or repair of infrastructure in the United States.

B. Buy America Requirements for Infrastructure Projects ("Buy America" requirements)
In accordance with Section 70914 of the BIL, none of the project funds (includes federal share and recipient cost share) may be used for a project for infrastructure unless:

> (1) all iron and steel used in the project are produced in the United States--this means all manufacturing processes, from the initial melting stage through the application of coatings, occurred in the United States;
>
> (2) all manufactured products used in the project are produced in the United States—this means the manufactured product was manufactured in the United States; and the cost of the components of the manufactured product that are mined, produced, or manufactured in the United States is greater than 55 percent of the total cost of all components of the manufactured product, unless another standard for determining the minimum amount of domestic content of the manufactured product has been established under applicable law or regulation; and
>
> (3) all construction materials[77] are manufactured in the United States—this means that all manufacturing processes for the construction material occurred in the United States.

The Buy America requirements only apply to articles, materials, and supplies that are consumed in, incorporated into, or affixed to an infrastructure project. As such, it does not apply to tools, equipment, and supplies, such as temporary scaffolding, brought to the construction site and removed at or before the completion of the infrastructure project. Nor does the Buy America requirements apply to equipment and furnishings, such as movable chairs, desks, and portable computer equipment, that are used at or within the finished infrastructure project, but are not an integral part of the structure or permanently affixed to the infrastructure project.

These requirements must flow down to all sub-awards, all contracts, subcontracts and purchase orders for work performed under the proposed project, except where the prime recipient is a for-profit entity. Based on guidance from the Office of Management and Budget (OMB), the Buy America requirements of the BIL do not apply to DOE projects in which the prime recipient is a

[77] Excludes cement and cementitious materials, aggregates such as stone, sand, or gravel, or aggregate binding agents or additives.

for-profit entity; the requirements only apply to projects whose prime recipient is a State, local government, Indian tribe, Institution of Higher Education, or nonprofit organization.

For additional information related to the application and implementation of these Buy America requirements, please see OMB Memorandum M-22-11, issued April 18, 2022: https://www.whitehouse.gov/wp-content/uploads/2022/04/M-22-11.pdf

Note that for all applicants—both non-Federal entities and for-profit entities—DOE is including a Program Policy Factor that the Selection Official may consider in determining which Full Applications to select for award negotiations that considers whether the applicant has made a commitment to procure U.S. iron, steel, manufactured products, and construction materials in its project.

C. Waivers

The DOE financial assistance agreement will require each recipient: (1) to fulfill the commitments made in its application regarding the procurement of U.S.-produced products and (2) to fulfill the commitments made in its application regarding the procurement of other key component metals and manufactured products domestically that are deemed available in sufficient and reasonably available quantities or of a satisfactory quality at the time of award negotiation.

In limited circumstances, DOE may waive the application of the Buy America requirements where DOE determines that:

> (1) applying the Buy America requirements would be inconsistent with the public interest;
>
> (2) the types of iron, steel, manufactured products, or construction materials are not produced in the United States in sufficient and reasonably available quantities or of a satisfactory quality; or
>
> (3) the inclusion of iron, steel, manufactured products, or construction materials produced in the United States will increase the cost of the overall project by more than 25 percent.

If an applicant or recipient is seeking a waiver of the Buy America requirements, it may submit a waiver request after it has been notified of its selection for award negotiations. A waiver request must include:

- A detailed justification for the use of "non-domestic" iron, steel, manufactured products, or construction materials to include an explanation as to how the non-domestic item(s) is essential to the project

- A certification that the applicant or recipient made a good faith effort to solicit bids for domestic products supported by terms included in requests for proposals, contracts, and nonproprietary communications with potential suppliers
- Applicant /Recipient name and Unique Entity Identifier (UEI)
- Total estimated project cost, DOE and cost-share amounts
- Project description and location (to the extent known)
- List and description of iron or steel item(s), manufactured goods, and construction material(s) the applicant or recipient seeks to waive from Domestic Content Procurement Preference requirement, including name, cost, country(ies) of origin (if known), and relevant PSC and NAICS code for each
- Waiver justification including due diligence performed (e.g., market research, industry outreach) by the applicant or recipient
- Anticipated impact if no waiver is issued.

DOE may require additional information before considering the waiver request.

Waiver requests are subject to public comment periods of no less than 15 days and must be reviewed by the Made in America Office. There may be instances where an award qualifies, in whole or in part, for an existing waiver described at [DOE Buy America Requirement Waiver Requests | Department of Energy].

DOE's decision concerning a waiver request is not appealable.

APPENDIX E – GLOSSARY

Applicant – The lead organization submitting an application under the FOA.

Continuation application – A non-competitive application for an additional budget period within a previously approved project period. At least ninety (90) days before the end of each budget period, the Recipient must submit to EERE its continuation application, which includes the following information:

i. A report on the Recipient's progress towards meeting the objectives of the project, including any significant findings, conclusions, or developments, and an estimate of any unobligated balances remaining at the end of the budget period. If the remaining unobligated balance is estimated to exceed 20 percent of the funds available for the budget period, explain why the excess funds have not been obligated and how they will be used in the next budget period.

ii. A detailed budget and supporting justification if there are changes to the negotiated budget, or a budget for the upcoming budget period was not approved at the time of award.

iii. A description of any planned changes from the negotiated Statement of Project Objectives and/or Milestone Summary Table.

Cooperative Research and Development Agreement (CRADA) – a contractual agreement between a national laboratory contractor and a private company or university to work together on research and development. For more information, see https://www.energy.gov/gc/downloads/doe-cooperative-research-and-development-agreements

Federally Funded Research and Development Centers (FFRDC) - FFRDCs are public-private partnerships which conduct research for the United States government. A listing of FFRDCs can be found at http://www.nsf.gov/statistics/ffrdclist/.

Go/No-Go Decision Points: – A decision point at the end of a budget period that defines the overall objectives, milestones and deliverables to be achieved by the recipient in that budget period. As of a result of EERE's review, EERE may take one of the following actions: 1) authorize federal funding for the next budget period; 2) recommend redirection of work; 3) discontinue providing federal funding beyond the current budget period; or 4) place a hold on federal funding pending further supporting data.

Project – The entire scope of the cooperative agreement which is contained in the recipient's Statement of Project Objectives.

Recipient or "Prime Recipient" – A non-federal entity that receives a federal award directly from a federal awarding agency to carry out an activity under a federal program. The term recipient does not include subrecipients.

Subrecipient – A non-federal entity that receives a subaward from a pass-through entity to carry out part of a federal program; but does not include an individual that is a beneficiary of such program. A subrecipient may also be a recipient of other federal awards directly from a federal awarding agency. Also, a DOE/NNSA and non-DOE/NNSA FFRDC may be proposed as a subrecipient on another entity's application. See section III.E.ii.

APPENDIX F – DEFINITION OF TECHNOLOGY READINESS LEVELS

TRL 1:	Basic principles observed and reported
TRL 2:	Technology concept and/or application formulated
TRL 3:	Analytical and experimental critical function and/or characteristic proof of concept
TRL 4:	Component and/or breadboard validation in a laboratory environment
TRL 5:	Component and/or breadboard validation in a relevant environment
TRL 6:	System/subsystem model or prototype demonstration in a relevant environment
TRL 7:	System prototype demonstration in an operational environment
TRL 8:	Actual system completed and qualified through test and demonstrated
TRL 9:	Actual system proven through successful mission operations

APPENDIX G – LIST OF ACRONYMS

AMMTO	Advanced Materials and Manufacturing Technologies Office
AMO	Advanced Manufacturing Office
AOI	Area of Interest
ASTM	American Society for Testing and Materials
BF	Blast furnace
BOF	Blast oxygen furnace
CCUS	Carbon capture, utilization, and storage
CFR	Code of Federal Regulation
CO	Carbon monoxide
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent (greenhouse gas emissions)
COI	Conflict of Interest
CRADA	Cooperative Research and Development Agreement
DEC	Determination of Exceptional Circumstances
DEI	Diversity, Equity, and Inclusion
DMP	Data Management Plan
DOE	United States Department of Energy
DOI	Digital Object Identifier
EAF	Electric arc furnace
EERE	Energy Efficiency and Renewable Energy
EPA	United States Environmental Protection Agency
FAPIIS	Federal Awardee Performance and Integrity Information System
FAR	Federal Acquisition Regulation
FFATA	Federal Funding and Transparency Act of 2006
FFRDC	Federally Funded Research and Development Center
FOA	Funding Opportunity Announcement
FOIA	Freedom of Information Act
GAAP	Generally Accepted Accounting Principles
GHG	Greenhouse gas
H_2	Hydrogen
HBCU	Historically Black Colleges and University
IEDO	Industrial Efficiency and Decarbonization Office
IHP	Industrial heat pump
kWh	Kilowatt-hour
LCA	Lifecycle assessment
LCFFES	Low-carbon fuels, feedstocks, and energy sources
M&O	Management and Operating
MFA	Multi-Factor Authentication
MMT	Million metric tons
MPIN	Marketing Partner ID Number
MSI	Minority-Serving institution

MW	Megawatt
MYPP	Multi-Year Program Plan
NAICS	North American Industrial Classification System
NDA	Non-Disclosure Acknowledgement
NEPA	National Environmental Policy Act
NNSA	National Nuclear Security Agency
NO_x	Nitrogen oxides
NSF	National Science Foundation
OIG	Office of Inspector General
OMB	Office of Management and Budget
OPC	Ordinary Portland Cement
OSTI	Office of Scientific and Technical Information
PGM	Platinum group metal
PII	Personal Identifiable Information
PM	Particulate matter
POC	Point of Contact
R&D	Research and Development
RD&D	Research, development, and demonstration
RDD&D	Research, development, demonstration and deployment
RFI	Request for Information
RFP	Request for Proposal
SAM	System for Award Management
SciENcv	Science Experts Network Curriculum Vita
SCM	Supplementary cementitious material
SMART	Specific, Measurable, Assignable, Realistic and Time-Related
SOPO	Statement of Project Objectives
SPOC	Single Point of Contact
SSN	Social Security Number
STEM	Science, Technology, Engineering, and Mathematics
TBtu	Trillion British thermal units
TEA	Technoeconomic analysis
TES	Thermal energy storage
TIA	Technology Investment Agreement
TRL	Technology Readiness Level
UCC	Uniform Commercial Code
UEI	Unique Entity Identifier
U.S.	United States
WBS	Work Breakdown Structure
WP	Work Proposal

APPENDIX H – COMMUNITY BENEFITS PLAN GUIDANCE

The DOE is committed to pushing the frontiers of science and engineering; catalyzing high-quality domestic clean energy jobs through research, development, demonstration, and deployment; and ensuring energy equity and energy justice[78] for disadvantaged communities. Therefore, and in accordance with the Administration's priority to empower workers and harness opportunities to create good union jobs as stated in EO 14008 (Executive Order on Tackling the Climate Crisis at Home and Abroad),[79] it is important to consider the impacts of the successful commercial deployment of any innovations resulting from this FOA on current and future workforce.

The goal of the three-section Community Benefits Plan is to allow the application to illustrate engagement in critical thought about implications of how the proposed work will benefit the broadest swaths of American people and lead to broadly shared prosperity, including for workers and disadvantaged communities.[80] The sections of the Community Benefits Plans are considered together because there may be significant overlap between audiences considered in workforce and disadvantaged communities.

Example DEIA, Energy Equity, and Workforce Plan Elements

Outlined below are examples of activities that applicants might consider when developing their Community Benefits Plan. Applicants are not required to implement any of these specific examples and should propose the Plan that best fits their research goals, institutional environment, team composition, and other factors. Creativity is encouraged.

DEIA

DOE strongly encourages applicants to involve individuals and entities from disadvantaged communities. Tapping all of the available talent requires intentional approaches and yields broad benefits.

Equity extends beyond diversity to equitable treatment. Equitable access to opportunity for members of the project team is paramount. This includes ensuring that all members of the

[78] At DOE, we define energy justice as "the goal of achieving equity in both the social and economic participation in the energy system, while also remediating social, economic, and health burdens on those disproportionately harmed by the energy system" (Initiative for Energy Justice, 2019). Aligned with that document, the remainder of this document refers to this as, 'energy equity,' and is meant to encompass energy justice as well as DOE's efforts related to Justice40. https://www.energy.gov/diversity/articles/how-energy-justice-presidential-initiatives-and-executive-orders-shape-equity

[79] https://www.federalregister.gov/documents/2021/02/01/2021-02177/tackling-the-climate-crisis-at-home-and-abroad

[80] See footnote 79 for guidance on the definition and tools to locate and identify disadvantaged communities.

team, including students, are paid a living wage, provided appropriate working conditions, and provided appropriate benefits. In the execution of their project plan, applicants are asked to describe efforts in diversity, equity, inclusion, and accessibility. In this context, efforts toward DEIA are defined as:[81]

1. the practice of including the many communities, identities, races, ethnicities, backgrounds, abilities, cultures, and beliefs of the American people,
2. the consistent and systematic fair, just, and impartial treatment of all individuals, including protecting workers rights and adhering to Equal Employment Opportunity laws,
3. the recognition, appreciation, and use of the talents and skills of employees of all backgrounds, and
4. the provision of accommodations so that all people, including people with disabilities, can fully and independently access facilities, information and communication technology, programs, and services.

Successful plans will not only describe how the project team seeks to increase DEIA, but will describe the overall approaches to retention, engagement, professional development, and career advancement. Specifically, they will demonstrate clear approaches to ensure all team members' strengths are meaningfully leveraged and all members are provided opportunities and paths for career development, especially including paths for interns and trainees to secure permanent positions. Diversity should be considered at all levels of the project team, not just leveraging early career individuals to meet diversity goals.

DOE strongly encourages applicants to consider partnerships as a means of promoting diversity, equity, inclusion, accessibility, justice, and workforce participation. Minority Serving Institutions, Minority Business Enterprises, Minority Owned Businesses, Disability Owned Business, Women Owned Businesses, Native American-owned Businesses, Veteran Owned Businesses, or entities located in an underserved community that meet the eligibility requirements are encouraged to lead these partnerships as the prime applicant or participate on an application as a proposed partner to the prime applicant.

When crafting the DEIA section of the Plan, applicants should describe the ways in which they will act to promote each of the four DEIA efforts above into their investigation. It is important to note that diversity, equity, inclusion, and accessibility are four different, but related, concepts that should not be conflated. That is, you can achieve diversity without equity; all four must be addressed. Applicants could discuss how the proposed investigation could contribute to training and developing a diverse scientific workforce. Applicants could describe the efforts they plan to take, or will continue to take, to create an inclusive workplace, free from

[81] https://www.whitehouse.gov/wp-content/uploads/2021/11/Strategic-Plan-to-Advance-Diversity-Equity-Inclusion-and-Accessibility-in-the-Federal-Workforce-11.23.21.pdf

retaliation, harassment, and discrimination. Applicants could outline any barriers to creating an equitable and inclusive workplace and address the ways in which the team will work to overcome these barriers within the bounds of the specific research project. The plan could detail specific efforts to inform project team members in any capacity of their labor rights and rights under Equal Employment Opportunity laws, and their free and fair chance to join a union. Note that this inclusion of informing project team members is also incorporated into awards through the National Policy Assurances.

Equal treatment of workers, including students, is necessary but overcoming institutional bias requires intentionally reducing sometimes hidden barriers to equal opportunity. Applicants could consider measures like childcare, flexible schedules, paid parental leave, pay transparency, and other supports to ensure that societal barriers are not hindering realization of DEIA intentions. Some of these considerations may result in common approaches in different sections of the plan, and that is acceptable, as long as the submission is not a singular approach to all sections.

EERE especially encourages applicants to form partnerships with diverse and often underrepresented institutions, such as Minority Serving Institutions, labor unions, and community colleges that otherwise meet the eligibility requirements. Underrepresented institutions that meet the eligibility requirements are encouraged to lead these partnerships as the prime applicant. The DEIA section of the Plan could include engagement with underrepresented institutions to broaden the participation of disadvantaged communities and/or with local stakeholders, such as residents and businesses, entities that carry out workforce development programs, labor unions, local government, and community-based organizations that represent, support, or work with disadvantaged communities. Applicants should ensure there is transparency, accountability, and follow-through when engaging with community members and stakeholders.

Specific examples include:

- Building collaborations and partnerships with researchers and staff at Minority Serving Institutions
- Addressing barriers identified in climate surveys to remove inequities
- Providing anti-bias training and education in the project design and implementation teams
- Offering training, mentorship, education, and other support to students and early/mid-career professionals from disadvantaged communities
- Providing efforts toward improving a workplace culture of inclusion
- Developing technology and technology integration innovations to meet the needs of disadvantaged communities
- Creating partnerships with local communities, especially under-resourced and disadvantaged communities

- Voluntary recognition of a union and informing employees of their rights, regardless of their classification
- Making research products and engagement materials accessible in a greater variety of formats to increase accessibility of research outputs
- Implementing training or distributing materials to reduce stigma towards individuals with disabilities
- Designing technologies that strategically fit within the existing workforce for installation and maintenance of the potential innovation

Energy Equity

The Energy Equity section should articulate how project proposals will drive equitable access to, participation in, and distribution of the benefits produced from successful technology innovations to disadvantaged communities and groups. Intentional inclusion of energy equity requires evaluating the anticipated long-term costs and benefits that will accrue to disadvantaged groups as a result of the project, and how research questions and project plans are designed for and support historically disadvantaged communities' engagement in clean energy decisions. Similar to potential cost reductions or groundbreaking research findings resulting from the research, energy equity and justice benefits may be uncertain, occur over a long period of time, and have many factors within and outside the specific proposed research influencing them.

Applicants should describe the influencing factors, and the most likely energy equity implications of the proposed research. Applicants should describe any long-term constraints the proposed technology may pose to communities' access to natural resources and Tribal Cultural resources. There may be existing equity research available to use and citation in this description or the applicant could describe milestone-based efforts toward developing that understanding through this innovation. These near and long term outcomes may include, but are not limited to: a decrease in the percent of income a household spends on energy costs (energy burden[82]); an increase in access to low-cost capital; a decrease in environmental exposure and burdens; increases in clean energy enterprise creation and contracting (e.g., women or minority-owned business enterprises); increased parity in clean energy technology access and adoption; increases in energy democracy, including community ownership; and an increase in energy resilience.

Specific examples include:

- Describing how a successful innovation will support economic development in diverse geographic or demographic communities
- Creating a plan to engage equity and justice stakeholders in evaluating the broader impacts of the innovation or in the development of the research methodology

[82] Energy burden is defined as the percentage of gross household income spent on energy costs: https://www.energy.gov/eere/slsc/low-income-community-energy-solutions

- Describe how the proposed research strategy and methodology was informed by input from a wide variety of stakeholders
- A literature review of the equity and justice implications of the outcomes of the specific research if the innovation is successful or a plan with dedicated budget and expertise (staffing or subawardee) to evaluate the potential equity implications of successful innovation outcomes.

Workforce

The Workforce section of the Community Benefits Plan should articulate the future workforce implications of the innovation or a milestone-driven plan for understanding those implications. This includes documenting the skills, knowledge, and abilities that would be required of workers installing, maintaining, and operating the technology that may be derivative of the applicant's research, as well as the training pathways and their accessibility for workers to acquire the necessary skills. There may be field-specific or relevant existing research that could be cited in this section. In addition, applicants could detail the process they will use to evaluate long-term impacts on jobs, including job growth or job loss, a change in job quality, disruptions to existing industry and resulting changes to relationships between employers and employees and improvements or reductions in the ability of workers to organize for collective representation, and anything else that could result in changes to regional or national labor markets.

For additional support with developing the Workforce section of a Community Benefits Plan, please refer to the DOE's Community Benefits Plan Frequently Asked Questions (FAQs) webpage (https://www.energy.gov/bil/community-benefits-plan-frequently-asked- questions-faqs). This new resource, though created primarily for projects funded by the Bipartisan Infrastructure Law (BIL), may be useful for non-BIL-funded RD&D projects which are the main subject of this FOA template.

Applicants will find section 2 of the FAQ ("Investing in America's Workforce") particularly helpful for understanding key federal policies, terms and concepts, as well as workforce development strategies relevant to examination of the workforce implications of applicants' proposed research.

Specific examples include:

- Outlining the challenges and opportunities for commercializing the technology in the US
- Creating a literature review of the workforce implications of the outcomes of the specific research if the innovation is successful or a plan with dedicated budget and expertise (staffing or subawardee) to evaluate the potential equity implications of successful innovation outcomes
- Creating a plan and milestones for assessing how a successful innovation will have implications for job savings or loss, either at the macroeconomic level or within specific industries

- Describing how the project will support training of workforce to address needs of successful innovation
- Voluntary recognition of a union and informing employees of their rights, regardless of their classification
- Creating a plan to evaluate how a successful innovation, will result in potential workforce shifts between industries or geographies.

Inclusion of SMART milestones

EERE requires that the applicant's Community Benefits Plan include one Specific, Measurable, Achievable, Relevant and Timely (SMART) milestone for each budget period. An exemplar SMART milestone clearly answers the following questions:

- What needs to be accomplished?
- What measures and deliverables will be used to track progress toward accomplishment?
- What evidence suggests that the accomplishment is achievable?
- Why choose this milestone?
- When will the milestone be reached?