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Office of Energy Efficiency and Renewable Energy (EERE)

FY20 Advanced Manufacturing Office Multi-Topic FOA

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Submission Deadline for Concept Papers:	June 25, 2020, 5:00pm ET
Submission Deadline for Full Applications:	August 31, 2020, 5:00pm ET
Expected Submission Deadline for Replies to Reviewer Comments:	October 2, 2020, 5:00pm ET
Expected Date for EERE Selection Notifications:	November 2020
Expected Timeframe for Award Negotiations:	November 2020 – February 2021

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

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Modifications

All modifications to the Funding Opportunity Announcement are **[HIGHLIGHTED]** in the body of the FOA.

Mod. No.	Date	Description of Modification
0001	7/30/2020	On pages 37 and 38 the table in “Subtopic 3.2 Candidate Targets and Metrics” within Section I.B. of the FOA has been modified to correct information.
0002	8/26/2020	On the cover page (page i), extend the Submission Deadline for Full Applications from August 26, 2020 5PM ET to August 31, 2020 5PM ET due to the Hurricane Laura’s impact on the gulf coast. Also change the Expected Submission Deadline for Replies to Reviewer Comments to October 2, 2020 at 5PM ET.

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I. Funding Opportunity Description

A. Background and Context

i. Background and Purpose

This Funding Opportunity Announcement (FOA) is being issued by the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) Advanced Manufacturing Office (AMO). The United States (U.S.) manufacturing sector uses 25% of the nation's energy and has an annual energy bill of more than \$200 billion.¹ Efficiency improvements in manufacturing not only benefit the Industrial sector, but can also impact the energy efficiency of products used throughout the economy.

Manufacturing competitiveness is a top priority for the Trump Administration. In 2018, the White House identified advanced manufacturing as one of the vital industries of the future. In its report, "Strategy for American Leadership in Advanced Manufacturing," the White House stated, "Federal, State, and local governments must work together to support advanced manufacturing through collective actions that support research and development, develop the workforce, promote free and fair trade, and create a regulatory and tax system that unleashes the private sector." As the strategy further explains, "Federal agencies play key roles in fostering the growth of advanced manufacturing through investments in research and development and in education and workforce development."²

AMO supports the development of technologies that improve energy efficiency in manufacturing as well as foundational, cross-cutting manufacturing processes, information, and materials technologies critical to efficient and competitive domestic manufacturing. AMO's goals are to stimulate technology innovation, improve the energy productivity of U.S. manufacturing, and enable the manufacture of cutting-edge products in the United States.

This FOA supports the Trump Administration's priorities to enhance manufacturing competitiveness through technological innovation by focusing in three main areas: 1) next-generation manufacturing for advancing process technologies that improve energy efficiency in energy intensive and energy dependent processes; 2) modular, hybrid, and/or catalytic processes to improve energy efficiency in chemical manufacturing; and 3) connected, flexible, and efficient manufacturing facilities, products and energy systems. The FOA

¹ EIA Energy Outlook, April, 2018. Available at [https://www.eia.gov/outlooks/aeo/pdf/0383\(2015\).pdf](https://www.eia.gov/outlooks/aeo/pdf/0383(2015).pdf)

² Strategy for American Leadership in Advanced Manufacturing, October 2018. Available at: <https://www.whitehouse.gov/wp-content/uploads/2018/10/Advanced-Manufacturing-Strategic-Plan-2018.pdf>

integrates identified research opportunities across AMO into a single funding opportunity and is intended to fund high-impact, applied research and development projects.

In 2016, the U.S. manufacturing sector accounted for 11.6% of gross domestic product (GDP),³ directly employed 12.3 million people,⁴ and sold products valued at \$5.4 trillion.⁵ In order to produce these goods, U.S. manufacturing firms used 24.1 quads of total primary energy for all purposes in 2014 (where a “quad” denotes one quadrillion (10^{15}) British thermal units (Btu)).⁶ Because manufacturing is highly connected with other sectors of the economy, manufacturing activities stimulate economic activity beyond the manufacturing sector itself. Recent reports have indicated that every \$1.00 spent in the U.S. manufacturing sector generates between \$1.33 and \$1.92 in other services and more production^{7,8}—a multiplier higher than that of any other sector. Manufacturing also has a positive effect on overall employment, with manufacturing-related employment ranging from mining to warehousing, as well as engineering, financial, and legal services.⁹ Advanced manufacturing technologies could have an even greater multiplier effect on employment than traditional manufacturing practices.¹⁰ As such, innovation in manufacturing offers an opportunity to leverage economic growth across the U.S. economy.

³ “Value Added by Industry as Percentage of Gross Domestic Product (2015).” U.S. Bureau of Economic Analysis. Release Date Nov. 3, 2016. Available at: <https://apps.bea.gov/iTable/iTable.cfm?ReqID=51&step=1>.

⁴ “National Income and Product Accounts Tables – Section 6: Income and Employment History, Table 6.4D: Full-Time and Part-Time Employees by Industry (A).” U.S. Bureau of Economic Analysis. Last revised August 3, 2016. Available at: <https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=2>.

⁵ “Census Bureau Releases 2014 Annual Survey of Manufactures Data.” U.S. Census Bureau. Release Number CB15-TPS.108. Released Dec. 18, 2015, revised March 1, 2016. Available at: <http://www.census.gov/newsroom/press-releases/2015/cb15-tps108.html>.

⁶ Manufacturing Energy and Carbon Footprint. September 2018. Based on 2014 EIA MECS data. Available at: https://www.energy.gov/sites/prod/files/2018/10/f56/2014_mecs_manufacturing_energy_footprint.pdf

⁷ “Manufacturing’s Multiplier Effect is Stronger than Other Sectors” Manufacturing Institute. Updated April 2014. Available at: <http://www.themanufacturinginstitute.org/Research/Facts-About-Manufacturing/Economy-and-Jobs/Multiplier/Multiplier.aspx>.

⁸ Stephen Gold. “The Competitive Edge: Manufacturing’s Multiplier Effect – It’s Bigger Than You Think,” by Stephen Gold, President and CEO, MAPI, IndustryWeek. Posted September 2, 2014. Available at: <http://www.industryweek.com/global-economy/competitive-edge-manufacturings-multiplier-effect-its-bigger-you-think>.

⁹ Thomas Kurfess. “Why Manufacturing Matters.” The American Society of Mechanical Engineers (ASME). November 2013. Available at: <https://www.asme.org/engineering-topics/articles/manufacturing-processing/why-manufacturing-matters>.

¹⁰ Joint Economic Committee. “Manufacturing Jobs for the Future.” December 2013. Available at: <https://www.jec.senate.gov/public/cache/files/a5c87e25-ff51-4b4f-9ced-2ee4b0bee12f/jec-manufacturing-report---final-combined-version.pdf>

ii. Technology Space and Strategic Goals

AMO supports innovative, advanced-manufacturing applied research and development (R&D) projects that focus on specific, high-impact manufacturing technology and process challenges. AMO invests in foundational, energy-related, advanced-manufacturing processes (where energy costs are a determinant of competitive manufacturing) and broadly applicable platform technologies (the enabling base upon which other systems and applications can be developed). The competitively selected projects from this FOA will focus on developing next-generation manufacturing material, information, and process technologies that improve energy efficiency in energy-intensive and energy-dependent processes, and facilitate the transition of emerging, cost-competitive energy technologies to domestic production.

AMO's vision and mission, as well as the strategic goals, targets, and metrics for key technology focus areas, are described in the Draft AMO Multi-Year Program Plan (MYPP).¹¹ AMO's strategic goals supported by this FOA are to:

- Improve the productivity and energy efficiency of U.S. manufacturing
- Reduce lifecycle energy and resource impacts of manufactured goods
- Leverage diverse domestic energy resources in U.S. manufacturing, while strengthening environmental stewardship
- Transition DOE supported innovative technologies and practices into U.S. manufacturing capabilities
- Strengthen and advance the U.S. manufacturing workforce

B. Topic Areas

This FOA integrates identified research opportunities across AMO into a single funding opportunity. AMO intends to fund high-impact, early- to mid-stage applied research through this FOA. Topics are organized in 3 main topic areas, as described below, with subtopics in each area. The activities to be supported under this FOA are authorized under § 911 (a)(2)(C) of the Energy Policy Act of 2005, as codified at 42 U.S.C. § 16191(a)(2)(C).

To ensure AMO meets the goal of energy efficiency improvements, all applicants are expected to identify a baseline technology to compare their improvement against and justify why that technology is the appropriate baseline. In addition, the applicant shall provide no less than three leading factors that will impact successful achievement of energy efficiency goals. The applicant shall identify metrics or goals associated with those leading factors such that the achievement of those goals will result in the energy efficiency improvement claimed in the proposal. Examples of

¹¹ AMO Multi-year Program Plan. Available at: <https://www.energy.gov/eere/amo/downloads/advanced-manufacturing-office-amo-multi-year-program-plan-fiscal-years-2017>

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potential factors that apply to each subtopic are provided in the descriptions below. These metrics are provided as examples. Applicants should use their knowledge and judgement to identify key factors that apply to their specific technology.

The technologies proposed may be at different levels of maturity. 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 E for EERE's definitions of TRLs. Maximum federal funding available for each proposal are detailed in Section II.A.i. Amounts requested must be justified, and should be commensurate with the scope of the work being proposed.

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

Topic 1: Efficiency Improvements in Advanced Manufacturing Processes

Research to improve manufacturing processing represents a major opportunity space with wide-ranging energy efficiency and economic benefits. Advances in technologies currently used in manufacturing processes, as well as entirely new methods of processing materials to lower energy consumption, which will lower manufacturing energy use, and associated costs, and also enable the manufacture of improved materials, technologies, and products.

Subtopic 1.1: Innovative Iron and Steelmaking Processes

Subtopic 1.1 Background: Steel is a vital material for many economic sectors, with uses in transportation, homes, commercial buildings, and industrial equipment, as well as many other applications used in everyday life. Steel is also a critical component in electricity infrastructure, machine tools, and many aspects of defense. 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.¹²

Subtopic 1.1 Opportunity: Steelmaking remains a relatively energy-intensive process, with iron and steel manufacturing consuming nearly 1.6 quads of primary energy in 2014, which includes offsite generation and transmission losses—or 1.6%

¹² American Iron and Steel Institute news releases. Available at: <https://www.steel.org/news/2019/02/december-steel-shipments-up-6-point-5-percent-from-december-2017> and <https://www.steel.org/news/2019/03/steel-imports-down-12-percent-in-2018>.

of total U.S. energy consumption that year.¹³ Onsite fuel used for heat and power in 2014 for the industry was estimated at 1,084 trillion Btu. The industry has a history of pursuing technology innovations and advances to foster energy efficiency and optimization of its diverse processes. However, a 2015 DOE energy bandwidth report on the industry indicated significant opportunities for energy efficiency improvement remain, despite the steel industry's innovations, adaptiveness, and federal research grant awards in this area totaling over \$4M in fiscal year 2019.¹⁴ Ironmaking process and blast furnace optimization offer the top opportunities for substantial energy savings through improved practices and technological advancements. In addition, the share of secondary steel production continues to grow in the United States; most of the scrap used is processed into steel directly through an electric arc furnace (EAF), using electricity as the main energy input.

Subtopic 1.1 Technology Focus: This subtopic will accelerate the development of novel technology innovations for iron and steelmaking. Recent advances in novel steel compositions, heat treatment processes, casting techniques, and refining methods have shown that significant innovations are still possible in steelmaking despite the high maturity level of these metallurgical systems. Applicants should develop and demonstrate new advances in manufacturing processes to improve energy efficiency in iron and steelmaking. Applications submitted under this subtopic must address at least one of the areas of interest stated below.

Area of Interest 1 – Furnace Innovations: This area of interest seeks applications in processes and associated materials for use in blast furnaces and electric arc furnaces, such as: affordable, alternative (nongraphitic) non-consumable electrodes; oxidizing/reducing processes and slags (including fluidizers) that use chemical energy more efficiently; advancements in waste heat recovery; and advanced sensing and measurement technologies.

Area of Interest 2 – Steel Process Co-Product Utilization: This area of interest seeks applications to develop technologies capable of reducing the amount of co-products from the steelmaking process that are not utilized (e.g., landfilled) and/or those which increase co-product utilization. Some co-products have an established utilization process. For example, slag handling results in slag products being used in construction, asphalt, and agricultural markets. There are other co-products (e.g., dust, sludge, chemicals, emulsions, oils) that do not currently have a path towards cost-effective reuse. Novel approaches are needed to increase the recycling and reuse of these other steelmaking co-products, including the recycling of process gases such as argon and hydrogen.

¹³ Based on Energy Information Administration statistics. A detailed analysis of 2014 steel industry energy consumption is available at:

https://www.energy.gov/sites/prod/files/2018/10/f56/2014_mecs_iron_steel_energy_footprint.pdf.

¹⁴ Bandwidth Study of Energy Use and Potential Energy Saving Opportunities in U.S. Iron and Steel Manufacturing. Available at: <https://www.energy.gov/eere/amo/downloads/bandwidth-study-us-iron-and-steel-manufacturing>.

Area of Interest 3 – Process Modeling and Simulation: This area of interest seeks applications that utilize advanced process modeling, simulation, and visualization for complex iron and steelmaking processes. This includes Artificial Intelligence (AI) and/or high-performance computing (HPC) with the goal of enhancing the efficiency of existing blast furnace operations, evaluating potential process improvements, and addressing challenges associated with developing or optimizing new processes and process scale-ups.

Subtopic 1.1 Candidate Metrics and Targets: Targets for processes and methodologies developed under this subtopic must be specified in the application, along with an analysis of the possible energy efficiency improvements. Applications must clearly identify the starting and ending TRL for the project and justify the TRLs assigned.

Applicants must identify and justify appropriate target metrics for their technology and application, and clearly indicate how the proposed innovation will satisfy them. Metrics should be specific to the proposed technology and must define appropriate benchmarks or baselines, minimum targets, and stretch targets. Examples of metrics include the following:

Objective/Goal	Metric	Minimum Target	Stretch Target	Baseline Performance/ Cost
Reduce energy consumption	Energy consumed per physical unit of output	10%	20%	<i>Applicant defined</i>
Decrease operating cost	\$/ton output	10%	20%	<i>Applicant defined</i>
Increase component lifetime (e.g., electrodes)	Hours before replacement	50%	100%	<i>Applicant defined</i>
Increase co-product recovery and utilization	Proportion of co-product utilized cost-effectively	50%	95%	<i>Applicant defined</i>

Subtopic 1.2: Enhanced Efficiency of Drying Processes

Subtopic 1.2 Background: Approximately 7 quads of annual manufacturing energy use are related to process heating (70% of all process energy use), with

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approximately 36% of that energy lost as waste heat, accounting for over 2,500 trillion Btus annually.¹⁵ Drying processes account for a significant portion of process heating demand, where thermal dehydration steps can occur multiple times throughout a manufacturing process. Furthermore, the thermal efficiencies for these drying processes range from 20% to 60%,¹⁶ and over 95% of the energy in these drying steps are from direct and indirect fossil fuel use. Thermal intensification is a route to reducing energy demand. Advances in technologies currently used for drying, as well as entirely new methods of processing materials, can reduce or eliminate the thermal demand of drying. Additionally, these approaches can lower manufacturing energy use, emissions, and associated costs, as well as enable the manufacture of improved materials, technologies and products.

Subtopic 1.2 Opportunity: Drying processes consumed an estimated 1,178 trillion Btu of energy in 2010 due to the typically high temperatures (200-700°F) required to remove water and organic compounds.¹⁷ As mentioned above, a significant portion of the energy utilized is currently sourced from fossil fuels. As fuels with a lower carbon intensity become more prevalent and affordable, there is an opportunity to utilize alternative heat and fuel sources that both improve the energy efficiency of the drying process and reduce or eliminate the need for fossil fuel use. Crosscutting technologies are sought in this subtopic to reduce the process energy required for drying and decouple carbon intensity from energy intensity through the use of low-carbon energy sources such as electricity, hydrogen, or bio-based fuels.

Subtopic 1.2 Technology Focus: Drying is the separation or concentration of a desired product through the removal of water and sometimes other organics or impurities. It is a frequently used process in manufacturing, with applications spanning the chemicals, biofuels, pulp and paper, and food industries. Current technologies are often thermally driven, which is energy intensive. Because of the temperature range limitations required to preserve product quality, traditional drying processes can also be time intensive, resulting in low throughput and productivity.

Improving drying processes is widely recognized as an area with a high potential for impact on industrial energy efficiency and productivity. This is reflected in prior

¹⁵ "Manufacturing Energy and Carbon Footprints (2014 MECS)." AMO/EERE/DOE. Available at: <http://energy.gov/eere/amo/manufacturing-energy-and-carbon-footprints-2010-mecs>.

¹⁶ Mujumdar A.S. and Wu Z.H. "Thermal Drying Technologies New Developments and Future R&D Potential; HEFAT2007

¹⁷ Chapas, R.B. and Colwell, J.A., "Industrial Technologies Program Research Plan for Energy-Intensive Process Industries," prepared by Pacific Northwest National Laboratory for the U.S. DOE (2007), available from: <https://www.osti.gov/biblio/1218715-industrial-technologies-program-research-plan-energy-intensive-process-industries> . Energy use scaled to 2010 Manufacturing Energy and Carbon Footprints (2010 MECS) data.

government funding in this area, including previous AMO funding in prior FOAs; and through the Rapid Advancement of Process Intensification Development (RAPID) Institute. RAPID has identified drying/de-watering in industrial processes as an area where intensified processes can deliver large benefits in process simplification and energy efficiency.

Research by these groups and others have shown that there are a range of technologies, alone or hybridized with other drying processes, that have the potential to deliver large energy efficiency improvements in drying processes, including:

- Ultrasonic vibration
- Electromagnetic (e.g. infrared, microwave and radio-frequency) energy-driven processes
- Spray drying
- Membrane filtration.

AMO is interested in complementing previous and current funding in these industrial drying processes to improve energy efficiency and enable the use of alternate heat and fuel sources for thermal drying. In addition to energy efficiency, the proposed technology should deliver additional benefits such as increased throughput, improved product quality, and inherently safer and more reliable operation. All benefits should be detailed in the application and quantified, if possible. This subtopic would consider validation of promising lab-scale technologies by addressing key scale-up challenges and cost barriers.

Subtopic 1.2 Candidate Metrics and Targets: Candidates should target novel drying processes that reduce energy consumption by at least 20% and reduce carbon intensity (ton of carbon dioxide (CO₂)/kg product) of the process by no less than 25%. Energy and carbon intensity analyses conducted should be included in the application, in addition to a baseline technology for comparison. Applications must clearly identify the starting and ending TRL for the project and justify the TRLs assigned.

Applicants must clearly explain how the proposed technology will meet the following metrics:

Objective/ Goal	Metric	Minimum Target	Stretch Target	Baseline Performance
Reduce energy consumption	% energy change as measured in kWh/kg (moisture)	20%	30%	<i>Applicant defined</i>
Reduce carbon intensity	% carbon intensity change as measured by ton CO ₂ e/kg product	25%	50%	<i>Applicant defined</i>

Additional metrics and critical criteria that will lead to successfully meeting the goals above should also be identified. Applicants must identify and justify appropriate metrics for their technology and clearly indicate how the proposed innovation will satisfy them. 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 Target	Stretch Target	Baseline Performance
Increase drying speed/throughput	Time (inlet to outlet moisture) or drying rate	20%	30%	<i>Applicant defined</i>
Decrease operating cost	\$/kg water removed	20%	30%	<i>Applicant defined</i>

Subtopic 1.3: Machine Learning to Increase Efficiencies in the Manufacturing of Large-Scale, High-Rate Aerostructures

Subtopic 1.3 Background: Artificial intelligence and machine learning (AI/ML) utilize computational tools to optimize processes, perform tasks, and make predictions/decisions. AI/ML facilitate the analysis of large and complex data sets, including data from the manufacture of high-reliability and/or high-value components. The application of AI/ML has the potential to significantly increase manufacturing efficiency in the U.S. aerospace industry.

Subtopic 1.3 Opportunity: The U.S. aerospace industry must continually increase efficiencies to meet production rate demands for aerostructures. Achieving increased efficiencies is particularly important for large, complex, and/or high-volume components. The application of AI/ML to the production of these aerostructures offers an opportunity to increase manufacturing efficiency and reduce energy consumption. The increased efficiency could be realized in multiple ways, including reduced cycle times, increased throughput, greater process flexibility, reduced defects, and/or a reduction in resources (e.g., energy, support activities/equipment, material).

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McKinsey and Company estimates that AI deployment in aerospace, defense, and the public sector has the potential to create hundreds of \$ billions of value. Likely areas for deployment in aerospace include production and supply chain operations, energy and raw materials, product certification, and reduction in manufacturing costs through optimizing production and assembly processes.¹⁸

Subtopic 1.3 Technology Focus: This subtopic is focused on developing methodologies and processes that utilize AI/ML to increase the efficiencies and performance of aerostructures and components, as well as processes used in their manufacture. The aerostructures targeted should be large-scale components produced at high-rates, such as airframe components and primary structures. The production of these components typically requires multiple manufacturing steps utilizing diverse processes with interdependent parameters. Currently, many of the manufacturing steps involve resource-intensive processes with empirically developed parameters. AI/ML can be applied to any phase of the processing or multiple phases. The application of AI/ML to manufacturing aerostructures has the potential to significantly increase processing efficiencies. Large-scale aerostructures produced at high-rates include diverse process-intensive components that would benefit from increased manufacturing efficiencies.

Applicants are strongly encouraged to leverage the DOE Advanced Scientific Computing Research (ASCR) program, including Leadership Computing Facility expertise.¹⁹

The approach should not require the redesign of the finished product. This Subtopic 1.3 does not address power and propulsion components, control surfaces, or launch and recover equipment. Approaches that require redesign of the finished product or that address power and propulsion components, control surfaces, or launch and recover equipment are considered unresponsive to this subtopic.

Subtopic 1.3 Candidate Metrics and Targets: Applications must clearly identify the airspace component(s) and associated manufacturing process(es) being targeted for increased efficiency. Applications of AI/ML that result in increased efficiency across multiple phases of manufacturing may be credited for each phase. For example, the use of AI/ML to manage residual stress can be credited for all efficiencies derived from the resulting component stability, reduced scrap rate, improved fit-up, reduced inspections, reduced cycle time, and improved performance. The reduction in resources achieved through the use of AI/ML is another form of increased efficiency that should be credited. The reduction in resources should not be limited to energy consumption, cost, and material usage.

¹⁸ McKinsey Global Institute, "Notes from the AI Frontier," Discussion Paper, Chui et al, April, 2018.

¹⁹ Advanced Scientific Computing Research (ASCR) program. Available at:
<https://www.energy.gov/science/ascr/advanced-scientific-computing-research>

Applicants must identify and justify appropriate target metrics for their technology and application, and clearly indicate how the proposed use of AI/ML will satisfy them. Metrics should be specific to the identified component(s) and process(es), and must define appropriate benchmarks or baselines, minimum targets, and stretch targets, and the increase in efficiency when put into full-rate production. Applications must clearly identify the starting and ending TRL for the project and justify the TRLs assigned. Examples of metrics include the following:

Objective/Goal	Metric	Minimum Target	Stretch Target	Baseline Performance/ Cost
Increased throughput	Component/hr	15%	30%	<i>Applicant defined</i>
Reduced number of defects	Defect/component	-10%	-25%	<i>Applicant defined</i>
Reduced cost of production	\$/component	-10%	-25%	<i>Applicant defined</i>
Improved material utilization	lb/component	15%	30%	<i>Applicant defined</i>

Subtopic 1.4: Integrated Additive Manufacturing Processes for Advanced Wind Blade Production

Subtopic 1.4 Background: Additive manufacturing (AM) processes have the potential to decrease material intensity, cut lead-times for parts, and enable entirely new designs. Recent work has proven AM viability in several industrial markets, including tooling, prototyping, and a limited number of direct-use applications.^{20,21} However, AM technologies require further development in order to meet the cost, size, and throughput demands of certain clean-energy systems like wind blade production. Current technologies are generally too slow, expensive, and small to directly print commercial blade structures.

²⁰ Modular Hydropower Engineering and Pilot Scale Manufacturing. Oak Ridge National Laboratory Cooperative Research and Development Agreement Final Report. September 2017.

https://www.ornl.gov/sites/default/files/2019-06/web_Emergy_MDF-TC-2017-112_Final%20Report.pdfhttps://www.ornl.gov/sites/default/files/2019-06/web_Emergy_MDF-TC-2017-112_Final%20Report.pdf

²¹ [Feasibility of using Big Area Additive Manufacturing to Directly Manufacture Boat Molds](https://www.ornl.gov/sites/default/files/2019-06/Alliance_UserAgreementFinal_Report.pdf). Oak Ridge National Laboratory User Facility Final Report. January 2018. https://www.ornl.gov/sites/default/files/2019-06/Alliance_UserAgreementFinal_Report.pdf

Subtopic 1.4 Opportunity: Wind energy provided 6.3% of the nation's electrical power in 2017, and has the potential to provide 20% or more of the nation's electrical power by 2030²². To fully harness this potential, the wind energy industry will need access to advanced production technologies that can make higher-performance blades that are larger in size, while maintaining a reasonable cost compared to today's production²³. Integrating flexible, net-shape AM capabilities with existing low-cost, high-throughput production systems may be a key enabler for the blades of the future.

Subtopic 1.4 Technology Focus: Previous AMO-funded research on wind blade tooling has demonstrated the potential to produce wind blades with AM via indirect tooling²⁴. This subtopic seeks to extend this research past the constraints of conventional blade production methods by leveraging AM to create novel blade designs and directly print blade structures at a scale, cost, and performance that is relevant to the industry. The technical objectives of this subtopic are to develop AM-enabled production techniques that are inherently scalable to large blade sizes (120m and up), enable novel blade designs, and allow for flexible process and tooling configurations, as described below:

Area of Interest 1 – Scalability to large blades. Proposed processes must be applicable to blades 120m and larger without a disproportionate increase to the cost of transportation, labor, and material compared to smaller conventional blades. Innovative processes may include, but are not limited to: modular/jointed blade assemblies, directly printed continuous blades, mobile robotic assembly, and flexible production location/mobile production processes.

Area of Interest 2 – Novel AM-enabled blade designs. Proposed processes must enable innovation in the blade structure itself and not rely entirely on conventional composite layup processes used in today's blades. Innovative blade design features may include, but are not limited to: modular blade tips, customized blades to match local resources, novel structural composite designs, and additively produced blade profiles and/or shear webbing.

²² Wind Vision: a New Era for Wind Power in the United States. U.S. Department of Energy. <https://www.energy.gov/eere/wind/wind-vision>; DE-FOA-0002071: Fiscal Year (FY) 2019 Wind Energy Technologies Office Funding Opportunity Announcement <https://eere-exchange.energy.gov/FileContent.aspx?FileID=0c03cd30-daf3-432c-899e-9d14ed73344a>

²³ See action 2.1.2 of Wind Vision Detailed Roadmap Actions 2017 Update. U.S. Department of Energy. https://www.energy.gov/sites/prod/files/2018/05/f51/WindVision-Update-052118-web_RMB.pdf https://www.energy.gov/sites/prod/files/2018/05/f51/WindVision-Update-052118-web_RMB.pdf

²⁴ Additive Manufacturing of Wind Turbine Molds. Oak Ridge National Laboratory Cooperative Research and Development Agreement Final Report. June 2017. https://www.ornl.gov/sites/default/files/2019-06/web_TPI_MDF-TC-2016-084_Final%20Report.pdf https://www.ornl.gov/sites/default/files/2019-06/web_TPI_MDF-TC-2016-084_Final%20Report.pdf

Area of Interest 3 – Flexible process and tooling configurations. Proposed processes must leverage additive capabilities in order to enable more flexible and less space-intensive blade production process configurations. Flexible production configurations may include, but are not limited to: modular tooling solutions that do not require monolithic full-size tooling structures, transportable processes that can be reasonably deployed near the site, continuous blade printing processes, and/or deployable robotic assembly systems.

Applications relying solely on conventional composite layup systems using today's processes to manufacture the blade structure, or relying solely on conventional full-scale composite molds (non-AM enabled, non-flexible process footprint), are considered nonresponsive to this FOA. See Section I.C. It is expected that AM-enabled processes will rely on and integrate with conventional composite techniques in order to achieve the cost, performance, and throughput required by the industry.

Subtopic 1.4 Candidate Metrics and Targets: Applicants must identify and justify appropriate target metrics for their technology and also specify an appropriate baseline for comparison. Targets should address objectives identified in the technology focus section above and showcase the technical merit of the proposed solution. Applications must clearly identify the starting and ending TRL for the project and justify the TRLs assigned. Benchmarks/baselines, minimum targets, and stretch targets should be specified for each metric. Generalized metric categories are provided for reference in the table below; proposed metrics should not be limited to these examples.

Objective/Goal	Metric	Minimum Target	Stretch Target	Baseline Performance/ Cost
Scalability to large blade sizes	Estimated reduction in production and transportation costs of 120m blade compared to smaller blade, per meter	None	25%	<i>Applicant defined</i>
Novel AM-enabled blade designs	Projected levelized cost of energy (LCOE); Improvement in mechanical properties	-15%	-25%	<i>Applicant defined</i>
Flexible process and tooling configuration	Reduction in cost and physical size of tooling;	15%	30%	<i>Applicant defined</i>

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	reduction of waste and embodied energy			
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Subtopic 1.5: Reducing Cost of Production of Ceramic Matrix Composites Used in High Temperature Applications

Subtopic 1.5 Background: There is an interest in lowering the cost of producing ceramic matrix composites (CMCs) for use in high-temperature applications. Some factors that impact cost in production of CMCs include long processing times, high fiber costs, and machining.²⁵ R&D is needed to reduce the cost of producing CMCs for use in harsh service conditions²⁶.

Subtopic 1.5 Opportunity: The market size for CMCs is estimated to be \$9.4 billion in 2019 and is expected to be \$23.3 billion by 2029, assuming a compound annual growth rate (CAGR) of 9.5%. Applications include aerospace and defense, energy and power, and automotive end-use industries.²⁷ Energy savings would be accomplished through reducing the weight of automobiles as well as air and land turbines. Efficiency improvements are also expected from higher temperature capabilities (e.g., reducing cooling air requirements in turbines), improved service life, and the potential for heat recovery. The application should provide an estimate of energy savings and clearly state the analysis assumptions and methodology.

Subtopic 1.5 Technology Focus: Current commercial or alternative processes include infiltration by reactive melt, slurry, sol-gel; polymer infiltration and pyrolysis; or combined infiltration methods. This subtopic seeks to develop production processes that lower the cost of producing CMCs. Unit processes of interest would include fiber production, prepreg fabrication, polymer infiltration, and thermal processes. Potential areas for improvement include reduction in fabrication time, reduction of porosity, as well as overall cost reduction for fiber, manufacturing steps, post processing, and inspection. Other areas of interest include, but are not limited to, the standardization of shapes, combined with new joining techniques.

²⁵ "Cost Effective Processing of CMC Composites by Melt Infiltration (Lsi-Process), German Aerospace Center, Stuttgart; Krenkel,W.

²⁶ Quadrennial Technology Review, Materials for Harsh Service Conditions Technology Assessment, U.S. Department of Energy, 2015, <https://www.energy.gov/sites/prod/files/2016/02/f29/QTR2015-6H-Materials-for-Harsh-Service-Conditions.pdf>

²⁷ Ceramic Matrix Composites Market by Matrix Type (Oxide/Oxide, C/SiC, C/C, SiC/SiC), End-Use Industry (Aerospace & Defense, Automotive, Energy & Power, Industrial), Region (North America, Europe, APAC, Middle East & Africa,) - Global Forecast to 2029. Available at: <https://www.marketsandmarkets.com/Market-Reports/ceramic-matrix-composites-market-60146548.html>

One possible example is improving polymer infiltration processes to produce silicon carbide or silicon nitride CMCs. This process typically starts with a fiber preform (or powder compact) and a preceramic organo-metallic polymer infiltrated to form a polymeric precursor followed by curing, pyrolysis, and densification. The infiltration/pyrolysis cycle is repeated until the desired density is achieved.²⁸

Subtopic 1.5 Candidate Metrics and Targets: The major barrier to widespread use of CMCs is cost. Improvements in high-rate manufacturing processes are sought. The application should clearly define potential improvements for cost, productivity, performance, and energy savings, and present a clear baseline for comparison. Applications must clearly identify the starting and ending TRL for the project and justify the TRLs assigned. Proposed targets and measurement of progress toward meeting targets must be substantiated. Metrics should be specific to the proposed technology and must define appropriate benchmarks or baselines, minimum targets, and stretch targets. Examples of metrics include the following:

Objective/Goal	Example Metric	Minimum Target	Stretch Target	Baseline Performance/ Cost
Cost reduction (explain focus area)	Part or assembly cost target/part or assembly cost as a fraction of the state of the art (SOTA)	20%	40%	<i>Applicant defined</i>
Performance (technical, e.g. fatigue, operating temperature, etc.)	Properties/properties SOTA	None	+15%	<i>Applicant defined</i>
Energy savings (total life cycle for 5 years after commercialization)	Kwh or Btu vs SOTA Kwh or Btu	10%	20%	<i>Applicant defined</i>

Topic 2: Efficiency Improvements in Chemical Manufacturing

The U.S. is the second-largest chemical producing nation²⁹ and the largest exporter delivering over 12% of the world's total chemical production. Chemical

²⁸ "Polymer Infiltration and Pyrolysis (PIP) Process," Kopeliovich, D., 2014. See: <https://www.sciencedirect.com/topics/chemistry/polymer-infiltration-and-pyrolysis> and www.substech.com and www.substech.com

²⁹ 2019 Guide to the Business of Chemistry (GBC), American Chemistry Council (ACC). Available at: <https://www.americanchemistry.com/GBC2019.pdf>

manufacturing is the largest energy user in the U.S. manufacturing sector³⁰ consuming more than 7 quads in 2018 and accounting for 30% of industrial energy consumption. Chemical manufacturing could account for almost 10% of all U.S. energy consumption by 2030.³¹

Innovative technologies through hybrid approaches and process intensification can reduce energy use in chemical manufacturing. The increased amounts of domestic shale gas is making additional technological advancements possible, for example, converting methane to higher value chemicals at the wellhead through modular chemical approaches. Furthermore, there are also opportunities for developing innovative technologies that take advantage of intermittent renewable energy sources for chemical production.

Since 80% - 90% of all chemical manufacturing rely on catalysts, any improvements to catalyst selectivity and reaction conversion could potentially have great impact on energy use. For the chemicals that require the most energy to manufacture, it is estimated that new catalysts and related process improvements could reduce the energy intensity of these products by 20% to 40% by 2050.³² The need for improved catalyst performance is requiring interdisciplinary approaches for catalyst design through computational technologies, enabling more directed experimentation and validation.

Subtopics in this area focus on improvements in modular, hybrid, and/or catalytic processes as well as advancements in tools and methodologies that make dynamic catalyst science possible.

Subtopic 2.1: Advanced Chemical Manufacturing R&D

Subtopic 2.1 Background: Commodity chemicals make up a significant share of the potential energy savings opportunities as cited in AMO's chemical manufacturing bandwidth study.³³ The top 18 chemicals account for 80% of the energy consumption in the chemical sector.³⁴ New innovative technologies are needed that

³⁰ U.S. Energy Consumption by Source and Sector, 2018, EIA. Available at:

https://www.eia.gov/totalenergy/data/monthly/pdf/flow/css_2018_energy.pdf

³¹ Annual Energy Outlook 2019, U.S. Energy Information Administration, January 2019, p. 152. Available at:

<https://www.eia.gov/outlooks/aeo/pdf/aeo2019.pdf>

³² Technology Roadmap: Energy and GHG Reductions in the Chemical Industry via Catalytic Processes, International Energy Agency, 2013. Available at: <https://www.iea.org/reports/technology-roadmap-energy-and-ghg-reductions-in-the-chemical-industry-via-catalytic-processes>

³³ AMO Chemical Industry Bandwidth Report:

https://www.energy.gov/sites/prod/files/2015/08/f26/chemical_bandwidth_report.pdf

³⁴ Technology Roadmap: Energy and GHG Reductions in the Chemical Industry via Catalytic Processes, International Energy Agency, 2013. Available at: <https://www.iea.org/reports/technology-roadmap-energy-and-ghg-reductions-in-the-chemical-industry-via-catalytic-processes>

can reduce the amount of energy currently required to produce these key chemicals.

Subtopic 2.1 Opportunity: Today's chemical manufacturing processes are primarily centralized, large-scale operations that run under steady state conditions. New chemical manufacturing technology that is smaller scale, modularized/distributed, and driven by an integrated system of renewable and other energy sources shows promise for increased productivity with decreased energy, capital, and operating costs. Such technology will require that operating conditions be flexible to changes in materials and processes.

The benefits of forced variable or periodic operation have not been widely exploited. R&D efforts are needed that can address variability in chemical manufacturing processes. These efforts can help our current infrastructure cope with unavoidable changes such as startup/shutdown, changes in feedstock composition, and market demands, etc. In addition, this research can forge a new path towards innovative, modular chemical manufacturing that can lead to improved productivity and efficiency, especially for the most energy-intensive chemical processes.

Subtopic 2.1 Technology Focus: This subtopic focuses on research capable of producing significant technical advances in industrial catalytic processes that are robust to variability or provide energy efficiency benefits through intentional intermittent or variable operation. Research under this subtopic will advance the understanding of how to make the operation of chemical processes and process control systems more robust, especially processes that use alternative feedstocks (as inputs to production) and/or rely on different energy sources for power. Applications that leverage the DOE Office of Basic Energy Sciences' Energy Frontier Research Center efforts in catalysis are encouraged (but not required). Within this subtopic, AMO is seeking applications that propose novel approaches to advancing catalytic processes that optimize conversion rates, selectivity, and stability, and enable at least a 50% improvement in energy intensity, including:

Area of Interest 1 – Variable Feedstock Streams. Selective active site catalysts that handle variability in feedstock streams, such as designing catalyst materials that have active sites capable of selecting the various molecules present in real-world feeds to produce a class of desired products and proportions.

Area of Interest 2 – Modeling/Computational Tools. Advancements in modeling/computational tools to enhance the fundamental understanding of how heterogeneous catalyst systems respond as operating conditions change in order to identify advances in selectivity, yield, stability and/or turnover rate.

Area of Interest 3 – Alternative Conversion Technologies. Development of new chemistries and/or smaller scale process designs or reductions of unit operations from process intensification that result in significantly lower energy intensity and are flexible to variable operating inputs or utilize intentional intermittent operation. Advancement of non-thermal or low-thermal budget approaches, such as hybrid processes and/or electro-technologies, to enable desired chemical transformations that are robust to variable feedstock input or are driven by variable or intermittent operations and offer significantly reduced energy use.

Subtopic 2.1 Candidate Metrics and Targets: Proposed efforts should enable alternative processes and/or potentially utilize alternative feedstocks for the production of the most energy intensive commodity chemicals.³³ Approaches that use alternative polymer/polymer precursor chemistry for any of the highest energy-intensive processes cited in the AMO chemical bandwidth study may also be considered for development. Projects should utilize industrially relevant catalytic materials as opposed to fundamental studies on non-relevant or well-defined systems. Claims of industrial relevance must be substantiated. New modeling tools developed should be vetted, verified, and validated. Projects that combine different elements of the proposed subtopics and/or work with existing efforts within AMO's advanced chemical manufacturing R&D project portfolio are highly encouraged.

Proposed processes of focus should target at least a 50% improvement in the conversion, selectivity, stability, energy usage and/or overall cost as compared to a current state-of-the-art baseline practice. Applications must clearly identify the starting and ending TRL for the project and justify the TRLs assigned. Proposed targets and measurement of progress toward meeting targets must be substantiated. Processes should be robust and allow 20% to 50% variability in one or more operating variables (temperature, pressure, flow rate, feed composition, etc.). Applicants must identify and justify appropriate target metrics for their technology and application, and clearly indicate how the proposed innovation will satisfy them. Metrics should be specific to the proposed technology and must define appropriate benchmarks or baselines, minimum targets, and stretch targets. Examples of metrics include the following:

Objective/Goal	Metric	Minimum Target	Stretch Target	Baseline Performance/ Cost
Process improvements	Decreased energy consumption per physical unit output	50%	90%	<i>Applicant defined</i>
	Yield improvement			
Decrease operating cost	\$/ton output	50%	90%	<i>Applicant defined</i>

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Increase component lifetime (e.g., catalyst stability)	Number of cycles or hours before regeneration or replacement	50%	90%	<i>Applicant defined</i>
Process robustness	Allowable variability in temperature, pressure, flow rate, feed composition, etc. from normal operating conditions	20%	50%	<i>Applicant defined</i>

Subtopic 2.2: Dynamic Catalyst Science with Data Analytics

Subtopic 2.2 Background: The energy efficiency and productivity of a chemical process can be controlled by the use of a catalyst to lower the thermal requirement and to direct the reaction mechanism away from wasteful byproducts such as carbon dioxide. The catalysts used in chemical manufacturing are typically complex, multicomponent, supported metals or mixed metal oxides. The complex surface chemistry of an industrial catalyst makes understanding how to improve their performance a challenge. This challenge can be addressed with dynamic catalyst science which may employ the use of temperature, concentration, or pressure transients to perturb the state of a chemical reaction system.

Subtopic 2.2 Opportunity: Surface science and computational chemistry provide a detailed understanding of how reactions take place on well-defined, modelled surfaces but results can be difficult to extrapolate to industrial materials. High-throughput methods can screen large libraries of industrial materials for steady-state performance but only provide coarse kinetic information and lack the detail needed for understanding why one catalyst performs better than another. Innovative tools and methods that can provide greater understanding for how a complex industrial catalyst controls a multistep reaction sequence is needed. This will enable high productivity, the energy efficient manufacture of essential commodity chemicals, and advance existing and develop new catalytic technologies.

Dynamic catalyst science (DCS) and testing refers to new tools and methodologies that can aid in the understanding of how catalysts can be designed to control chemical reactions more efficiently. DCS provides a unique opportunity to address the complexity of an industrial catalyst from the top-down by observing how structural and kinetic features respond to stimulus and change. Compared to conventional techniques that take place at steady-state, observation of structural and kinetic relaxation phenomena can dramatically expand the experimental space and accelerate testing. The tools of data analytics can be employed to advance the

analysis and interpretation of the rich output from dynamic experiments. As opposed to a trial-and-error approach using physical experiments as well as numerical experiments in multi-physics models, a combination of dynamic catalyst testing with data analytics can yield greater information for explaining how and why certain materials perform better (activity, selectivity, stability, durability, etc.) as well as support predictive computational models that lead to superior materials.

Subtopic 2.2 Technology Focus: As this is an emerging technology for catalyst science, advanced catalyst testing methods are needed that offer detailed kinetic understanding of complex, industrial catalytic materials in order to improve performance characteristics. Dynamic catalyst science can begin to address these needs but the state-of-the-art tools and methodologies need to be improved. For example, operando spectroscopic tools simultaneously collect structural and kinetic data on complex catalytic materials in a working environment, but these methods are also limited by time-resolution and generally use spectroscopic reactor cells that only offer coarse kinetic information.³⁵ Pulsed titration methods, such as temporal analysis of products,³⁶ can be used to monitor detailed kinetics as materials change but predictive methods for deactivation have not been developed. In addition, the complex physics of any transient reactor can limit the ability to separate transport from kinetics or to extrapolate long-term trends. R&D efforts for new dynamic catalyst science tools and methods are needed that can address two or more of the following:

- Improve the time-resolution and modelling of operando spectroscopic reactors in order to accurately describe intrinsic kinetic features. Rate constants of elementary processes are needed as opposed to global/lumped rate constants.
- Derive new kinetic characterization criteria from time-resolved transient data using the methods of data science. For example, artificial intelligence, informatics, and machine learning can be used as opposed to conventional physics-based approaches. Methods should not rely on theoretical assumptions about a reaction mechanism. The new methods should be robust to accommodate data from different experimental techniques and integrate with multiscale modeling and simulation tools.
- Kinetically distinguish different deactivation phenomena on multiple time-scales as well as predict catalyst stability without the need for extensive time-on-stream studies. Methods should enable the identification of working regimes and advancements in catalyst design that lead to improved catalyst stability and process economics.

³⁵ Meunier, F., *Chemical Society Reviews* 39 12 (2010): 4602-4614. Srinivasan, P., *Reaction Chemistry & Engineering*, 4 5 (2019): 862-883.

³⁶ Morgan, K., *Catalysis Science & Technology*, 7 12 (2017): 2416-2439.

Subtopic 2.2: Candidate Metrics and Targets: Proposed efforts should support alternative processes for the conversion of a variety of feedstock resources to the commodity chemicals that are currently among the most energy-intensive.³³

Approaches that use alternative polymer/polymer precursor chemistry or any of the highest energy-intensive processes cited in the AMO chemical bandwidth study may also be considered for development. Projects should utilize industrially-relevant catalytic materials as opposed to fundamental studies on non-relevant or well-defined systems. Claims of industrial relevance must be substantiated. New modeling tools should be vetted, verified and validated. Projects that combine multiple elements within this subtopic and/or work with existing efforts within AMO's advanced chemical manufacturing R&D project portfolio are highly encouraged.

Projects may focus on one chemistry for development but should lead to methods that are more broadly applicable to numerous chemical processes. As outlined in the table below, methods for predicting catalyst deactivation should reduce the evaluation time of conventional methods by 70% with demonstrated accuracy near 90%. Advanced operando spectroscopic methods should offer time-resolution on the scale of 10^{-3} seconds and be capable of achieving processes operating temperatures of at least 850°C. Data science tools developed for analysis of transient data should be supported by multiscale modeling and simulation activities. Methods developed should extract kinetic features from simulated data with at least 90% statistical accuracy.

Applications must clearly identify the starting and ending TRL for the project and justify the TRLs assigned. Proposed targets and measurement of progress toward meeting targets must be substantiated. Metrics should be specific to the proposed technology and must define appropriate benchmarks or baselines. Proposed targets must include at least three of the following:

Objective/Goal	Metric	Minimum Target	Stretch Target	Baseline Performance/ Cost
Reduce evaluation time for predicting catalyst deactivation	% Reduction in evaluation time	70%	90%	<i>Applicant defined</i>
Improve time resolution of operando spectroscopic characterization	Experimental time resolution (seconds)	10^{-3}	10^{-5}	<i>N/A</i>
Operating temperature	Temperature (°C)	850	<i>N/A</i>	<i>N/A</i>

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Statistically relevant predictions from data science	Correlation of method output and model simulation	> 90%	N/A	<i>Applicant defined</i>
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Topic 3: Connected, Flexible, and Efficient Manufacturing Facilities, Products, and Energy Systems

The manufacturing sector is becoming more engaged in supporting the energy framework of the nation and making a significant impact. Manufacturing is moving from its traditional role as the main economic engine for the country to one where, in addition, it actively supports important national energy initiatives such as enhancing the electricity grid's resilience.

Subtopics in this area focus on the potential for integrating carbon capture from dilute sources into industrial processes and the active role that district energy systems can play in stabilizing the national electricity grid by connecting with flexible combined heat and power (CHP) systems and renewable generation capabilities (geothermal, wind, and photovoltaic).

Subtopic 3.1: Integrating Carbon Capture and Utilization into Industrial Processes

The objective of this research area is to reduce the carbon intensity of manufacturing and lower the barriers to deploying carbon capture systems. This subtopic seeks innovative solutions that will integrate carbon capture systems in industry; develop manufacturing processes for new technologies that are effective at capturing carbon dioxide from dilute sources including direct air capture (DAC); and enable the cost-effective utilization of captured carbon dioxide in industry.

Subtopic 3.1 Background: Diverse types of industrial processing steps and energy inputs are used in manufacturing.³⁷ As a result, reducing emissions and capturing CO₂ from the industrial sector poses unique challenges and will be more difficult to abate than other sectors, such as transportation and power generation. While

³⁷ The U.S. Manufacturing Sector Static Sankey diagram. Available under "Energy Data and Information" at this website: <https://www.energy.gov/eere/amo/energy-analysis-data-and-reports>

reducing industrial emissions is challenging, there have been identified a number of technologies and strategies that show promise.³⁸

While several approaches can and should be utilized to reduce emissions from the industrial sector,³⁹ carbon capture will play an integral role in total emissions reduction. Integrating carbon capture systems with industrial processes and utilizing intensified processes in the unit design will enhance efficiency, further reduce emissions, and make carbon capture more economical.⁴⁰ Utilization of captured carbon could provide further emissions and economic benefits, for example, if it were converted to chemicals or if it could replace fossil fuel feedstock use in some industrial processes.⁴¹

Subtopic 3.1 Opportunity: Industrial sources of CO₂ include the production of food and drink, pulp and paper, refining, chemicals, cement, iron and steel, non-ferrous metals, and other sources. The CO₂ is from the combustion of fossil fuels, pre-combustion processing, chemical reactions integral to the formation of a final product (process emissions), or a combination of these sources.⁴²

Capturing CO₂ from industrial sources will largely depend on the concentration of the gas stream and the conditions (e.g., whether there are fouling contaminants). The concentration of the gas stream depends on the energy source and the industrial process. Industrial carbon capture and direct air capture are both candidate pathways to achieve net-zero industrial emissions, if proven cost effective.

CO₂ is currently used as a feedstock in select industrial processes, including food and chemical production, and welding.⁴³ The cost-effective use of CO₂ as a feedstock resource could be expanded. Carbon utilization is a broad term used to

³⁸ "Technologies and policies to decarbonize global industry: Review and assessment of mitigation drivers through 2070;" Applied Energy, Vol. 266, 15 May 2020, 114848. Available at:

<https://doi.org/10.1016/j.apenergy.2020.114848>.

³⁹ "Technologies and policies to decarbonize global industry: Review and assessment of mitigation drivers through 2070;" Applied Energy, Vol. 266, 15 May 2020, 114848. Available at:

<https://doi.org/10.1016/j.apenergy.2020.114848>.

⁴⁰ "Intersection of Advanced Manufacturing with Clean Coal and Carbon Capture Technologies."

<https://www.energy.gov/sites/prod/files/2019/10/f67/Special%20Report%20on%20Coal.pdf>

⁴¹ National Research Council, "[Carbon Management: Implications for R & D in the Chemical Sciences and Technology \(A Workshop Report to the Chemical Sciences Roundtable\)](#)," 2001-06-27.

⁴² 2015 DOE Quadrennial Technology Review, Chapter 4, Technology Assessments - "Carbon Dioxide Capture for Natural Gas and Industrial Applications. Available at:

<https://www.energy.gov/sites/prod/files/2015/12/f27/QTR2015-4D-Carbon-Dioxide-Capture-for-Natural-Gas-and-Industrial-Applications.pdf>.

⁴³ IPCC Special Report on Carbon dioxide Capture and Storage, Chapter 7, Mineral carbonation and industrial uses of carbon dioxide, 2018. Available at: https://www.ipcc.ch/site/assets/uploads/2018/03/srccs_chapter7-1.pdf

describe the many different ways that captured carbon oxides—principally CO₂, and in some cases carbon monoxide (CO)—can be used or “recycled” to produce economically valuable products or services.⁴⁴ The captured carbon is utilized as CO₂ or the carbon atoms react with other elements.

New technologies that can capture carbon released in manufacturing—as well as increase the utilization of the captured carbon as a valued feedstock (especially where fossil fuel feedstocks can be displaced)—could make reducing industrial emissions more economically viable. The capture of the carbon could be co-located where it is used. Otherwise, the captured carbon will need to be stored and later transferred to a productive use.

The DOE Office of Fossil Energy (FE)’s carbon capture and utilization programs are focused on early-stage R&D to provide step-change reductions in both cost and energy requirements of carbon capture technologies and develop novel ways to transform waste carbon streams into value-added products.⁴⁵ FE and DOE’s Office of Science (SC) are funding fundamental and applied research in process development, materials and chemical sciences to develop DAC prototypes.⁴⁶ This AMO FOA subtopic will focus on the applied R&D needed to integrate carbon capture technologies and captured carbon into manufacturing operations. In addition, this subtopic will focus on the development and commercialization of direct air capture technologies on a significant scale, as recommended by Congress.⁴⁷ This subtopic is responsive to recommendations from the National Academies of Sciences, Engineering, and Medicine.⁴⁸

Subtopic 3.1 Technology Focus:

Technology innovations to capture carbon and utilize carbon in diverse sectors and diverse industrial processes, facilities, and systems will be considered. The carbon can be captured from many manufacturing sources of CO₂, including from direct fuel use, onsite electricity generation, onsite steam generation, and industry-specific processes (like clinkers in cement manufacturing).

Proposals are requested in the following areas that, if addressed, will improve the efficiency and value proposition for the use of carbon capture systems:

⁴⁴ Carbon Utilization at the DOE Office of Fossil Energy. Available at: <https://www.energy.gov/fe/carbon-utilization>.

⁴⁵ Carbon Utilization at the DOE Office of Fossil Energy. Available at: <https://www.energy.gov/fe/carbon-utilization>.

⁴⁶ Department of Energy to Provide \$22 Million for Research on Capturing Carbon Dioxide from Air. Press release, March 30, 2020. Available at: <https://www.energy.gov/articles/department-energy-provide-22-million-research-capturing-carbon-dioxide-air>.

⁴⁷ Energy and Water Development Appropriations Bill, 2020, p. 84. Available at: <https://www.congress.gov/116/crpt/srpt102/CRPT-116srpt102.pdf>.

⁴⁸ Negative Emissions Technologies and Reliable Sequestration, A Research Agenda, 2019. Available at: <https://www.nap.edu/catalog/25259/negative-emissions-technologies-and-reliable-sequestration-a-research-agenda>.

- Research is needed to develop manufacturing processes, including material scale up, for new technologies that are effective at capturing carbon from industrial and dilute sources.
- Research is needed to solve system integration challenges associated with integrating carbon capture technologies in industry.
- Research is needed to address scale-up and “numbering up” (i.e. replication; nth plant) challenges of emerging carbon capture technology to achieve economies-of-scale cost reductions.
- New technologies are sought that will enable the utilization of captured carbon as a feedstock in a specific industrial processing step(s). The carbon captured could be from concentrated and dilute industrial sources or from ambient air. Research efforts to capture carbon and utilize the carbon in co-located processes are encouraged.

Proposed technology development and system integration efforts should employ the principles of process intensification and/or modular/distributed manufacturing. These principles include:

- Methods and design practices that enable module standardization to: (1) reduce the nonrecurring engineering costs for development of modular carbon capture technologies, (2) reduce incremental module unit manufacturing costs, and/or (3) allow for efficient customization or management of change. Novel methods that improve upon current practices are encouraged.
- The development of intensified processes that integrate or eliminate process steps to achieve higher production efficiencies. This includes integrating carbon capture and utilization into a single process step.

Modeling, simulation, and analysis tools should be developed and leveraged as part of this research, if applicable.

New technologies that enable the use of low-carbon fuels and low-carbon alternative feedstocks will not be considered. Research to advance carbon storage will not be considered. Applications that only propose incremental improvements to existing carbon capture technology will not be considered responsive to this FOA. See Section I.C.

Subtopic 3.1 Candidate Metrics and Targets: Applicants should identify the benefits that could be attained from advancing technologies proposed in manufacturing processes, facilities, and systems. The eligible technologies are listed in the Technology Focus section. Applicants should describe how the proposed new carbon capture or carbon utilization technology can be integrated in industry and

deliver direct as well as life-cycle energy, carbon, and productivity advantages. Applicants should describe how the CO₂ can be utilized in industry (if applicable), the energy input needed, and the system economics. The objective is to advance the development of efficient and cost-effective technologies for carbon capture from industrial sources.

All applicants must include metrics for carbon intensity reduction, energy productivity improvement, and emissions intensity reduction. Applicants must also identify and justify appropriate metrics and critical criteria for meeting the energy productivity and carbon intensity improvements for their technology and clearly indicate how the proposed innovation will satisfy them. For example, applicants should show how improvements in energy productivity (e.g., mass of product/unit energy) and/or carbon intensity (mass of CO₂e/mass of product) will reduce emissions intensity, and the applicant should show targets and metrics for these compared to an identified baseline. Energy productivity and carbon intensity analyses conducted should be included in the application, in addition to a baseline technology used for comparison. A quantifiable improvement goal (e.g., relative or absolute improvement) should be included.

In addition, applicants should identify technology-specific metrics that will lead to successful achievement of energy and emissions targets. Examples include captured waste heat to power carbon capture system, enhanced sorbent kinetics, and enhanced selectivity of CO₂ purification.

Benchmarks or baselines, minimum targets, and stretch targets should be included for each metric. Applications must clearly identify the starting and ending TRL for the project and justify the TRLs assigned. Examples of metrics include the following:

Candidate Objective/Goal	Example Metric	Example Minimum Target	Example Stretch Target	Baseline Performance / Cost
Captured waste heat to power carbon capture system	% heat demand displaced by waste heat	10%	20%	<i>Applicant defined</i>
Enhanced sorbent kinetics	Reduced temperature between adsorption and desorption	50°C	100°C	<i>Applicant defined</i>
Enhanced selectivity of CO ₂ purification	Increase in absolute CO ₂ purity	5%	20%	<i>Applicant defined</i>
% Carbon intensity reduction	Mass of CO ₂ e/ product mass	20%	50%	<i>Applicant defined</i>
% Energy productivity improvement	Product mass/ unit of energy	20%	50%	<i>Applicant defined</i>
% Emissions intensity reduction	Mass of CO ₂ e/ unit of energy	20%	50%	<i>Applicant defined</i>

Subtopic 3.2: Flexible CHP Demonstration in a District Energy System Integrated with a Renewably-Fueled Municipal Generating Station

Subtopic 3.2 Background: In a district energy (DE) system, a central plant (or plants) produce steam, hot water, or chilled water, which is then pumped through a network of insulated pipes to provide space heating, cooling, and/or hot water for nearby buildings. DE systems can provide electricity through the use of conventional power plants, combined heat and power (CHP) and renewable energy technologies (geothermal, wind and photovoltaic).

According to a recent U.S. Energy Information Administration report,⁴⁹ there are more than 660 DE systems operating in the United States with installations in every state. These systems provide heating to an estimated 5.5 billion square-feet of floor space and cooling to 1.9 billion square-feet of floor space (2012 data). The majority of floor space served by DE is located in commercial and institutional buildings across the country. CHP plays a significant role in DE. CHP is included in 281 installations (43% of all DE systems), provides over 6,700 MW of capacity, and generates 30 million MWh of electricity (2012 data).⁵⁰

⁴⁹ U.S. Energy Information Administration (EIA). 2018. U.S. District Energy Market Characterization. Prepared by ICF and International District Energy Association (IDEA). Page 1. Available at: <https://www.eia.gov/analysis/studies/buildings/districtservices/pdf/districtservices.pdf>.

⁵⁰ Data provided by the International District Energy Association.

Subtopic 3.2 Opportunity: Our nation's electric grid is the backbone of our economy, a key factor in future economic growth, and a critical component of our energy security. Because many of the DE systems in our country have the capability to generate electricity, they can serve as an important asset to the national grid system. As the national grid becomes more stressed by the rapid penetration of renewable generation systems, particularly wind and photovoltaic,⁵¹ DE systems can serve to stabilize the larger grid.

However, DE systems are increasingly using wind and photovoltaic systems to generate their electricity, so they are impacted by the same destabilization issues that arise for the national grid. Recently, DOE announced an effort to develop Flexible CHP systems that would be able to serve as back-up generation assets for the grid.^{52,53} These systems would also be able to stabilize a DE system that employs renewable generation systems.

In addition to the call for DE systems to provide increased grid flexibility, incorporating renewable energy into DE systems is increasingly of interest. Solar- and wind-based systems are becoming increasingly common. However, it is not generally recognized that geothermal energy resources can also have significant contributions to DE systems. In particular, geothermal systems can provide bi-directional energy storage, without the need for battery storage, to provide district heating and cooling. DE systems with geothermal technologies can use thermal energy directly from the earth to provide warm water for direct thermal heating through a heat exchanger and also use a ground source heat pump to provide district cooling.

Subtopic 3.2 Technology Focus: AMO seeks to fund projects that would research and develop, design and test, and install and demonstrate the use/operation of Flexible CHP systems in DE systems that have renewable (principally geothermal, wind or photo-voltaic) generation capabilities. The Flexible CHP system should have the capability to automatically and seamlessly respond to variations in electric power generation by the renewable generation resources, while at the same time, maintain their base-load operation. The developed Flexible CHP system may be

⁵¹ Wu, Raphael, Georgios Mavromatidis, and Kristina Orehounig. "Reliability Optimisation of a District Multi-Energy System." In 19. Status-Seminar" Forschen für den Bau im Kontext von Energie und Umwelt". ETH Zurich, 2016.

⁵² DOE EERE news announcement. Energy Department Selects Seven Projects to Develop Combined Heat and Power Technologies that Offer Services to the Electric Grid. Available at: <https://www.energy.gov/eere/articles/energy-department-selects-seven-projects-develop-combined-heat-and-power-technologies>

⁵³ DOE EERE AMO Flexible Combined Heat and Power (CHP) Systems - Fact Sheet, 2018. Available at: <https://www.energy.gov/eere/amo/downloads/flexible-combined-heat-and-power-chp-systems-fact-sheet-2018>

fueled by natural gas, a renewable fuel, or a combination of natural gas and a renewable fuel.

The developed CHP system must be capable of meeting the following requirements:

1. Part load (50% rated electrical capacity):
 - a. Reciprocating engine based CHP system must be able to operate at a fuel-to-electricity generation efficiency of 30%.⁵⁴
 - b. Gas turbine based CHP system must be able to operate at a fuel-to-electricity generation efficiency of 25%.
 - c. Both types of CHP systems must demonstrate a total CHP efficiency of 85%.⁵⁵
2. Full load (100% rated electrical capacity):
 - a. Reciprocating engine based CHP system must be able to operate at a fuel-to-electricity generation efficiency of 45%.
 - b. Gas turbine based CHP system must be able to operate at a fuel-to-electricity generation efficiency of 40%.
 - c. Both types of CHP systems must demonstrate a total CHP efficiency of 85%.
3. The units must demonstrate a capability of switching from 50% electrical capacity to maximum electrical capacity automatically based on an external request from the electric grid system.
4. The units must also demonstrate a capability to ramp up and down between 50% rated electrical capacity and 100% rated electrical capacity, including maximum active power and maximum reactive power, in less than 2 minutes.
5. Smaller sized units (>100 kWe) may be used to establish system performance. However, supporting computational models must be able to extrapolate the efficiency and emissions performance to CHP systems between 1 and 20 MWe. Applicants should describe in their technical approach how their technology would be capable of meeting the technical requirements on a 1-20 MWe system.
6. The system must meet established emissions and grid connection requirements that exist in current potential markets. For example, for California:
 - a. Air Resources Board distributed generation (DG) emissions certification standards⁵⁶ ($\text{NO}_x \leq 0.07$)

⁵⁴ All efficiencies are defined based on natural gas lower heating value (LHV).

⁵⁵ Total CHP efficiency = fuel to electricity generation efficiency + heat recovery efficiency.

⁵⁶ Final regulation order, Amendments to the distributed generation certification regulation. Available at: <https://ww3.arb.ca.gov/energy/dg/2006regulation.pdf>

lb./MWh, CO \leq 0.1 lb./MWh, and VOC \leq 0.02 lb./MWh) at rated electrical capacity. Credit shall be applied at the rate of 1 MWh for each 3.4 million Btu of heat recovered.

- b. The units must meet Independent System Operator (CAISO) direct telemetry requirements as outlined in CAISO's Business Practice Manual for Direct Telemetry⁵⁷ (Version 12) to allow for participation of the generating unit in California energy and ancillary services markets.
- c. The units must meet interconnection requirements (CPUC Rule 21), while also allowing manufacturing site operations to continue without compromising planned internal duty cycle of the plant (e.g., process steam production).

Because the CHP system will be integrated into the DE system micro-grid, in addition to the above performance requirements, the CHP system must be able to comply with the functions defined by the referenced standards and must be capable of implementing a communication interface for coordination and control with the micro-grid:

1. Power electronics equipment and controls systems must be designed to enable engagement of a CHP system with the DE micro-grid controls, including the ability to interoperate with multiple dispatchable generation sources and loads and ability to island from and reconnect with the larger grid; as defined by the Institute of Electrical and Electronic Engineers (IEEE) 2030.7 - Standard for the Specification of Microgrid Controllers, and tested per IEEE 2030.8 - Standard for the Testing of Microgrid Controllers.
2. Power electronics must be designed to enable CHP systems to meet the stringent requirements for interconnection at the distribution system level with high penetration of distributed generation, including utility-interactive grid-support functions, grid stabilizing response to abnormal conditions, and no impacts on power quality at the manufacturing site and other customer sites on the utility distribution system; compliance with the IEEE 1547-2018 - Standard for Interconnection and Interoperability of Distributed Energy Resources with Associated Electric Power Systems Interfaces, and tested per IEEE P1547.1-2020-Standard for Conformance Test Procedures for Equipment Interconnecting Distributed Energy Resources with Electric Power Systems and

⁵⁷ [California ISO Metering and Telemetry](#)

Associated Interfaces.

3. Power electronics equipment and control systems must be capable of being implemented into a variety of existing and future CHP systems with no major modifications, and provide a means to meet the IEEE 1547-2018 distribution grid requirement using a wide range of CHP generator technologies.

The projected installed future cost of the entire system must not exceed \$1,800/kWe rated power. The application will need to include a substantive techno-economic analysis to support the estimated cost of commercially available systems.

Finally, the research project should be organized into three distinct phases:

1. System research and development,
2. System design and testing,
3. System installation and demonstration.

Subtopic 3.2 Candidate Targets and Metrics: Applications must clearly identify the starting and ending TRL for the project and justify the TRLs assigned. Proposed targets and measurement of progress toward meeting targets must be substantiated. Metrics should be specific to the proposed technology and must define appropriate benchmarks or baselines, minimum targets, and stretch targets. In addition to meeting the specific minimum goals stated above, applicants are encouraged to consider the following metrics as examples:

Objective/Goal	Metric	Minimum Target	Stretch Target	Baseline Performance / Cost
Electricity generation at 50% load	Reciprocating engine electricity generation efficiency	30%	32%	<i>Applicant defined</i>
	Turbine electricity generation efficiency	25%	27%	<i>Applicant defined</i>
Electricity generation at 100% load	Reciprocating engine electricity generation efficiency	45%	50%	<i>Applicant defined</i>

	Turbine electricity generation efficiency	40%	45%	<i>Applicant defined</i>
CHP system performance	Overall CHP system performance at all loads	85%	85%	<i>Applicant defined</i>

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).
- Submissions that describe a technology, but do not propose an adequate R&D plan in the Technical Volume that allows EERE to evaluate the submission under the applicable merit review criteria provided in Section V. of the FOA.
- For Subtopic 1.3: Machine Learning to Increase Efficiencies in the Manufacturing of Large-Scale, High-Rate Aerostructures, approaches that require redesign of the finished product or that address power and propulsion components, control surfaces, or launch and recover equipment will be considered unresponsive.
- For Subtopic 1.4: Integrated Additive Manufacturing Processes for Advanced Wind Blade Production, applications relying solely on conventional composite layup systems per today's processes for blade structure or relying solely on conventional full-scale composite molds (non-AM enabled, non-flexible process footprint) will be considered unresponsive.
- For Subtopic 3.1: Integrating Carbon Capture and Utilization into Industrial Processes, applications that propose technology that only improves the carbon capture system, independent of the integration with industrial systems, will be considered unresponsive.

D. Authorizing Statutes

The programmatic authorizing statute is EPL 2005, Section 911 (a)(2)(C), as codified at 42 U.S.C. 16191(a)(2)(C), which authorizes, as relevant to this FOA, research and development programs of "advanced technologies to improve the energy efficiency, environmental performance, and process efficiency of energy-intensive and waste-intensive industries[.]"

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.

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II. Award Information

A. Award Overview

i. Estimated Funding

EERE expects to make a total of approximately \$67 million of federal funding available for new awards under this FOA, subject to the availability of appropriated funds. EERE anticipates making up to 33 awards under this FOA. EERE may issue one, multiple, or no awards. Individual awards may vary, ranging between up to \$1 million and up to \$10 million, depending on sub-topic area, as outlined in the table below.

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

Sub-Topic Area	Sub-Topic Description	# of Awards (estimated range)	Federal \$ per award (estimated)	Total Federal Funding (estimated)
1.1	Innovative Iron and Steelmaking Processes	Up to 3	Up to \$10M	\$15M
1.2	Efficiency Improvements to Drying Processes	Up to 4	Up to \$3M	\$7M
1.3	Machine Learning for Optimization of Large-Scale, High-Rate Aerostructures	Up to 4	Up to \$3M	\$5M
1.4	Integrated Additive Manufacturing Processes for Advanced Wind Blade Production	Up to 2	Up to \$4M	\$4M
1.5	Reducing Cost of Production of Ceramic Matrix Composites Used in High Temperature Applications	Up to 6	Up to \$3M	\$6M
2.1	Advanced Chemical Manufacturing R&D	Up to 4	Up to \$4M	\$7M
2.2	Dynamic Catalyst Science with Data Analytics	Up to 2	Up to \$5M	\$5M
3.1	Integrating Carbon and Utilization into Industrial Processes	Up to 5	Up to \$5M	\$10M
3.2	Flexible CHP for District Energy Systems	Up to 3	Up to \$5M	\$8M
	TOTAL	Up to 33		\$67M

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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 and may be subject to, among other things, the availability of funds.

ii. Period of Performance

EERE anticipates making awards that will run up to 36 months in length, comprised of one or more budget periods 12 to 18 months in length. Project continuation to the next budget period will be contingent upon several elements, including satisfactory performance and Go/No-Go decision review. For a complete list, see Section VI.B.xiv. At the Go/No-Go decision points, EERE will evaluate project performance, project schedule adherence, the extent milestone objectives are met, compliance with reporting requirements, and overall contribution to the program goals and objectives. As a result of this evaluation, EERE 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.

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 eligibility requirements 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. Eligible Applicants for Sub-Topic 1.2

Consistent with the congressional direction for the FY 2020 appropriations⁵⁸, Subtopic 1.2 Efficiency Improvements to Drying Processes is limited to domestic university or industry-led teams. Specifically, only institutions of higher education and industry entities are eligible to apply to apply for funding as a prime recipient. An industry entity includes non-profit and for-profit entities engaged in processing of raw materials or manufacturing of goods. An industry entity does not include national laboratories, institutions of higher education, or government entities.

The following types of domestic entities are eligible to participate as a subrecipient in a university or industry-led team funded under Subtopic 1.2 of this FOA:

1. Institutions of higher education;
2. For-profit entities;
3. Non-profit entities;
4. DOE National Laboratories;
5. Non-DOE National Laboratories;
6. State, local and tribal governments; and
7. Federal agencies and instrumentalities other than DOE.

⁵⁸ Further Consolidated Appropriations Act, 2020, COMMITTEE PRINT OF THE COMMITTEE ON APPROPRIATIONS, U.S. HOUSE OF REPRESENTATIVES ON H.R. 1865/PUBLIC LAW 116-94, at 456 [Legislative Text and Explanatory Statement], available at <https://www.govinfo.gov/content/pkg/CPRT-116HPRT38679/pdf/CPRT-116HPRT38679.pdf>

To qualify as a domestic entity, the applicant must be incorporated (or otherwise formed) under the laws of a particular State or territory of the United States with majority domestic ownership or control and have a physical place of business in the United States. For entities seeking waiver to allow foreign entity to participate as a prime recipient or subrecipients, see Section III.A.ii.c and Appendix C.

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 for funding under this FOA.

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

Entities identified on a Department of Homeland Security (DHS), Binding Operational Directives (BOD) as an entity publicly banned from doing business with the United States government are not eligible. See <https://cyber.dhs.gov/directives/>.

ii. Eligible Applicants for All Other Sub-Topics

a. Individuals

U.S. citizens and lawful permanent residents are eligible to apply for funding as a prime recipient or subrecipient.

b. Domestic Entities

For-profit entities, educational institutions, and nonprofits that are incorporated (or otherwise formed) under the laws of a particular state or territory of the United States with majority domestic ownership or control and have a physical location for business operations in the United States are eligible to apply for funding as a prime recipient or subrecipient.

State, local, and tribal government entities are eligible to apply for funding as a prime recipient or subrecipient.

DOE/NNSA FFRDCs are eligible to apply for funding as a prime recipient or subrecipient with the approval of their relevant contracting officer.

Non-DOE/NNSA FFRDCs are eligible to apply for funding as a subrecipient, but are not eligible to apply as a prime recipient with the approval of their relevant contracting officer.

Federal agencies and instrumentalities (other than DOE) are eligible to apply for funding as a subrecipient, but are not eligible to apply as a prime recipient. Federal agencies and instrumentalities must provide its authority to receive Federal grant funds.

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.

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

Entities identified on a Department of Homeland Security (DHS), Binding Operational Directives (BOD) as an entity publicly banned from doing business with the United States government are not eligible. See <https://cyber.dhs.gov/directives/>.

c. Foreign Entities (applicable to all Topics/Sub-Topics)

All prime recipients and subrecipients receiving funding under this FOA must be incorporated (or otherwise formed) under the laws of a state or territory of the United States with majority domestic ownership and control and have a physical location for business operations in the United States. If a foreign entity applies for funding as a prime recipient, it must designate in the Full Application a domestic subsidiary or affiliate to be the prime recipient. The Full Application must state the nature of the corporate relationship between the foreign entity and domestic subsidiary or affiliate.

Foreign entities may request a waiver of the requirement to designate a subsidiary in the United States as the prime recipient in the Full Application (i.e., a foreign entity may request that it remains the prime recipient on an award). To do so, the applicant must submit an explicit written waiver request in the Full Application. 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 necessary information that must be included in a request to waive this requirement. The applicant does not have the right to appeal EERE's decision concerning a waiver request.

d. Incorporated Consortia

Incorporated consortia, are eligible to apply for funding 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 in foreign countries, please refer to the requirements in “Foreign Entities” above.

Each incorporated 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 EERE Contracting Officer.

e. 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. The eligibility of the consortium will be determined by the eligibility of the prime recipient/consortium representative under Section III.A. of the FOA.

Upon request, unincorporated consortia must provide the EERE Contracting 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 discuss, among other things, 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.

B. Cost Sharing

Cost Share Requirements for all Sub-Topics, Excluding Sub-Topic 3.2

The cost share must be at least 20% of the total allowable costs for research and development projects (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) and 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.) The 20% minimum cost share must be maintained throughout the project period, including the award’s initial budget period.

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Cost Share Requirements for Sub-Topic 3.2

Subtopic 3.2 will be broken into three (3) phases: research and development (phase 1), design and testing (phase 2), and installation and demonstration (phase 3). For phases 1 and 2, 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 phase 3, the demonstration phase, the cost share must be at least 50% of total allowable costs. 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.) Applications must clearly identify what work and which costs are associated with each phase.

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;
- Appropriated 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 Contracting 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

EERE 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 EERE Contracting 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 Contracting 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 Contracting Officer must approve all such requests before they go into effect.

C. Compliance Criteria

Concept Papers, Full Applications and Replies to Reviewer Comments must meet all compliance criteria listed below or they will be considered noncompliant. EERE will not review or consider noncompliant submissions, including Concept Papers, Full Applications, and Replies to Reviewer Comments that were: submitted through

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means other than EERE Exchange; submitted after the applicable deadline; and/or submitted incomplete. EERE will not extend the submission deadline for applicants that fail to submit required information by the applicable deadline due to server/connection congestion.

i. Compliance Criteria

1. Concept Papers

Concept Papers are deemed compliant if:

- The Concept Paper complies with the content and form requirements in Section IV.C. of the FOA; and
- The applicant successfully uploaded all required documents and clicked the “Submit” button in EERE Exchange by the deadline stated in this FOA.

2. Full Applications

Full Applications are deemed compliant if:

- The applicant submitted a compliant Concept Paper;
- The Full Application complies with the content and form requirements in Section IV.D. of the FOA; and
- The applicant successfully uploaded all required documents and clicked the “Submit” button in EERE Exchange by the deadline stated in the FOA.

3. Replies to Reviewer Comments

Replies to Reviewer Comments are deemed compliant if:

- The Reply to Reviewer Comments complies with the content and form requirements in Section IV.E. of the FOA; and
- The applicant successfully uploaded all required documents to EERE Exchange by the deadline stated in the FOA.

D. Responsiveness Criteria

A preliminary technical review of all Concept Papers and Full Applications is performed to determine if the submissions are responsive to the FOA requirements. 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.
(end of acceptable authorization)

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:

1. *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.

2. *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.

3. *Value/Funding*

The value of and funding for the FFRDC portion of the work will not normally be included in the award to a successful applicant. Usually, DOE will fund a DOE/NNSA FFRDC contractor through the DOE field work proposal (WP) system and non-DOE/NNSA FFRDC through an interagency agreement with the sponsoring agency.

4. *Cost Share*

Although the FFRDC portion of the work is usually excluded from the award to a successful applicant, 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.

5. *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 contractor.

6. *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 Sub-Topic area of this FOA. If an entity submits more than one Concept Paper and one Full Application to the same Sub-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 Sub-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 Sub-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.

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IV. Application and Submission Information

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.** At each phase, EERE performs an initial eligibility review of the applicant submissions to determine whether they meet the eligibility requirements of Section III of the FOA. EERE will not review or consider submissions that do not meet the eligibility requirements of Section III. All submissions must conform to the following form and content requirements, including maximum page lengths (described below) and must be submitted via EERE Exchange at <https://eere-exchange.energy.gov/>, unless specifically stated otherwise. **EERE will not review or consider submissions submitted through means other than EERE Exchange, submissions submitted after the applicable deadline, or incomplete submissions.** EERE will not extend deadlines for applicants who fail to submit required information and documents due to server/connection congestion.

A **Control Number** will be issued when an applicant begins the EERE Exchange application process. This control number must be included with all application documents, as described below.

The Concept Paper, Full Application, and Reply to Reviewer Comments must conform to the following requirements:

- 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 Times New Roman 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;
- The Control Number must be prominently displayed on the upper right corner of the header of every page. 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.

Applicants are responsible for meeting each submission deadline. **Applicants are strongly encouraged to submit their Concept Papers and Full Applications at least 48**

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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.

EERE urges applicants to carefully review their Concept Papers, and Full Applications and to allow sufficient time for the submission of required information and documents. All Full Applications that pass the initial eligibility review will undergo comprehensive technical merit review according to the criteria identified in Section V.A.ii. of the FOA.

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.

A. Application Forms

The application forms and instructions are available 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 10MB. Files in excess of 10MB cannot be uploaded, and hence cannot be submitted for review. If a file exceeds 10MB 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:

ControlNumber_LeadOrganization_Project_Part_1

ControlNumber_LeadOrganization_Project_Part_2

B. 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.

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i. Concept Paper Content Requirements

EERE will not review or consider ineligible Concept Papers (see Section III of the FOA).

Each Concept Paper must be limited to a single concept or technology. Unrelated concepts and technologies should not be consolidated into a single Concept Paper.

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 FOA Sub-Topic Area and Area of Interest, if applicable, being addressed, both the technical and business points of contact, names of all team member organizations, and any statements regarding confidentiality.
Technical Description and Impacts	3 pages maximum	<p>Applicants are required to describe succinctly:</p> <ul style="list-style-type: none"> • The proposed technology, including its basic operating principles and how it is unique and innovative; • 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 (the baseline technology) 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 pages maximum	<p>Applicants are required to describe succinctly the qualifications, experience, and capabilities of the proposed project team, including:</p> <ul style="list-style-type: none"> • 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. <p>Applicants may provide graphs, charts, or other data to supplement their Technology Description.</p>

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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. An applicant who receives a “discouraged” notification may still submit a Full Application. EERE will review all eligible Full Applications. However, by discouraging the submission of a Full Application, EERE intends to convey its lack of programmatic interest in the proposed project in an effort to save the applicant the time and expense of preparing an application that is unlikely to be selected for award negotiations.

EERE may include general comments provided from reviewers on an applicant’s Concept Paper in the encourage/discourage notification posted on EERE Exchange at the close of that phase.

C. Content and Form of the Full Application

Applicants must submit a Full Application by the specified due date and time to be considered for funding under this FOA. Applicants must complete the following application forms found 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. Applicants will receive a control number upon clicking the “Create Concept Paper” button in EERE Exchange, and should include that control number in the file name of their Full Application submission (i.e., *Control number_Applicant Name_Full Application*).

i. Full Application Content Requirements

EERE will not review or consider ineligible Full Applications (see Section III. of the FOA).

Each Full Application shall be limited to a single concept or technology. Unrelated concepts and technologies shall not be consolidated in a single Full Application. Full Applications must conform to the following requirements:

Submission	Components	File Name
Full Application (PDF, unless stated otherwise)	Technical Volume (See Chart in Section IV.D.ii.)	ControlNumber_LeadOrganization_TechnicalVolume
	Resumes (1 page maximum per person)	ControlNumber_LeadOrganization_Resumes
	Letters of Commitment, if applicable (1 page maximum per letter)	ControlNumber_LeadOrganization_LOCs
	Statement of Project Objectives (SOPO) (Microsoft Word format. 20 page limit)	ControlNumber_LeadOrganization_SOPO
	SF-424 Application for Federal Assistance	ControlNumber_LeadOrganization_App424
	Budget Justification (Microsoft Excel format. Applicants must use the template available in EERE Exchange)	ControlNumber_LeadOrganization_Budget_Justification
	Summary for Public Release (1 page limit)	ControlNumber_LeadOrganization_Summary
	Summary Slide (Microsoft PowerPoint format. 1 page limit)	ControlNumber_LeadOrganization_Slide
	Subrecipient Budget Justification, if applicable (Microsoft Excel format. Applicants must use the template available in EERE Exchange)	ControlNumber_LeadOrganization_Subrecipient_Budget_Justification
	DOE WP for FFRDC, if applicable (See DOE O 412.1A, Attachment 3)	ControlNumber_LeadOrganization_WP
	Authorization from cognizant Contracting Officer for FFRDC, if applicable	ControlNumber_LeadOrganization_FFRDCAuth
	SF-LLL Disclosure of Lobbying Activities	ControlNumber_LeadOrganization_SF-LLL
	Foreign Entity and Foreign Work waiver requests, if applicable	ControlNumber_LeadOrganization_Waiver
	U.S. Manufacturing Plan	ControlNumber_LeadOrganization_USMP
	Data Management Plan (Microsoft Word format)	ControlNumber_LeadOrganization_DMP
	Table of Personnel	ControlNumber_LeadOrganization_ToP

Note: The maximum file size that can be uploaded to the EERE Exchange website is 10MB. Files in excess of 10MB cannot be uploaded, and hence cannot be submitted for review. If a file exceeds 10MB 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:

ControlNumber_LeadOrganization_TechnicalVolume_Part_1

ControlNumber_LeadOrganization_TechnicalVolume_Part_2

EERE will not accept late submissions that resulted from technical difficulties due to uploading files that exceed 10MB.

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EERE provides detailed guidance on the content and form of each component below.

ii. Technical Volume

The Technical Volume must be submitted in Adobe PDF format. The Technical Volume must conform to the following content and form requirements, including maximum page lengths. If applicants exceed the maximum page lengths indicated below, EERE will review only the authorized number of pages and disregard any additional pages. This volume must address the Merit Review Criteria as discussed in Section V.A.ii. 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. The Technical Volume must conform to the following content requirements:

SECTION/PAGE LIMIT	DESCRIPTION
Cover Page	The cover page should include the project title, the specific FOA Subtopic Area being addressed, both the technical and business points of contact, names of all team member organizations, and any statements regarding confidentiality.

<p>Project Overview (This section should constitute approximately 10% of the Technical Volume)</p>	<p>The Project Overview should contain the following information:</p> <ul style="list-style-type: none"> • 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 no less than 3 critical success factors in achieving that goal. Metrics for the critical success factors should be identified and included in a metrics table. • 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.
<p>Technical Description, Innovation, and Impact (This section should constitute approximately 30% of the Technical Volume)</p>	<p>The Technical Description should contain the following information:</p> <ul style="list-style-type: none"> • 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. The impact of the technology improvement on energy efficiency should be clearly made.
<p>Workplan and Market Transformation Plan (This section should constitute approximately 40% of the Technical Volume)</p>	<p>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:</p> <ul style="list-style-type: none"> • 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.

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	<ul style="list-style-type: none">• 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. Each critical success factor identified in the Project Overview should have a milestone that demonstrates progress towards the goal. 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.xiv. 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.
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	<ul style="list-style-type: none"> • 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 associated with each critical success factor. 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. • Project Management: The applicant should discuss the team's proposed management plan, including the following: <ul style="list-style-type: none"> ○ 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: <ul style="list-style-type: none"> ○ 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, U.S. Manufacturing Plan, and product distribution
Technical Qualifications and Resources (Approximately 20% of the Technical Volume)	<p>The Technical Qualifications and Resources should contain the following information:</p> <ul style="list-style-type: none"> • 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.

	<ul style="list-style-type: none">• 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:<ul style="list-style-type: none">○ The roles and the work to be performed by each PI and Key Participant○ Business agreements between the applicant and each PI and Key Participant○ How the various efforts will be integrated and managed○ Process for making decisions on scientific/technical direction○ Publication arrangements○ Intellectual Property issues○ Communication plans
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iii. Resumes

Applicants are required to submit resumes for key participating team members. Multi-page resumes are not allowed. 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, also include any letters of commitment from partners/end users (1 page maximum per letter). Save the letters of commitment in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_LOCs".

v. Statement of Project Objectives (SOPO)

Applicants are required to complete a SOPO. A SOPO template is available on EERE Exchange at <https://eere-Exchange.energy.gov/>. The SOPO, including the Milestone Table, must not exceed 20 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. 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

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

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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_App424”.

vii. Budget Justification Workbook

Applicants are required to complete the Budget Justification Workbook. This form is available on EERE Exchange at <https://eere-Exchange.energy.gov/>. Prime recipients 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/Abstract for Public Release

Applicants are required to submit a one-page summary/abstract of their project. The project summary/abstract must contain a summary of the proposed activity 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 are required to provide a single PowerPoint slide summarizing the proposed project. The slide must be submitted in Microsoft PowerPoint format. This slide is used during the evaluation process. Save the Summary Slide in a single file using the following convention for the title
“ControlNumber_LeadOrganization_Slide”.

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 Key Participant information; and
- Requested EERE funds and proposed applicant cost share.

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 3, available at: <https://www.directives.doe.gov/directives-documents/400-series/0412.1-BOrder-a/@@images/file>. 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)

Prime 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.

Prime 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: Foreign Entities and Foreign Work (if applicable)

1. Foreign Entity Participation:

As set forth in Section III.A.iii., all prime recipients receiving funding under this FOA must be incorporated (or otherwise formed) under the laws of a state or territory of the United States majority domestic ownership or control and have a physical location for business operations 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 necessary information that must be included in a request to waive this requirement.

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

As set forth in Section IV.J.iii., all work under EERE funding agreements must be performed in the United States. This requirement does not apply to the purchase of supplies and equipment, so a waiver is not required for foreign purchases of these items. However, the prime recipient should make every effort to purchase supplies and equipment within the United States. Appendix C lists the necessary 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. U.S. Manufacturing Commitments

Pursuant to the DOE Determination of Exceptional Circumstances (DEC) dated September 9, 2013, each applicant is required to submit a U.S. Manufacturing Plan as part of its application. The U.S. Manufacturing Plan represents the

applicant's measurable commitment to support U.S. manufacturing as a result of its award.

Each U.S. Manufacturing Plan must include a commitment 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 applicant can show to the satisfaction of DOE that it is not commercially feasible to do so (referred to hereinafter as “the U.S. Competitiveness Provision”). The applicant further agrees to make the U.S. Competitiveness Provision binding on any subawardee and any assignee or licensee or any entity otherwise acquiring rights to any subject invention, including subsequent assignees or licensees. A subject invention is any invention conceived of or first actually reduced to practice under an award.

Due to the lower technology readiness levels of this FOA, DOE does not expect the U.S. Manufacturing Plans to be tied to a specific product or technology. However, in lieu of the U.S. Competitiveness Provision, an applicant may propose a U.S. Manufacturing Plan with more specific commitments that would be beneficial to the U.S. economy and competitiveness. For example, an applicant may commit specific products to be manufactured in the U.S., commit to a specific investment in a new or existing U.S. manufacturing facility, keep certain activities based in the U.S. or support a certain number of jobs in the U.S. related to the technology. An applicant which is likely to license the technology to others, especially universities for which licensing may be the exclusive means of commercialization the technology, the U.S. Manufacturing Plan may indicate the applicant's plan and commitment to use a specific licensing strategy that would likely support U.S. manufacturing.

If DOE determines, at its sole discretion, that the more specific commitments would provide a sufficient benefit to the U.S. economy and industrial competitiveness, the specific commitments will be part of the terms and conditions of the award. For all other awards, the U.S. Competitiveness Provision shall be incorporated as part of the terms and conditions of the award as the U.S. Manufacturing Plan for that award.

The U.S. Competitiveness Provision is also a requirement for the Class Patent Waiver that applies to domestic large business under this FOA (see Section VIII.K. Title to Subject Inventions).

Save the U.S. Manufacturing Plan in a single PDF file using the following convention for the title “ControlNumber_LeadOrganization_USMP”.

xvi. Data Management Plan (DMP)

Applicants are required to submit a DMP with their Full Application.

An applicant may select one of the template Data Management Plans (DMP) listed below. Alternatively, instead of selecting one of the template DMPs below, an applicant may submit another DMP provided that the DMP, at a minimum, (1) describes how data sharing and preservation will enable validation of the results from the proposed work, how the results could be validated if data are not shared or preserved and (2) has a plan for making all research data displayed in publications resulting from the proposed work digitally accessible at the time of publications. DOE Public Access Plan dated July 24, 2014 provides additional guidance and information on DMPs.

Option 1: For the deliverables under the award, the recipient does not plan on making the underlying research data supporting the findings in the deliverables publicly-available for up to five (5) years after the data were first produced because such data will be considered protected under the award. The results from the DOE deliverables can be validated by DOE who will have access, upon request, to the research data. Other than providing deliverables as specified in the award, the recipient does not intend to publish the results from the project. However, in an instance where a publication includes results of the project, the underlying research data will be made available according to the policies of the publishing media. Where no such policy exists, the recipient must indicate on the publication a means for requesting and digitally obtaining the underlying research data. This includes the research data necessary to validate any results, conclusions, charts, figures, images in the publications.

Option 2: For any publication that includes results of the project, the underlying research data will be made available according to the policies of the publishing media. Where no such policy exists, the recipient must indicate on the publication a means for requesting and digitally obtaining the underlying research data. This includes the research data necessary to validate any results, conclusions, charts, figures, images in the publications.

Save the DMP in a single Microsoft Word file using the following convention for the title "ControlNumber_LeadOrganization_DMP".

xvii. Table of Personnel

Applicants must submit a list of personnel who are proposed to work on the project, both at the recipient and sub-recipient level. The table must include the

individuals' names, job titles, and their organization. The personnel that fall in one or more of the following categories must be included:

- Principal Investigator
- Business Agent
- Co-Principal Investigator
- Co-Investigator
- Other professional
- Collaborator

Save the Table in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_ToP".

D. 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 responding to the comments however they desire or supplementing their Full Application. The Reply to Reviewer Comments is an optional submission; applicants are not required to submit a Reply to Reviewer Comments. 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 Replies to Reviewer Comments.

EERE will not review or consider ineligible Replies to Reviewer Comments (see Section III of the FOA). EERE will review and consider each eligible Full Application, even if no Reply is submitted or if the Reply is found to be ineligible.

Replies to Reviewer Comments must conform to the following content and form requirements, including maximum page lengths, described below. If a Reply to Reviewer Comments is more than three (3) pages in length, EERE will review only the first three (3) pages and disregard any additional pages.

SECTION	PAGE LIMIT	DESCRIPTION
Text	2 pages max	Applicants may respond to one or more reviewer comments or supplement their Full Application.
Optional	1 page max	Applicants may use this page however they wish; text, graphs, charts, or other data to respond to reviewer comments or supplement their Full Application are acceptable.

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E. Post Selection Information Requests

If selected for award, EERE reserves the right to request additional or clarifying information regarding the following (non-exhaustive list):

- Indirect cost information;
- Other budget information;
- Commitment Letters 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);
- Representation of Limited Rights Data and Restricted Software, if applicable;
- Foreign Involvement; and
- Environmental Questionnaire.

F. Dun and Bradstreet Universal Numbering System (DUNS) Number 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 DUNS 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 DUNS 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.

G. Submission Dates and Times

Concept Papers, Full Applications, and Replies to Reviewer Comments 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.

H. Intergovernmental Review

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

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I. Funding Restrictions

i. Allowable Costs

All expenditures must be allowable, allocable, and reasonable in accordance with the applicable federal cost principles.

Refer to the following applicable federal cost principles for more information:

- Federal Acquisition Regulation (FAR) Part 31 for For-Profit entities; and
- 2 CFR Part 200 Subpart E - Cost Principles for all other non-federal entities.

ii. Pre-Award Costs

Selectees 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 Contracting 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 Contracting Officer. If the applicant elects to undertake activities that DOE determines

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may have an adverse effect on the environment or limit the choice of reasonable alternatives prior to receiving such written authorization from the Contracting 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 Contracting Officer override these NEPA requirements to obtain the written authorization from the Contracting 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 Contracting 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 EERE awards must be performed in the United States. This requirement does not apply to the purchase of supplies and equipment; however, the prime recipient should make every effort to purchase supplies and equipment within 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, EERE 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

There may be limited circumstances where it is in the interest of the project to perform a portion of the work outside the United States. To seek a foreign work waiver, the applicant must submit a written waiver request to EERE. Appendix C lists the necessary information that must be included in a request for a foreign work waiver.

The applicant must demonstrate to the satisfaction of EERE that a waiver would further the purposes of the FOA and is in the economic interests of the United States. EERE may require additional information before

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

iv. Construction

Recipients are required to obtain written authorization from the Contracting 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 Contracting Officer assigned to the award.

vi. Equipment and Supplies

To the greatest extent practicable, all equipment and products purchased with funds made available under this FOA should be American-made. This requirement does not apply to used or leased equipment.

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. Domestic Preference – Infrastructure Projects

If selected for an award, as appropriate and to the extent consistent with law, recipients must ensure that, to the greatest extent practicable, iron and aluminum as well as steel, cement, and other manufactured products (items and construction materials composed in whole or in part of non-ferrous metals such as aluminum; plastics and polymer-based products such as polyvinyl chloride pipe; aggregates such as concrete; glass, including optical fiber; and lumber) used in the proposed project are produced in the United States. The recipients must flow this requirement to all sub-awards, contracts, subcontracts and purchase orders for work performed under the proposed project.

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

Prior to making a federal award, the DOE is required by 31 U.S.C. 3321 and 41 U.S.C. 2313 to review information available through any Office of Management and Budget (OMB)-designated repositories of government-wide eligibility qualification or financial integrity information, such as SAM Exclusions and "Do Not Pay."

In addition, DOE evaluates the risk(s) posed by applicants before they receive federal awards. This evaluation may consider: results of the evaluation of the applicant's eligibility; the quality of the application; financial stability; quality of management systems and ability to meet the management standards prescribed in 2 CFR Part 200, as amended by 2 CFR Part 910; history of performance; reports and findings from audits; sufficiency of measures to identify and manage conflicts of interest; adequacy of measures to control sensitive information and protect against unauthorized transfer of scientific and technical information; and the applicant's ability to effectively implement statutory, regulatory, or other requirements imposed on non-federal entities.

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.

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 personnel hours report;
- 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 Talent Recruitment Programs

One of the objectives of this FOA is to improve the productivity and energy efficiency of U.S. manufacturing. Participation in a foreign government talent recruitment program could conflict with this objective by resulting in unauthorized transfer of scientific and technical information to foreign government entities. Therefore, no individual on a project team may participate in foreign government talent recruitment programs of foreign countries of risk. The purpose of this action is to ensure the continued flow of scientific and technical information consistent with DOE's broad scientific mission, while also ensuring protection of U.S. competitive, economic and national security interests and DOE program objectives; and limiting unauthorized transfers of scientific and technical information. Special terms and conditions and reporting obligations implementing this requirement will be incorporated into any award issued under this FOA.

Prior to award, the selectees must certify to DOE in their initial disclosures, based on due diligence, that all individuals on the project team, including the prime recipient, subrecipients, contractors, members, and any other party, are not participants in foreign government talent recruitment programs of countries of risk (currently includes: Russia, Iran, North Korea, and China).

During the award performance, recipients will be required to continue to exercise due diligence and regularly file reports with certifications to DOE on whether there is a reasonable basis to report that an individual on the project team is a participant in a foreign government talent recruitment program of a foreign country of risk. Further, the recipient must notify DOE within five (5)

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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. All individuals on the project team must submit a signed statement to DOE within the first quarter of the award or within thirty days of joining the project team, which (1) certifies the individual is not a participant in a in a foreign government talent recruitment program of a foreign country of risk, and (2) discloses, if any, the individual's ties to foreign universities, private entities and governments of foreign countries of risk.

In general, foreign government talent recruitment programs include any foreign-state-sponsored attempt to acquire U.S. scientific-funded research or technology through foreign government-run or funded recruitment programs that target scientists, engineers, academics, researchers, and entrepreneurs of all nationalities working or educated in the United States. These recruitment programs are often part of broader whole-of-government strategies to reduce costs associated with basic research while focusing investment on military development or dominance in emerging technology sectors.

Distinguishing features of a foreign government talent recruitment program covered by this paragraph include:

- a) Compensation provided by the foreign state to the targeted individual in exchange for the individual transferring their knowledge and expertise to the foreign country. The compensation can take several forms, such as cash, research funding, honorific titles, career advancement opportunities, promised future compensation, or other types of remuneration or consideration.
- b) Recruitment in this context refers to the foreign-state-sponsor's active engagement in attracting the targeted individual to join the foreign-sponsored program and transfer their knowledge and expertise to the foreign state. The targeted individual may be employed and located in the U.S., or in the foreign state. Recruitment would not necessarily include any invitation for engagement extended by the foreign state, for example, an invitation to attend or present work at an international conference.
- c) Many, but not all, programs aim to incentivize the targeted individual to physically relocate to the foreign state. Of particular concern are those programs that allow for continued employment at U.S. research facilities or receipt of DOE research funds while concurrently receiving compensation from the foreign state.

V. Application Review Information

A. Technical Review Criteria

i. Concept Papers

Concept Papers are evaluated based on consideration 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 sub-criteria:

- 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 (50%)

This criterion involves consideration of the following sub-criteria:

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.

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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.

Criterion 2: Project Research and Market Transformation Plan (30%)

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 and Information Security Risks

- The degree to which the applicant demonstrated a clear understanding of the key technical risk areas involved in the proposed work and the quality of the mitigation strategies to address them.
- The degree to which the project team has appropriate measures in place to control sensitive information and protect against unauthorized transfer of scientific and technical information.

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, U.S. manufacturing plan, and product distribution.

Criterion 3: Team and Resources (20%)

This criterion involves consideration of the following factors:

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- 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 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 and how well they are integrated into the Workplan; and
- The reasonableness of the budget and spend plan for the proposed project and objectives.

iii. Criteria for Replies to Reviewer Comments

EERE 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 April 14, 2017, 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;

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- 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; and
- 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 will occur in a Qualified Opportunity Zone or otherwise advance the goals of Qualified Opportunity Zones.⁵⁹ The goals include spurring economic development and job creation in distressed communities throughout the United States

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. 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 information about the applicant that is in the designated integrity and performance system accessible through SAM (currently FAPIIS) (see 41 U.S.C. 2313).

The applicant, at its option, may review information in the designated integrity and performance systems accessible through SAM and comment on any information about itself that a federal awarding agency previously entered and is currently in the designated integrity and performance system accessible through SAM.

⁵⁹ Opportunity zones were added to the Internal Revenue Code by section 13823 of the Tax Cuts and Jobs Act of 2017, codified at 26 U.S.C. 1400Z-1. The list of designated Qualified Opportunity Zones can be found in IRS Notices 2018-48 (PDF) and 2019-42 (PDF). Further, a visual map of the census tracts designated as Qualified Opportunity Zones may also be found at Opportunity Zones Resources. Also see, frequently asked questions about Qualified Opportunity Zones.

DOE will consider any written comments by the applicant, in addition to the other information in the designated integrity and performance system, 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 C.F.R. § 200.205.

iii. 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 Contracting 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.

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.

A notification encouraging the submission of a Full Application does not authorize the applicant to commence performance of the project. Please refer to Section IV.J.ii. of the FOA for guidance on pre-award costs.

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 Contracting 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 Exchange

Register and create an account on EERE Exchange at <https://eere-Exchange.energy.gov>.

This account will then allow the user to register for any open EERE FOAs that are currently in EERE 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 EERE 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. DUNS Number

Obtain a DUNS number (including the plus 4 extension, if applicable) at <http://fedgov.dnb.com/webform>.

3. 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. In accordance with OMB-M-20-17, SAM registration is not required to submit an application under this FOA. If selected, SAM registration will be required prior to award.

4. 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.

5. 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.

6. 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 Access Under DOE Order 142.3A, "Unclassified Foreign Visits and Assignments Program"

All applicants selected for an award under this FOA may be required to provide information to DOE in order to satisfy requirements for foreign nationals' access to DOE sites, information, technologies, equipment, programs or personnel. A foreign national is defined as any person who is not a U.S. citizen by birth or naturalization. If a selected applicant (including any of its subrecipients, contractors or vendors) anticipates involving foreign nationals in the performance of its award, the selected applicant may be required to provide DOE with specific information about each foreign national to ensure compliance with the requirements for access approval. National laboratory personnel already cleared for site access may be excluded. Access approval for foreign nationals from countries identified on the U.S. Department of State's list of [State Sponsors of Terrorism](#) must receive final approval authority from the Secretary of Energy or the Secretary's assignee before they commence any work under the award.

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 contractors 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*

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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.

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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. This helpful EERE checklist can be accessed at <https://www.energy.gov/eere/funding/eere-funding-application-and-management-forms>. See Attachment 2 Federal Assistance Reporting Checklist, after clicking on "Model Cooperative Agreement" under the Award Package section.

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. At the Go/No-Go decision points, EERE 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

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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) EERE's Go/No-Go decision; (7) the recipient's submission of a continuation application; and (8) written approval of the continuation application by the Contracting 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, EERE 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 Contracting 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 Contracting 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 Contracting Officer may direct.

xvi. Table of Personnel

If selected for award negotiations, the selected applicant must submit an updated table of personnel. The table should include the individuals' names, job titles, and their organization. The personnel that fall in one or more of the following categories must be included:

- Principal Investigator
- Business Agent
- Co-Principal Investigator
- Co-Investigator
- Postdoctoral associate
- Other professional
- Collaborator

Recipients will have an ongoing responsibility to notify DOE of changes to the personnel and submit an updated list during the life of the award when there are changes to the personnel working on the project.

xvii. Conflict of Interest Disclosure Statements

Upon selection of award negotiations, DOE may require the selectee provide signed conflict of interest disclosure statements for personnel proposed to participate in the award negotiations or the project itself.

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: AMOMultitopicFOA@ee.doe.gov. Questions must be submitted not later than three (3) business days prior to the application due

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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 three (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 Contracting 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 Contracting Officer, either express or implied, is invalid.

D. Treatment of Application Information

Applicants should not include trade secrets or commercial or financial information that is privileged or 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 trade secrets or information that is commercial or financial, or information that is confidential or privileged, it is furnished to the Government in confidence with the understanding that the information shall be

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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.

Concept Papers, Full Applications, Replies to Reviewer Comments, and other submissions containing confidential, proprietary, or privileged information must be marked as described below. Failure to comply with these marking requirements may result in the disclosure of the unmarked information under the Freedom of Information Act or otherwise. The U.S. Government is not liable for the disclosure or use of unmarked information, and may use or disclose such information for any purpose.

The cover sheet of the Concept Paper, Full Application, Reply to Reviewer Comments, or other submission must be marked as follows and identify the specific pages containing trade secrets, confidential, proprietary, or privileged information:

Notice of Restriction on Disclosure and Use of Data:

Pages [list applicable pages] of this document may contain trade secrets, confidential, proprietary, or privileged 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 or loan 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]

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

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 Concept Papers, Full Applications, Replies to Reviewer Comments, 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;

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- Domestic Large Businesses: 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, unless DOE agrees that the commitments proposed in the U.S. Manufacturing Plan are sufficient; and
- 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 that party requests and DOE grants a patent waiver for that party.
- DEC: Each applicant is required to submit a U.S. Manufacturing Plan as part of its application. If selected, the U.S. Manufacturing Plan shall be incorporated into the award terms and conditions for domestic small businesses and nonprofit organizations. DOE has determined that exceptional circumstances exist that warrants the modification of the standard patent rights clause for small businesses and non-profit awardees under Bayh-Dole to the extent necessary to implement and enforce the U.S. Manufacturing Plan. Any Bayh-Dole entity (domestic small business or nonprofit organization) affected by this DEC has the right to appeal it.

K. Government Rights in Subject Inventions

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

1. Government Use License

The U.S. 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.

2. March-In Rights

The U.S. 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.

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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 U.S. 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 U.S. 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 awards 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 U.S. government regulates the transfer of information, commodities, technology, and software considered to be strategically important to the U.S. 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”. To ensure compliance with Export Controls, it is the prime recipient’s responsibility to determine when its project activities trigger Export Controls and to ensure compliance.

Export Controls may apply to individual projects, depending on the nature of the tasks. When Export Controls apply, the recipient must take the appropriate steps to obtain any required governmental licenses, monitor and control access to restricted information, and safeguard all controlled materials. Under no circumstances may foreign entities (organizations, companies or persons) receive access to export controlled information unless proper export procedures have been satisfied and such access is authorized pursuant to law or regulation.

Applicants are advised that some of the results of the research conducted under this FOA are expected to be restricted for proprietary reasons and not published or shared broadly within the scientific community.

O. 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-07-16 dated May 22, 2007, found at:

<https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/memoranda/2007/m07-16.pdf>

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

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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).

P. 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 C.F.R. § 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 C.F.R. § 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:

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

- FAR Part 31 for For-Profit entities, (48 CFR Part 31); and
- 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.

DOE Financial Assistance Rules 2 CFR Part 200 as amended by 2 CFR Part 910

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

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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 Contracting 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 Contracting 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 Contracting 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

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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)

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APPENDIX C – WAIVER REQUESTS AND APPROVAL PROCESSES: 1. FOREIGN ENTITY PARTICIPATION; AND 2. PERFORMANCE OF WORK IN THE UNITED STATES (FOREIGN WORK WAIVER)

1. Waiver for Foreign Entity Participation

As set forth in Section III.A., all prime recipients and subrecipients receiving funding under this FOA must be incorporated (or otherwise formed) under the laws of a state or territory of the United States with majority domestic ownership or 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

EERE invests in research and development as part of the DOE's broad portfolio approach to addressing our Nation's energy and environmental challenges. In part, this FOA is intended to support AMO's overall objectives to improve the productivity and energy efficiency of U.S. manufacturing; transition DOE supported innovative technologies and practices into U.S. manufacturing capabilities; and strengthen and advance the U.S. manufacturing workforce. To ensure those objectives are not frustrated by foreign involvement, foreign entities seeking to participate in a project funded under this FOA must demonstrate to the satisfaction EERE that:

- Its participation is in the best interest of the U.S. industry and U.S. economic development;
- The project team has appropriate measures in place to control sensitive information and protect against unauthorized transfer of scientific and technical information;
- Adequate protocols exist between the U.S. subsidiary and its foreign parent organization to comply with export control laws and any obligations to protect proprietary information from the foreign parent organization;
- The work is conducted within the U.S. and the entity acknowledges and demonstrates that it has the intent and ability to comply with the U.S. Manufacturing Plan; and
- The foreign entity will satisfy other conditions that may be deemed necessary by EERE to protect U.S. interests.

Content for Waiver Request

A Foreign Entity Participation waiver request must include the following:

- a. Information about the entity: name, point of contact, and proposed type of involvement with the Institute, and DUNS number for the proposed foreign participant and any foreign parent organization;
- 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 ownership/control by foreign entities, foreign shareholders, foreign state or foreign individuals;
- c. The rationale for proposing a foreign entity participate (must address the waiver criteria stated above);
- d. A description of the project's anticipated contributions to the U.S. economy:
 - i. How the foreign entity's participation will benefit U.S. research, development and manufacturing, including contributions to employment in the U.S. and growth in new markets and jobs in the U.S.;
 - ii. How the foreign entity's participation will promote domestic manufacturing of products and/or services;
- e. A description of why 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 U.S., the applicant must also complete a separate request for a foreign work waiver).

EERE 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, 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.

EERE may require additional information before considering the waiver request.

The applicant does not have the right to appeal EERE's decision concerning a waiver request.

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

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As set forth in Section IV.J.iii., all work under EERE funding agreements must be performed in the United States. This requirement does not apply to the purchase of supplies and equipment, so a waiver is not required for foreign purchases of these items. However, the prime recipient should make every effort to purchase supplies and equipment within the United States. There may be limited circumstances where it is in the interest of the project to perform a portion of the work outside 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 EERE 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 to waive the *Performance of Work in the United States* requirement must include the following:

- The rationale for performing the work outside the U.S. (“foreign work”);
- A description of the work proposed to be performed outside the U.S.;
- An explanation as to how the foreign work is essential to the project;
- A description of the anticipated benefits to be realized by the proposed foreign work and the anticipated contributions to the US economy;
- The associated benefits to be realized and the contribution to the project from the foreign work;
- How the foreign work will benefit U.S. research, development and manufacturing, including contributions to employment in the U.S. and growth in new markets and jobs in the U.S.;
- How the foreign work will promote domestic American manufacturing of products and/or services;
- A description of the likelihood of Intellectual Property (IP) being created from the foreign work and the treatment of any such IP;
- The total estimated cost (DOE and recipient cost share) of the proposed foreign work;
- The measures in place to control sensitive information and protect against unauthorized transfer of scientific and technical information;The countries in which the foreign work is proposed to be performed; and
- The name of the entity that would perform the foreign work.

EERE may require additional information before considering the waiver request.

The applicant does not have the right to appeal EERE’s decision concerning a waiver request.

APPENDIX D – 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 E – 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

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APPENDIX F – LIST OF ACRONYMS

Insert other acronyms applicable to this FOA (e.g., technology office name, technical terms or metrics)

AI	Artificial Intelligence
AM	Additive Manufacturing
AMO	Advanced Manufacturing Office
BTU	British Thermal Unit
CAGR	Compound Annual Growth
CHP	Combined Heat and Power
CMC	Ceramic Matrix Composite
CO ₂ e	Carbon Dioxide Equivalent
COI	Conflict of Interest
DAC	Direct Air Capture
DCS	Dynamic Catalyst Science
DE	Distric Energy
DEC	Determination of Exceptional Circumstances
DMP	Data Management Plan
DOE	Department of Energy
DOI	Digital Object Identifier
EAF	Electric Arc Furnace
EERE	Energy Efficiency and Renewable Energy
FAR	Federal Acquisition Regulation
FFATA	Federal Funding and Transparency Act of 2006
FOA	Funding Opportunity Announcement
FOIA	Freedom of Information Act
FFRDC	Federally Funded Research and Development Center
GAAP	Generally Accepted Accounting Principles
HPC	High Performance Computing
IPMP	Intellectual Property Management Plan
kg	Kilogram
kWh	Kilowatt hour
LCOE	Levelized Cost of Energy
ML	Machine Learning
M&O	Management and Operating
MPIN	Marketing Partner ID Number
MW	Megawatt
MWh	Megawatt Hour
MYPP	Multi-Year Program Plan
NDA	Non-Disclosure Acknowledgement
NEPA	National Environmental Policy Act
NNSA	National Nuclear Security Agency
NO _x	Nitrogen Oxides
OMB	Office of Management and Budget
OSTI	Office of Scientific and Technical Information

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PII	Personal Identifiable Information
R&D	Research and Development
RAPID	Rapid Advancement of Process Intensification Development
RFI	Request for Information
RFP	Request for Proposal
SAM	System for Award Management
SC	Office of Science
SOPO	Statement of Project Objectives
SOTA	State of the Art
SPOC	Single Point of Contact
TIA	Technology Investment Agreement
TRL	Technology Readiness Level
UCC	Uniform Commercial Code
VOC	Volatile Organic Compounds
WBS	Work Breakdown Structure
WP	Work Proposal