

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

FY19 Advanced Manufacturing Office Multi-Topic FOA

Funding Opportunity Announcement (FOA) Number: DE-FOA-0001980

FOA Type: Initial

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FOA Issue Date:	5/7/2019
Submission Deadline for Concept Papers:	6/20/2019; 5:00pm ET
Submission Deadline for Full Applications:	8/29/2019; 5:00pm ET
Expected Submission Deadline for Replies to Reviewer Comments:	10/16/2019; 5:00pm ET
Expected Date for EERE Selection Notifications:	January 2020
Expected Timeframe for Award Negotiations:	March 2020

- 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 cancellation of further award negotiations and rescission of the Selection.

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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 U.S. manufacturing sector uses 25% of the nation's energy and has an annual energy bill of more than \$130 billion.¹ In addition, advancements in manufacturing impact the energy efficiency of products used throughout the economy. To drive manufacturing innovation and spur job creation, AMO supports the development of technologies that significantly 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.

In 2016, the U.S. manufacturing sector accounted for 11.6% of gross domestic product (GDP),² directly employed 12.3 million people,³ and sold products valued at \$5.4 trillion.⁴ 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 (10¹⁵) British thermal units (Btus)).⁵

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 \$1.81 in other services and

¹ 2014 MECS Table 7.9. EIA. Available online at:

https://www.eia.gov/consumption/manufacturing/data/2014/pdf/table7_9.pdf.

² "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>.

³ "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 online at: <https://apps.bea.gov/iTable/iTable.cfm?reqid=19&step=2>.

⁴ "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 online at: <http://www.census.gov/newsroom/press-releases/2015/cb15-tps108.html>.

⁵ See Manufacturing Energy and Carbon Footprint available at:

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

production^{6,7} – 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.⁸ Advanced manufacturing technologies could have an even greater multiplier effect on employment than traditional manufacturing practices.⁹ As such, manufacturing is an opportunity to leverage economic growth across the U.S. economy.

ii. Technology Space and Strategic Goals

AMO supports innovative advanced manufacturing applied 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 strategic goals, targets, and metrics for key technology focus areas, are described in the Draft AMO Multi-Year Program Plan (MYPP).¹⁰ AMO 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.

⁶ "Manufacturing's Multiplier Effect is Stronger than Other Sectors'." Manufacturing Institute. Updated April 2014. Available online at: <http://www.themanufacturinginstitute.org/Research/Facts-About-Manufacturing/Economy-and-Jobs/Multiplier/Multiplier.aspx>.

⁷ 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 online at: <http://www.industryweek.com/global-economy/competitive-edge-manufacturings-multiplier-effect-its-bigger-you-think>.

⁸ Thomas Kurfess. "Why Manufacturing Matters." The American Society of Mechanical Engineers (ASME). November 2013. Available online at: <https://www.asme.org/engineering-topics/articles/manufacturing-processing/why-manufacturing-matters>.

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

¹⁰ AMO Multi-year Program Plan - <https://www.energy.gov/eere/amo/downloads/advanced-manufacturing-office-amo-multi-year-program-plan-fiscal-years-2017>

- Transition DOE supported innovative technologies and practices into U.S. manufacturing capabilities.
- Strengthen and advance the U.S. manufacturing workforce.

Multi-Topic FOA:

In fiscal year 2019, AMO is issuing a multi-topic FOA that integrates identified research opportunities across AMO into a single funding opportunity. With this FOA, the AMO intends to fund high-impact, early to mid-stage research in the following topic areas (More detailed descriptions of each topic area can be found in Section I.B. below):

Topic 1: Innovations for the Manufacture of Advanced Materials

- **Subtopic 1.1:** Accelerate the Manufacturing Process Design and Development Cycle for Advanced Energy Conversion and Storage Materials
- **Subtopic 1.2:** Innovative Manufacturing Processes for Battery Energy Storage
- **Subtopic 1.3:** Materials and Manufacturing Process Development of Nanocrystalline Metal Alloys
- **Subtopic 1.4:** Process-Informed Science, Design, and Engineering of Materials and Devices Operating in Harsh Service Conditions

Topic 2: Lower Thermal Budget (LTB) Processes for Industrial Efficiency & Productivity

- **Subtopic 2.1:** Advances in Industrial and Process Drying
- **Subtopic 2.2:** Thermal Process Intensification

Topic 3: Connected, Flexible and Efficient Manufacturing Facilities and Energy Systems

- **Subtopic 3.1:** Medium-Voltage Power Conditioning Systems to Enable Grid-Dispatchable and Resilient Manufacturing Facilities
- **Subtopic 3.2:** High Power to Heat Ratio, High Efficiency Combined Heat and Power (CHP)
- **Subtopic 3.3:** Verification and Validation of CHP and District Energy

Funding Levels:

The applicants' technologies may be at different levels of maturity; proposed funding levels and project durations should be commensurate with the workscope necessary to advance the technology to the proposed readiness level. Awards will be made at one of two funding levels:

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- **Tier 1 - up to \$500,000 for up to 2 years** - concept definition and proof of concept projects are limited to Technology Readiness Level (TRL) 2 and TRL 3 activities.
- **Tier 2 - up to \$4,000,000 for up to 3 years (up to \$12,000,000 for Subtopic 1.2 and up to \$10,000,000 for Subtopic 2.2)** – Tier 2 projects can include activities in Tier 1, but must also include scope to bring the technology to later stage TRLs.

Funding requests must be justified, and should be commensurate with the scope of the work being proposed. More detail about estimated funding levels can be found in Section II.A.i.

Applications must clearly identify the starting and ending TRL for the project and justify the TRLs assigned. See Appendix E for EERE’s definitions of TRLs.

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

B. Topic Areas

Topic 1: Innovations for the Manufacture of Advanced Materials

The development and manufacture of new materials and devices with desirable properties can improve many energy and industrial applications, as well as downstream products. AMO activity in this area focuses on innovating and accelerating the development of specific, promising next generation materials and associated processes. These include materials with improved energy storage or conversion properties, and materials for use under harsh service conditions. Research to improve material processing represents a major opportunity space with wide-ranging energy efficiency and economic benefits.

Subtopic 1.1: Accelerate the Manufacturing Process Design and Development Cycle for Advanced Energy Conversion and Storage Materials

Subtopic 1.1 Background: Advances in processing science and engineering are required to accelerate the design and development of advanced energy materials manufacturing processes, including for energy storage and conversion technologies with applications in the energy, industrial, and transportation sectors. Achieving

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volume, cost, and performance targets requires breakthroughs in the manufacture of advanced energy materials.

Subtopic 1.1 Opportunity: While new data analysis methods using artificial intelligence and machine learning (AI/ML) have been applied to screen extensive material property data sets rapidly for desirable material functions,¹¹ the use of AI and ML for the design of materials manufacturing processes has been limited. AI and ML techniques offer the promise of reducing development times for new energy material manufacturing from discovery to marketable product to 4-5 years, down from the current 15-20 years, with a corresponding reduction in development costs.

Subtopic 1.1 Technology Focus: This subtopic requests applications for AI and ML approaches to advancing the manufacture of new energy materials leading to improved performance and lower manufacturing costs. The AI and ML approaches that will lead to the next generation of commercially viable energy materials manufacturing will require new models of materials and processes based on experimental and computational data, and the use of models to predict material compositions of optimal material functionality correlated to manufacturing process conditions. Responsive applications must develop an experimental methodology that includes the three critical areas listed below:

- **High Throughput Experimental Methods (HTEM):** HTEM refers to the specific materials synthesis and characterization/measurement tools that will be used to collect data on the materials manufacturing process including material composition, structure, and functional properties under process relevant conditions. HTEM can generate data at significantly faster rates than traditional methods, and numerous collection points are expected to generate data sets that are more dense than in conventional process development. Applicants are encouraged to provide details of experimental throughput capabilities of the tools to be used, to justify their classification as high throughput. Any additional experimental equipment needed should also be included.
- **Data collection, reporting, sharing, and archiving:** Responsive applications will follow guidelines for best practices in HTEM data management¹² and will

¹¹ Examples include new, more efficient permanent magnets; metals and alloys designed for additive manufacturing; new electrocatalysts for energy uses; and very low thermal hysteresis nickel-titanium (NiTi) based shape memory alloys; see page 8 of AMO Summary Report “Workshop on Artificial Intelligence Applied to Materials Discovery and Design,” available here: <https://www.energy.gov/sites/prod/files/2018/03/f49/AI%20Applied%20to%20Materials%20Discovery%20and%20Design%20Workshop%20Summary%20Report.pdf>

¹² Best practices guidelines have been developed to ensure findable, accessible, interoperable, and reusable (FAIR) data reporting and archiving that make it transparent for anyone to analyze and reproduce experimental results. Incorporating data management practices and adopting data management solutions early in the research data lifecycle is encouraged. An emphasis should be placed on adopting or extending existing solutions that are open and have broadly-applicable utility. Examples of solutions include:

include a data management plan (DMP) (refer to Section IV.D.xiv.). Applicants are also encouraged to collaborate with relevant standards/research organizations¹³ to develop, refine, and adopt relevant standards for data formatting, data interchange protocols, and related software and tools.

- **Algorithm development and application:** Algorithms to be applied to model development, based on the experimental data to be collected, will be carefully described in the application. This is especially important if these techniques are new approaches outside of well-known approaches.

Other activities for applicants to consider include: 1) publishing data and software in appropriate repositories in coordination with relevant standards organizations, consortia and working groups;¹⁴ and 2) registering published data, software, and other relevant resources in an appropriate resource registry in coordination with relevant standards organizations, consortia, and working groups.¹⁵

Applications submitted under Subtopic 1.1 must address the area of interest below.

Subtopic 1.1 Area of Interest – Manufacture of Materials for Energy Conversion and Storage: Materials for energy conversion tend to have low efficiencies and mechanical or chemical properties that restrict how and where they can be used. Furthermore, most materials in this class remain too expensive to be economically viable as energy sources/converters. This area of interest solicits applications for AI and ML approaches to the design and development of new materials manufacturing processes to produce energy conversion materials, systems and devices. Energy

-
- Cordra, <https://www.cordra.org/>
 - Materials Data Curation System, <https://github.com/usnistgov/mdcs-stratton>
 - 4CeeD, <https://4ceed.github.io/>
 - CKAN, <https://ckan.org/>
 - PRISMS, <http://www.prisms-center.org/#/home>

Examples are not intended to be endorsements of any one system over another. Applicants are welcome to include other resources not on the above list in their DMP.

¹³ For example, National Institute of Standards and Technology (NIST), and Center for Hierarchical Materials Design (CHiMaD).

¹⁴ Examples of repositories include:

- NIST High-Throughput Experimental Materials Registry and Repository, <https://hte.registry.nist.gov/>
- Materials Data Facility (MDF), <https://materialsdatafacility.org/>
- Materials Project, <https://materialsproject.org/>
- NIST Materials Data Repository, <https://materialsdata.nist.gov/>

Examples listed above are not intended to be endorsements of any one system over another. Applicants are welcome to include other resources not on the above list in their DMP if the applicant chooses to publish data and software in a repository.

¹⁵ Examples of registries include:

- NIST High-Throughput Experimental Materials Registry and Repository, <https://hte.registry.nist.gov/>.
- NIST Materials Resource Registry, <https://materials.registry.nist.gov/>.

Examples listed above are not intended to be endorsements of any one system over another. Applicants are welcome to include other resources not on the above list in their DMP if the applicant chooses to register published data, software, and other relevant resources.

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conversion can include heat to electricity and chemical energy to electricity, and examples include the design and development of direct thermal energy conversion (DTEC) materials, systems and devices¹⁶ such as thermoelectrics and piezoelectrics; new or improved formulations for redox flow batteries; electrocatalysts used in high and low temperature fuel cell applications; and other innovative energy conversion materials, systems, and devices. Also included are wide bandgap semiconductor materials to be used in electronic and optoelectronic devices and applications. Photovoltaic materials, either thin film or semiconductor based, are specifically not of interest. Other materials used in energy conversion applications will be considered on a case-by-case basis.

Energy storage may or may not involve the conversion of one form of energy to another – batteries, for example, convert chemical energy to electrical energy and vice versa; phase change thermal storage materials may store heat in sensible and latent forms. The efficiency of the reversibility of the energy storage process is paramount for these materials along with cost effectiveness and durability. This area of interest seeks applications for AI and ML approaches to the design and development of new materials manufacturing processes to produce energy storage materials, systems, and devices. Examples of components of energy storage systems considered under this area of interest include cells for advanced Li-ion batteries, and powders and densified layers for solid state electrochemical energy storage. Other components used in energy storage applications will be considered on a case-by-case basis, such as: phase change thermal energy storage materials with high thermal latency and thermal storage reversibility; high voltage supercapacitor materials; high temperature superconducting materials for superconducting magnetic electricity storage; and novel hybrid materials that combine energy conversion and energy storage functions (e.g. thermoelectric materials engineered to store and convert thermal energy to electrical energy).

Not of interest in Subtopic 1.1: DOE is not interested in funding applications focused on photovoltaic materials, either thin film or semi-conductor based. See Section I.C. and III.D. of the FOA.

Subtopic 1.1 Candidate Metrics and Targets: Targets for material properties to be developed within this subtopic must be specified in the application and include an analysis of the energy efficiency improvements possible with the new materials in their proposed end uses. 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 performance and cost-appropriate benchmarks or baselines,

¹⁶ See the Technology Assessment “Direct Thermal Energy Conversion Materials, Devices, and Systems” available here: <https://www.energy.gov/sites/prod/files/2015/12/f27/QTR2015-6G-Direct-Thermal-Energy-Conversion-Materials-Devices-and-Systems.pdf>

minimum targets, and stretch targets. Example metrics include:

Subtopic 1.1 Objective/ Goal	Example Metric	Example Minimum	Example Stretch Target	Baseline Performance/ Cost
Subtopic 1.1 Area of Interest				
Energy Conversion Materials				
Increased Conversion Efficiency	% energy converted	20%	50%	<i>Applicant Defined</i>
Reduce cost of production	\$/component	-10%	-50%	<i>Applicant Defined</i>
Energy Storage Materials				
Increased energy density of storage component	J/kg or W/kg depending on application	10%	50%	<i>Applicant Defined</i>
Increased lifetime of storage component	# of charge-discharge cycles	30%	100%	<i>Applicant Defined</i>

At appropriate intervals during the project, applicants must provide the experimental methodology and samples of the material or materials they discover, design, and develop as a result of this research effort. A portion of the proposed budget should be designated for independent testing and evaluation of the material developed and will be conducted by independent laboratories selected by mutual agreement between the research partners and the technology manager for the project.

Subtopic 1.2: Innovative Manufacturing Processes for Battery Energy Storage

Note: It is expected that applications to this subtopic will be Tier 2 for a total of up to \$12,000,000 over 3 years. More detail about estimated funding levels can be found in Section II.A.i.

Subtopic 1.2 Background: Significant advances in battery energy storage technologies have occurred in the last five years, leading to energy density increases commensurate with battery pack cost decreases of approximately 85% reaching \$176/kWh in 2018¹⁷. However, more pervasive uptake will require improved performance characteristics that will allow existing/emerging energy storage technologies to compete with incumbent technologies. For example, transportation

¹⁷ “A Behind the Scenes Take on Lithium-ion Battery Prices.” BloombergNEF. March 9, 2019. Available online at: <https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/>

applications will require additional advances including cost reductions to \$80/kWh of usable energy at the pack level, fast charging capabilities (<15 minutes), and energy densities that will allow a range of >300 miles between recharge for battery electric vehicles with size, weight, cycle, lifespan, durability, safety and other vehicle-specific requirements.¹⁸ Similarly, targets and requirements will need to be met to enable the widespread adoption of energy storage technologies for other applications, but those requirements (e.g. grid storage) can be significantly different. Manufacturing advances for energy storage are needed to enable application-specific cost and performance requirements to be met.

Subtopic 1.2 Opportunity: High volume, consistent, controllable, and robust manufacturing technologies are needed to manufacture the next generation of energy storage technologies at cost targets that allow for uptake across a range of applications. There is an opportunity to improve the processing of materials for energy storage applications, which can also lead to technological advances in the manufacture of components that are under development for other products such as membranes used for separations. High volume, high precision, rapid, and repeatable manufacturing processes are required to advance energy storage and conversion technologies toward widespread commercialization.

Roll-to-roll (R2R) processing is one example of a high-throughput technique for continuous two-dimensional deposition of materials on a roll of flexible plastic, glass, ceramic, composite, or metal foil.¹⁹ R2R can enable low-cost production and improved performance of complex-functional, large surface area devices that are supplied in the form of a continuous roll and needed for many clean energy applications. A R2R processing platform may be the most viable way to make a sheet or roll at high volume and at an acceptable cost. R2R manufacturing processes can be improved in the areas of increased precision, in-line quality control, and defect detection.²⁰ In addition, new methodologies can be developed to replace multi-layer coatings with a single layer (or single process) construction with the same performance, thus reducing the number of process steps and the manufacturing cost.

Beyond R2R, improved or new manufacturing approaches are needed for a wide range of energy storage technologies whether as a drop-in process replacement, or as an enabling technology for new products.

¹⁸ For additional information and resources regarding vehicle electric charging, see:

<https://www.energy.gov/eere/vehicles/batteries-charging-and-electric-vehicles>

¹⁹ See Technology Assessment on roll-to-roll processing here:

<https://www.energy.gov/sites/prod/files/2016/02/f30/QTR2015-6K-Roll-to-Roll-Processing.pdf>

²⁰ See final report from EERE Quality Control Workshop: <https://www.nrel.gov/docs/fy14osti/61889.pdf>

Subtopic 1.2 Technology Focus: This subtopic seeks new and/or improved manufacturing processes for energy storage applications. Key application areas are battery energy storage for transportation and grid energy storage, but there is opportunity for other product development as well – including latent heat thermal energy storage, and integrated energy conversion and energy storage (e.g. thermoelectric energy conversion integrated with storage). Examples of processes that are of interest include multi-layer lamination, anisotropic particle deposition, decal transfer and bonding, microwave-assisted drying/curing, novel composite deposition technologies such as electrospinning, electrophoretic deposition, cold plasma spraying, photochemical rapid curing, and atomic and molecular layer deposition.

Considering the complexity of opportunity and the need for disparate skills and backgrounds, assembling an effective and synergistic team will be a critical component. Experts and facilities exist across the corporate/national lab/academic complex, and successful projects will require strong collaborations.

Applications submitted under Subtopic 1.2 must address at least one of the areas of interest stated below.

Subtopic 1.2 Area of Interest 1 – Battery energy storage: This area of interest seeks applications to improve or develop new and improved manufacturing processes for battery energy storage materials and integration with scale-up and device development. The goal is to scale-up and validate new lower cost manufacturing processes to catalyze increased levels of domestic battery manufacturing. The project should also improve battery energy storage performance and lifetime performance (i.e., cycles to reach a 20% reduction in initial state-of-charge (SOC)) compared to state-of-the-art battery technologies. These efforts align with DOE/EERE priorities, such as those identified in the DOE Advanced Energy Storage Initiative to ensure grid reliability and resiliency.²¹

Subtopic 1.2 Area of Interest 2 – Novel energy storage concepts: This area of interest seeks to support new manufacturing concepts that will lead to new energy storage products. (e.g. latent heat plus storage, thermoelectric plus storage, etc.).

Subtopic 1.2 Candidate Metrics & Targets: Targets for processes (e.g. production scale and rate) and materials performance to be developed within this subtopic must be specified in the application. Metrics will involve energy savings in the processes and the manufactured products as well, and cost savings in the processes

²¹ See pages 1 and 20 of the DOE FY2020 Congressional Budget Request, Budget in Brief, available here: https://www.energy.gov/sites/prod/files/2019/03/f60/doe-fy2020-budget-in-brief_0.pdf

and in the products. 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. Example metrics include:

Subtopic 1.2 Objective/Goal	Example Metric	Example Minimum	Example Stretch Target	Baseline Performance /Cost
Increase throughput of R2R process for energy storage materials ²²	m ² /min	5x over 2015 baseline	10x over 2015 baseline	<i>Applicant Defined</i>
Decrease manufactured cost of energy storage materials	\$/KWh	50% over 2015 baseline	75% over 2015 baseline	<i>Applicant Defined</i>
Increase energy density of storage component	J/kg or W/kg depending on application	10%	50%	<i>Applicant Defined</i>
Increase lifetime	# of charge-discharge cycles to 80% SOC	30%	100%	<i>Applicant Defined</i>

At the end of the project, applicants must provide the experimental methodology and samples of the materials and/or devices they developed as a result of this research effort. A portion of the proposed budget should be designated for independent testing and evaluation of the materials and/or devices developed and will be conducted by independent laboratories selected by mutual agreement between the research partners and the technology manager for the project.

Subtopic 1.3: Materials and manufacturing process development of nanocrystalline metal alloys

Subtopic 1.3 Background: Nanocrystalline metals have the potential to provide improved performance over conventional metals due to unique combinations of properties that result from their nanocrystalline grain structure.²³

Subtopic 1.3 Opportunity: Compared to conventional alloys—whose properties are derived through combinations of alloying, thermomechanical processing, and heat treatment—nanocrystalline metals usually derive their properties through an

²² Roll-to-Roll Processing in Advanced Manufacturing Office Multi-Year Program Plan (AMO MYPP), 2017 through 2021, DRAFT: https://www.energy.gov/sites/prod/files/2017/01/f34/Draft%20Advanced%20Manufacturing%20Office%20MYPP_1.pdf

²³ R Z Valiev et al., "Superstrength of nanostructured R Z alloys produced by SPD processing," 2011 J. Phys.: Conf. Ser. 291 012029

additional processing step of severe plastic deformation (for example, using Equal Channel Angular Processing or High Pressure Torsion). This is often cost-prohibitive and makes the nanocrystalline metals uncompetitive because of the capital cost of the extra processing equipment, low throughput rates, and the extra operating costs which can include significant tool wear.

Although strength can be enhanced by a factor of 2 to 4, or greater, there can be a penalty in the + of these materials, which limits their range of applications.

Subtopic 1.3 Technology Focus: This subtopic seeks concept definition and proof of concept applications for tackling key technical hurdles in approaches for the production of nanocrystalline materials that can realistically compete against conventional metals. Applicants should demonstrate that their proposed approach would result in: significant performance-to-cost advantages over conventional materials processing approaches that result in high throughput, leveraging economies of scale; and processing methods that avoid the high capital costs and high operating costs typically associated with nanocrystalline metals.

Subtopic 1.3 Candidate Metrics and Targets: Applications must include comparative benchmarks against realistic competitive materials. For example, high strength claims of "stronger than steel" must be compared against realistic steel products (i.e. steels that are specifically produced for high strength and low cost) for the example application. 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 and baseline comparison of conventional materials, minimum targets, and stretch targets. Example metrics include:

Subtopic 1.3 Objective/Goal	Example Metric	Example Minimum	Example Stretch Target	Baseline Performance /Cost
Increase strength/weight ratio over benchmark materials	MPa/(g/cm ³)	200 MPa/(g/cm ³)	300 MPa/(g/cm ³)	<i>Applicant Defined</i>
Decrease added cost of weight saved	\$/kg weight saved	\$7/kg weight saved	\$4/kg weight saved	<i>Applicant Defined</i>

At the end of the project, applicants must provide the experimental methodology and samples of the materials they developed as a result of this research effort. A portion of the proposed budget should be designated for independent testing and evaluation of the materials developed and will be conducted by independent

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laboratories selected by mutual agreement between the research partners and the DOE technology manager for the project.

Subtopic 1.4: Process-informed Science, Design, and Engineering of Materials and Devices Operating in Harsh Service Conditions

Subtopic 1.4 Background: Harsh service environments (and the associated materials durability challenges) are common across multiple industrial applications and sectors. High performance materials are subjected to high temperatures and/or mechanical loads often in combination with aggressive chemical environments. These environments can involve high temperatures or massive temperature fluctuations, high pressures, corrosive chemicals, wear and tear, or rapid aging from hydrogen or radiation and are shared across many applications.

Subtopic 1.4 Opportunity: Engineers have long been limited in their ability to innovate by the physical limitations of materials they use. Some manufacturing processes involve extremely harsh conditions, and many other industries use products in harsh conditions. New materials and new materials processing solutions are needed to meet stringent application demands for future products that will provide energy savings, emissions reductions, and other benefits.²⁴

Subtopic 1.4 Technology Focus: This subtopic seeks approaches for new materials and new materials processing solutions to meet the extreme demands for future products to provide energy savings and other benefits. The overarching objective is to advance technologies that increase the durability and reduce the cost of materials and components operating in harsh and extreme environments. Materials that can perform better under harsh service conditions can have improved resistance to corrosion, oxidation, severe mechanical loading, and other factors that can lead to improved energy efficiency and life cycle energy benefits. The approach is to enable improved and new manufacturing approaches for the production of these materials, by incorporating state-of-the-art as well as new and emerging techniques for integrated computational materials engineering (ICME). New approaches are encouraged, such as artificial intelligence (AI) and machine learning (ML) that can leverage the improved fundamental understanding of extreme and complex conditions to improve design of materials manufacturing processes.

Applications submitted under Subtopic 1.4 must address the area of interest stated below.

²⁴ See the “Materials for Harsh Service Conditions” Technology Assessment, available here: <https://www.energy.gov/sites/prod/files/2016/02/f29/QTR2015-6H-Materials-for-Harsh-Service-Conditions.pdf>

Subtopic 1.4 Area of Interest 1 –Manufacturing of New Materials: This area of interest seeks to improve the design and manufacturing process development of materials used in harsh or extreme conditions. The goal is to develop advanced cost-effective manufacturing pathways including production of materials and assembly of parts which requires integration of new and emerging materials in structures and devices with consideration of the supply chain. Specific R&D needs include, but are not limited to, net-shape processing, coatings, functionally graded materials, lower cost-tooling, and high-rate, larger-scale manufacturing approaches, and life cycle cost neutral new materials or material substitutions for harsh service conditions. Also needed are predictive capabilities and models applicable to simple and complex systems that apply data from laboratory experiments to validate models, aid in accelerated testing, address limiting criteria for material failure, capture long-term mechanical behavior, and conform readily to industry standards. New materials must meet harsh service conditions and end user requirements without an unsupported cost penalty. Applications responding to this area of interest should specify the proposed end use of the materials, the characteristics of commercially available materials and the targets for proposed material property improvements. Performance metrics that quantify the expected improvement in performance of materials designed for harsh service conditions include the increase in possible temperature, pressure, stress, or corrosion resistance of materials in their service applications. Applications should also address the energy savings possible with new materials in their proposed end uses as well as possible cost savings in both end uses and materials development.

Subtopic 1.4 Candidate Metrics & Targets: Targets for material properties to be developed within this subtopic must be specified in the application, as well as an analysis of the energy efficiency improvements possible with new materials or technologies in their proposed end uses. 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 baseline, minimum targets, and stretch targets, and the gain in energy productivity when the new material is put into an application. Example metrics include:

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Subtopic 1.4 Objective/ Goal	Example Metric	Example Minimum	Example Stretch Target	Baseline Performance/ Cost	Energy Efficiency Improvement
Decreased cost per service operating hour	\$/OpHr	-15%	-25%	<i>Applicant Defined</i>	<i>Applicant Defined</i>
Increased durability of material in targeted industrial application	Hours of operation	10%	30%	<i>Applicant Defined</i>	<i>Applicant Defined</i>

Topic 2: Lower Thermal Budget (LTB) Processes for Industrial Efficiency & Productivity

Process heating operations supply thermal energy needed to transform materials into a wide variety of commodities and end-use consumer products. Approximately 7.5 quads of manufacturing energy use annually are related to process heating (70% of all process energy use), with approximately 36% of that energy lost as waste heat, accounting for over 2,500 trillion Btus annually.²⁵ Advances in technologies currently used for process heating, as well as entirely new methods of processing materials to lower or obviate the thermal demand, can lower manufacturing energy and emissions and associated costs, and also enable the manufacture of improved materials, technologies, and products.

Subtopic 2.1: Advances in Industrial and Process Drying

Subtopic 2.1 Background: Most industrial subsectors involve thermal dehydration during one or several phases of their manufacturing processes, mainly using fossil fuels at thermal efficiencies in the range of 20-60%.²⁶ Drying is often the most energy intensive process in industry, relying on numerous dryer types for many process and end product forms with different drying requirements. In addition, dryer inlet moistures are often driven by product quality requirements and drying load requirements vary widely.

²⁵ See “All Manufacturing” footprint on this webpage: “Manufacturing Energy and Carbon Footprints (2014 MECS),” available at: <https://www.energy.gov/eere/amo/manufacturing-energy-and-carbon-footprints-2014-mecs>.

²⁶ Mujumdar A.S. and Wu Z.H. “Thermal Drying Technologies New Developments and Future R&D Potential; HEFAT2007 5th International Conference on Heat Transfer, Fluid Mechanics and Thermodynamics

Subtopic 2.1 Opportunity: As a component of process heating, drying represents a significant area of energy utilization. Water and organic compound removal, typically operating in the temperature range of 200 – 700°F, consumed an estimated 1,178 trillion Btu of energy (2010)²⁷. Crosscutting technologies are sought in this subtopic area to increase thermal efficiencies or reduce the amount of process energy required for drying.

Subtopic 2.1 Technology Focus: This subtopic seeks applications for research on industrial and process drying technologies that increase energy efficiency and throughput, while improving product quality. Applications submitted under Subtopic 2.1 must address at least one of the areas of interest stated below.

Subtopic 2.1 Area of Interest 1 – Novel Drying Systems in Manufacturing: This area of interest seeks novel drying systems that utilize a combination of pretreatments, mechanical dewatering, process heating technologies and/or other approaches to optimize energy performance and increase overall thermal efficiency. Cost reduction of new or retrofit drying systems and selective targeting of different stages of drying is needed. These systems should improve drying processes by increasing the speed, efficiency, and product quality, as compared to benchmarked approaches which can be rate-limited. This area of interest would also consider validation of promising laboratory technologies by addressing key scale-up technical challenges and cost barriers.

Subtopic 2.1 Area of Interest 2 – Drying Modeling, Sensing, and Control Strategies: This area of interest seeks advances in modeling, in-process sensors and control strategies that will contribute to a reduction in energy consumption, increase speed/throughput, and improve product quality. It is reported that efforts to implement artificial intelligence (AI) control in drying have not been widely implemented due to the interaction complexity of process variables, lack of fundamental mathematical models of drying, and lack of adequate process sensors.²⁸ A better understanding of drying processes and systems is needed.

Subtopic 2.1 Candidate Metrics & Targets: Targets for processes and methodologies to be developed within this subtopic must be specified in the application, as well as an analysis of the energy efficiency improvements possible with the new technologies. 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

²⁷ 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://www1.eere.energy.gov/manufacturing/pdfs/itp_research_plan.pdf. Energy use scaled to 2010 Manufacturing Energy and Carbon Footprints (2010 MECS) data.

²⁸ Alex Martynenko (2018) Artificial intelligence: Is it a good fit for drying?, *Drying Technology*, 36:8, 891-892, DOI: <https://doi.org/10.1080/07373937.2017.1362153>

define appropriate benchmarks or baseline, minimum targets, and stretch targets. Example metrics include:

Subtopic 2.1 Objective/ Goal	Example Metric	Example Minimum	Example Stretch Target	Baseline Performance/ Cost
Reduce energy consumption	kWh/kg (moisture)	20%	30%	<i>Applicant Defined</i>
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>
Develop low-thermal-budget manufacturing technologies that reduce energy intensity	(energy consumed per unit of physical output)	50% over 2015 baseline	75% over 2015 baseline	<i>Applicant Defined</i>
Develop advanced sensors, controls, platforms, and models for targeted applications that reduce energy intensity	(energy consumed per unit of physical output)	15% over 2015 baseline	25% over 2015 baseline	<i>Applicant Defined</i>

Subtopic 2.2: Thermal Process Intensification

Note: It is expected that applications to this subtopic will be Tier 2 for a total of up to \$10,000,000 over 3 years. More detail about estimated funding levels can be found in Section II.A.i.

Subtopic 2.2 Background: Traditional industrial thermal processes can be inefficient, difficult to control, and result in materials and products with compromised quality and performance. As such, new and innovative approaches are sought that thermally intensify processes, as well as use low/no direct application of heat to transform materials into higher value products.

Subtopic 2.2 Opportunity: 95% of process heating energy is attributable to direct and indirect (fossil) fuel use: i.e., in the U.S., less than 5% of process heating operations utilize electricity.²⁹ Since electromagnetic (EM) energy interacts with different materials in unique ways, EM technologies (electrotechnologies) have the potential to intensify existing process heating methods, as well as enable new approaches and processes, in some cases even obviating the thermal demand. These

²⁹ See Process Heating Technology Assessment here: <https://energy.gov/sites/prod/files/2016/06/f32/QTR2015-6I-Process-Heating.pdf>

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alternative approaches to materials processing can lead to materials and products with improved properties, as well as entirely new products.

While some electrotechnologies have been adopted by the manufacturing sector where mechanisms are well understood (e.g. dielectric heating), uptake is limited. There is a vast EM spectrum that can be harnessed, and other wave/material mechanisms that could enable new applications. In addition, the potential of hybrid technologies has not been capitalized upon. For example, the development of integrated, enhanced, and compact process equipment to synergistically intensify thermal, mass, and momentum processes³⁰ has the potential to significantly improve advanced manufacturing energy productivity.

Subtopic 2.2 Technology Focus: This subtopic seeks applications that propose a research partnership or consortium that will work together to develop novel technologies to decrease thermal budgets via thermal process intensification.

A research partnership or consortium is a collaboration of two or more entities to conduct research with the objective of developing solutions to a problem or a challenge common to the entities by pooling their resources for achieving a common goal. To facilitate this collaboration, the research partnership or consortium should operate subject to a binding agreement entered into by each member of the research partnership or consortium. The agreement should define the governance and management structure, how the partners will collaborate, and how intellectual property and conflicts of interest will be managed.

The lead entity for the research partnership or consortia must qualify as an “Eligible Applicant” as defined in Section III.A. Further, the partners or consortia members must also meet the eligibility requirements for subrecipients. See Section III.A.

Applications to Subtopic 2.2 must address **both** areas of interest described below.

Subtopic 2.2 Area of Interest 1 – R&D of Electromagnetic Sources for

Manufacturing: While some forms of electromagnetic energy have found targeted applications in industrial operations (e.g. lasers for high speed cutting or selective melting in additive manufacturing; induction heating for bulk metals melting and heat treating); many sources of electromagnetic energy are either underutilized, or not used at all. This area of interest seeks applications to expand the use of EM sources for manufacturing applications. There exists a wealth of information regarding the use of electromagnetic sources in medicine, national security, and fundamental sciences that can be mined to assess their viability for manufacturing

³⁰ See Process Intensification Technology Assessment here:
<https://energy.gov/sites/prod/files/2015/11/f27/QTR2015-6J-Process-Intensification.pdf>

applications. For example, there are more than 30,000 particle accelerators³¹ deployed globally (including X-rays, photons, electrons, protons or heavy ions), with applications in medicine ranging from imaging to treatment, where large amounts of data are gathered and processed in equipment that is commercially deployed. Similarly, this technology is being deployed at increasing levels for national security applications, such as cargo scanning, materials characterization, radiography, and in support of non-proliferation efforts. Particle accelerators have a long history of invention, innovation, development, and utilization in the fundamental sciences central to activities across the DOE complex. Significant capabilities exist within the National Laboratory system, where an opportunity exists to leverage ongoing research directed towards industrial uses via DOE Accelerator Stewardship activities.³²

Applicants are expected to leverage the expertise and facilities of the existing U.S. accelerator R&D ecosystem to drive sustained innovation towards practical, testable designs for specific, targeted industrial applications (as described in Subtopic 2.2 Area of Interest 2).

Subtopic 2.2 Area of Interest 2 – Electromagnetic Energy for Advanced

Manufacturing Applications: Electrotechnologies can lead to process efficiency and/or improved materials/products, as well as a pathway to new materials and products. This area of interest seeks novel technology processes and system design concepts that will enable transformational manufacturing applications, including new technologies related to energy efficiency, and high-value products. Advances in designs and sources of electromagnetic energy are needed to achieve industrially relevant scale and cost structures for a range of potential applications (see Table 1).

³¹ “The Medical Applications of Particle Accelerators,” see: <https://www.azom.com/article.aspx?ArticleID=11950>

³² See: <https://science.energy.gov/hep/research/accelerator-stewardship/>

Table 1 - Examples of Electromagnetic (EM) Energy Opportunities in Manufacturing

Application Area	Examples of Operations where EM could lead to productivity advancements
Processing of Ceramics	<i>Joining & Welding Binder Burnout and Sol-Gel Processing Sintering, Annealing and Ablation</i>
Processing of Polymers	<i>Composites Curing Polymerization Acceleration Solid Phase Polymerization Microwave Processing of Heat Sensitive Polymer Emulsions</i>
Synthesis & Reactions, Process Intensification	<i>Organic Synthesis – Accelerated Reactions & New Materials Catalysis Inorganic Reactions – Hard Coatings, Oxides and Complexes Synthetic Diamond Production Extraction and Separation Techniques</i>
Processing of Conductive Materials	<i>Curing of Carbon Fiber Reinforced Plastics (CFRPs) Sintering of Powdered Metals Metals and Conductive Materials Processing</i>
Waste Processing and Environmental Applications	<i>Medical and Bio-Medical Waste Sterilization Hazardous Waste Processing</i>
Drying	<i>Heat sensitive materials including textiles, polymers, etc.</i>

Applicants are expected to develop and employ multi-scale models and simulation tools to inform R&D to predict the performance and optimize the design and operation of new electrotechnologies applications and systems. High performance computer (HPC) simulations can guide electromagnetic energy/material interactions, lead to better tooling/applicator designs, and optimize manufacturing. Computing and associated analysis is critical to provide feedback to better inform and evaluate the potential for various electromagnetic sources, applications, and designs. Multi-scale modeling will improve experimental outputs and inform future R&D, and is expected to extend from fundamental energy/material multi-physics modeling, to process modeling, and to systems modeling that can address systems and technology options at scale. Systems-scale modeling includes not only technology integration implications resulting from advances in new electromagnetic sources, but also alternative design approaches such as “scaling-up” (i.e., increasing the capacity of a single unit operation) versus “scaling-out” (i.e., gaining capacity by addition of smaller units in parallel).

Subtopic 2.2 Candidate Metrics & Targets: Targets for processes and methodologies to be developed within this subtopic must be specified in the application, as well as an analysis of the energy efficiency improvements possible with the new technologies. Applicants must identify a current technology baseline and justify appropriate target metrics for their technology and application, and clearly indicate

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how the proposed innovation will satisfy them. Metrics should be specific to the proposed technology and must define appropriate benchmarks, minimum targets, and stretch targets. Applications should clearly state the energy, cost, and emissions improvements of their proposed technology over incumbent technologies (e.g. natural gas heating). Example metrics include:

Subtopic 2.2 Objective/ Goal	Example Metric	Example Minimum	Example Stretch Target	Baseline Performance/ Cost
Develop advanced thermal intensification, LTB operations that provide improved properties, quality, and/or product value at cost parity to conventional techniques	Process specific	+15%	+25%	<i>Applicant Defined</i>
Develop process intensification technologies that increase energy efficiency	Process specific: (kJ/kg)	10x over 2015 baseline	20x over 2015 baseline	<i>Applicant Defined</i>
Develop low-thermal-budget manufacturing technologies that reduce energy intensity	(energy consumed per unit of physical output)	50% over 2015 baseline	75% over 2015 baseline	<i>Applicant Defined</i>

Topic 3: Connected, Flexible and Efficient Manufacturing Facilities and Energy Systems

The U.S. electric power system is the centerpiece of the nation’s energy economy. However, the design and operation of today’s grid is being challenged to meet the evolving security, cost, and environmental needs of a low-carbon, digital economy. A modernized electric power system will need to dynamically optimize distributed resources, rapidly detect and mitigate disturbances, and engage millions (if not billions) of intelligent devices. It must integrate diverse generation sources, demand response, and energy-efficiency resources, and enable consumers to manage their electricity use and participate in markets. Finally, it must provide strong protection against physical and cyber risks.

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Subtopic 3.1: Medium-Voltage Power Conditioning Systems to enable Grid-Dispatchable and Resilient Manufacturing Facilities

Note: It is expected that applications to this subtopic will be Tier 2 for a total of up to \$4,000,000 over 3 years. More detail about estimated funding levels can be found in Section II.A.i.

Subtopic 3.1 Background: Recent advancements in Wide-Bandgap (WBG) semiconductors include new high-voltage, high-frequency switching (>10 kV, >20 kHz) power semiconductor devices that meet industry standard reliability qualification requirements. These devices enable Medium-Voltage (MV) power electronics with transformative performance in industrial power system applications.

Subtopic 3.1 Opportunity: Manufacturing consumes approximately one-fourth of the energy demand in the U.S. and draws on a diverse set of energy resources to serve a variety of end uses. As such, energy generation and delivery are tightly coupled with manufacturing, and the resiliency and cyber security of one is dependent on the other. Multi-megawatt Power Conditioning Systems (PCS) provide the potential to utilize the intrinsic chemical, thermal and mechanical energy of manufacturing processes to provide electricity generation and storage to the grid as well as to provide resiliency and flexibility to manufacturing processes.

Subtopic 3.1 Technology Focus: This Subtopic seeks proposals for facility power system architectures comprised of cybersecure bidirectional multi-megawatt MV inverters and DC-to-DC converters that can be produced at low cost. While power electronics are used extensively in manufacturing processes at the point-of-use, increased electrification at the plant power system level is needed to take full advantage of advanced facility energy management and process controls. The focus of this subtopic is to enable Flexible Manufacturing Plants with controlled electric power flow between asynchronously connected electrical equipment and subsystems.

Applications must focus research on manufacturing, assembly and laboratory testing of the PCS, as well as defining the use cases for the PCS implementation to provide resiliency and flexibility to the grid and manufacturing facilities.

Not of interest in Subtopic 3.1: DOE is not interested in funding applications including research on new power semiconductor devices and their process integration, controls or communications, or energy conversion technologies (such as electro-mechanical, electro-thermal, or electro-chemical conversion). See Section I.C. and III.D. of the FOA.

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Subtopic 3.1 Candidate Metrics and Targets: Applications must define Flexible Manufacturing Plant use case scenarios where MV PCS architectures can provide:

- 10% increase in dispatchable load/generation without process interruptions
- electricity generation/storage meeting IEEE 1547 distributed-energy-resources (DER) interconnection standards including ride-through without process interruptions

Projects must demonstrate back-to-back 1-Mega Volt Amp (MVA), 3-phase bidirectional inverters with the following targets: grid-side must be 13.8 kV AC and load-side must be either 13.8 kV AC or 4160 V AC, and must be capable of multiple asynchronous AC or DC power ports scalable to 10 MVA. Projects should also address the cybersecurity issues at the interface between the grid and those manufacturing facilities where electricity can be generated and stored. Applicants must clearly indicate how the proposed approach will satisfy the following metrics:

Subtopic 3.1 Objective/Goal	Metric	Minimum	Stretch Target
Increase manufacturing plant dispatchable load/generation without process interruptions	Calculated increase in dispatchability for PCS use cases compared to existing plants	>10% over applicant defined baseline	20%
Increase efficiency of 13.8 kV inverters	Full load efficiency per 13.8 kV inverter	>99.4 %	>99.7
Decrease Manufacturing Cost of 10 kV SiC module-based power electronic assemblies	Cost per 13.8 kV inverter excluding cost of SiC die	<\$30/kW	<\$15/kW
Increase service life of 10 kV SiC module power electronic assemblies	Calculated using existing qualification standards and partial discharge tests	> 10 years	> 30 years
Compact 13.8 kV power electronic assemblies	Each 13.8 kV three phase inverter volume	0.3 m3 per MVA	0.15 m3 per MVA

Subtopic 3.2: High Power to Heat Ratio, High Efficiency Combined Heat & Power (CHP)

Subtopic 3.2 Background: Combined Heat & Power (CHP) is the concurrent production of electricity or mechanical power and useful thermal energy (heating and/or cooling) from a single source of energy. CHP technologies provide manufacturing facilities, commercial buildings, institutional facilities, and communities with ways to reduce energy costs and emissions while also providing more resilient and reliable electric power and thermal energy. CHP systems combine the production of heat (for both heating and cooling) and electric power into one

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process, using much less fuel than when heat and power are produced separately. CHP can operate in one of two ways: either a "topping" cycle, where engines, turbines, or fuel cells generate electricity and the waste heat is used for either heating or cooling, or a "bottoming" cycle, where waste heat from an industrial or other source is used to drive an electricity generator, frequently a steam turbine.

Today's CHP systems are generally designed to meet the thermal demand of the energy user – whether at building, plant or city-wide levels – because it maximizes system efficiency and costs less to transport surplus electricity than to pipe surplus heat from a CHP plant³³. CHP systems can achieve energy efficiencies of 75 percent or more, compared to producing heat and power separately, which is on average less than 50 percent efficient³⁴.

Subtopic 3.2 Opportunity: The focus on facilities that are dominated by thermal demands leaves out a significant population of manufacturing plants which are dominated by electrical needs. These include assembly plants, electrochemical plants such as chlor-alkali manufacturers, and industrial gas facilities, among others. This population does not include the large commercial and institutional sectors, where electric demand frequently dominates. A comprehensive discussion of the issues and opportunities that are associated with deploying highly-efficient CHP to applications that fall outside of the traditional thermally-driven systems appears in a technology assessment on combined heat and power systems³⁵. An analysis examined how much increased technical potential and energy savings could be captured if CHP systems could be deployed in manufacturing applications with a power to heat (P/H) ratio of up to 1.5 (P/H ratios in existing CHP systems are closer to 0.75). This analysis showed that expanding the market applications for CHP systems to those driven more by electrical rather than thermal output could save an additional 144 trillion Btu of energy beyond existing CHP technologies alone.

Subtopic 3.2 Technology Focus: This subtopic seeks R&D activities that focus on increasing the CHP electricity generation efficiency while at the same time maintaining the overall efficiency of the CHP system. The potential for CHP systems that produce more electricity than conventional systems is large. However, for such systems to be effective from an energy and cost point of view they would have to offer electricity generation efficiencies much greater than currently available. By increasing the power to heat (P/H) ratio and maintaining the high efficiencies of

³³ Combined Heat and Power – Evaluating the Benefits of Greater Global Investment, IEA 2008. Available at - http://www.iea.org/publications/freepublications/publication/chp_report.pdf.

³⁴ U.S. Department of Energy (DOE) and U.S. Environmental Protection Agency (EPA). Combined Heat and Power: A Clean Energy Solution. DOE/EE-0779. August 2012. Available at - <https://www.energy.gov/eere/amo/downloads/chp-clean-energy-solution-august-2012>.

³⁵ Chapter 6: Innovating Clean Energy Technologies in Advanced Manufacturing Technology Assessments: Combined Heat and Power Systems, pp. 10-16, 2015, <https://www.energy.gov/sites/prod/files/2015/12/f27/QTR2015-6D-Combined-Heat-and-Power-Systems.pdf>

current, thermally-sized CHP systems, there is a significant energy and cost savings opportunity. Increasing P/H without loss of efficiency would entail the development of ultra-high efficient generating technologies. Ultra-efficient electricity generation could be a transformative technology leap for providing power to end-use customers. To achieve this, new heat recovery technologies that can recover low temperature waste heat will be needed as well. In order to enhance the reliability and resilience of the grid, new CHP technologies would also be designed with enhanced cybersecurity in mind.

Subtopic 3.2 Candidate Metrics and Targets: 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 for conventional technologies, minimum targets, and stretch targets. The proposed metrics and targets should advance the development of cost-effective CHP systems that are responsive to site demands as well as grid requirements. Example metrics include:

Subtopic 3.2 Objective/ Goal	Metric	Minimum	Stretch Target	Baseline Performance/ Cost
Fuel to electricity conversion efficiency (Lower Heating Value - LHV)	Efficiency	>65%	>70%	<i>Applicant Defined</i>
Overall system efficiency (LHV)	Efficiency	>75%	>80%	<i>Applicant Defined</i>

Subtopic 3.3: Verification & Validation of CHP & District Energy

Subtopic 3.3 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 also provide electricity through the use of CHP or other technologies.

There were more than 660 estimated DE systems operating in the U.S. in 2012, with installations in every state, providing heating to an estimated 5.5B square feet of floor space and cooling to 1.9B square feet of floor space. DE distribution systems have a number of benefits:

- They serve as a type of energy storage, with steam, hot water or chilled water circulating in the system, effectively smoothing the load for the central plant.

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- They promote higher load factors by serving a more stable, predictable combined load, while reducing the need for excess peak heating or cooling capacity.
- They aggregate energy requirements of many different buildings providing economies of scale that allow DE systems to employ high efficiency technologies and industrial-grade equipment that would not be economically or technically feasible for individual buildings.

Subtopic 3.3 Opportunity: New technical challenges and opportunities have been identified that, if addressed, can lead to the development of new DE systems that can provide energy security and resiliency. These include:

- Low temperature DE systems conversion
- Integration of renewable, intermittent energy sources and/or thermal energy storage
- Incorporating efficient CHP systems and community-based microgrids
- Advanced metering, monitoring, and system optimization
- Enhanced cybersecurity of highly-networked DE systems
- Distribution system improvements
- Innovative new business models that efficiently and cost-effectively link end use customers with heat sources

Subtopic 3.3 Technology Focus: AMO seeks to fund projects that incorporate new technologies, innovative solutions, and/or novel modeling and simulation approaches to existing DE systems in order to explore the technical challenges and opportunities identified above. Projects funded should validate, verify and advance the body of knowledge of key district energy areas, such as the integration of renewables and/or energy storage into DE systems and/or assist in clarifying and or quantifying crucial district energy benefits, such as grid services and resiliency.

Subtopic 3.3 Candidate Metrics & Targets: 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 for conventional technologies, minimum targets, and stretch targets. Example metrics include:

Subtopic 3.3 Objective/ Goal	Example Metric	Example Minimum	Example Stretch Target	Baseline Performance /Cost
Improve System wide energy efficiency	BTUs fuel input/BTUs delivered energy, above the existing baseline	20%	40%	<i>Applicant Defined</i>
Increase Heat recovery	Temperature threshold at which heat can reliably be reused	20%	35%	<i>Applicant Defined</i>
Reduce capital and operating costs	Reduction in US Dollars relative to existing baseline (for operating costs) or modeled baseline (for capital costs)	20%	40%	<i>Applicant Defined</i>
Increase resiliency	Increase in number of continuous operating hours in the face of an electric grid outage	25%	50%	<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 and areas of interest 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.
- Other subtopic areas designated specifically not of interest can be found within each Subtopic Area description in Section I.B. above. These include:
 - **Subtopic 1.1:** Applications focused on photovoltaic materials, either thin film or semi-conductor based are specifically not of interest in Subtopic 1.1.
 - **Subtopic 3.1:** Applications including research on new power semiconductor devices and their process integration, controls or communications, or energy conversion technologies (such as electro-mechanical, electro-thermal, or electro-chemical conversion) are specifically not of interest in Subtopic 3.1.

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D. Authorizing Statutes

The programmatic authorizing statutory provisions are Section 911 (a)(2)(A) and (a)(2)(C) of the Energy Policy Act of 2005, as codified at 42 U.S.C. § 16191(a)(2)(A) and (C).

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

II. Award Information

A. Award Overview

i. Estimated Funding

EERE expects to make a total of approximately \$88,840,000 of federal funding available for new awards under this FOA, subject to the availability of appropriated funds. EERE anticipates making up to 55 awards under this FOA. EERE may issue one, multiple, or no awards. Individual awards may be up to \$500,000 for Tier 1 projects, and up to \$4 million for Tier 2 projects, except for Tier 2 awards for Subtopic 1.2, which may be up to \$12 million and Subtopic 2.2, which may be up to \$10 million.

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

Topic 1: Innovations for the Manufacture of Advanced Materials

EERE may issue up to 25 awards in this topic area, with awards up to \$500,000 for Tier 1 projects, and up to \$4 million for Tier 2 projects, except for Tier 2 awards for Subtopic 1.2, which may be up to \$12 million.

Topic 2: Lower Thermal Budget (LTB) Processes for Industrial Efficiency & Productivity

EERE may issue up to 15 awards in this topic area, with awards up to \$500,000 for Tier 1 projects, and up to \$4 million for Tier 2 projects, except for Tier 2 awards for Subtopic 2.2, which may be up to \$10 million.

Topic 3: Connected, Flexible and Efficient Manufacturing Facilities and Energy Systems

EERE may issue approximately up to 15 awards in this topic area, with awards up to \$500,000 for Tier 1 projects, and up to \$4 million for Tier 2 projects.

More details about funding amount of Tier1/Tier 2 by Topic and Subtopic is shown in the table below.

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Topic	Subtopic	Funding Amount
Topic 1: Innovations for the Manufacture of Advanced Materials Up to \$53.25M Up to 25 Awards	Subtopic 1.1. Accelerate the Manufacturing Process Design and Development Cycle for Advanced Energy Storage and Conversion Materials	Up to \$5 million Total <i>Tier 1: up to \$500,000 per award</i> <i>Tier 2: up to \$4 million per award</i>
	Subtopic 1.2. Innovative Manufacturing Processes for Battery Energy Storage	Up to \$30M Total <i>Tier 2: up to \$12 million per award</i>
	Subtopic 1.3. Materials and Manufacturing Process Development of Nanocrystalline Metal Alloys	Up to \$5M Total <i>Tier 1: up to \$500,000 per award</i> <i>Tier 2: up to \$4 million per award</i>
	Subtopic 1.4. Process-Informed Science, Design, and Engineering of Materials and Devices Operating in Harsh Service Conditions	Up to \$13.25M Total <i>Tier 1: up to \$500,000 per award</i> <i>Tier 2: up to \$4 million per award</i>
Topic 2: Lower Thermal Budget (LTB) Processes for Industrial Efficiency & Productivity Up to \$18.5M Up to 15 Awards	Subtopic 2.1. Advances in Industrial and Process Drying	Up to \$8.5M Total <i>Tier 1: up to \$500,000 per award</i> <i>Tier 2: up to \$4 million per award</i>
	Subtopic 2.2. Thermal Process Intensification	Up to \$10M Total <i>Tier 2: up to \$10 million per award</i>
Topic 3: Connected, Flexible and Efficient Manufacturing Facilities and Energy Systems Up to \$17.09M Up to 15 Awards	Subtopic 3.1. Medium-Voltage Power Conditioning Systems to Enable Grid-Dispatchable and Resilient Manufacturing Facilities	Up to \$8.795M Total <i>Tier 2: up to \$4 million per award</i>
	Subtopic 3.2. High Power to Heat Ratio, High Efficiency Combined Heat and Power (CHP)	Up to \$4.295M Total <i>Tier 1: up to \$500,000 per award</i> <i>Tier 2: up to \$4 million per award</i>
	Subtopic 3.3. Verification & Validation of CHP & District Energy	Up to \$4M Total <i>Tier 1: up to \$500,000 per award</i> <i>Tier 2: up to \$4 million per award</i>

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

ii. Period of Performance

EERE anticipates making awards that will run up to 36 months in length, comprised of one or more budget periods. Project continuation will be contingent upon satisfactory performance and Go/No-Go decision review. See Section VI.B.xiii. At the Go/No-Go decision points, EERE will evaluate project performance, project schedule adherence, meeting milestone objectives,

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compliance with reporting requirements, overall contribution to the program goals and objectives, and deliverables to be achieved by the recipient in that budget period. 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 criteria set forth below. If the application does not meet these eligibility requirements, it will be considered ineligible and removed from further evaluation.

A. Eligible Applicants

i. Individuals

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

ii. Domestic Entities

Domestic 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 and have a physical location for business operations in the United States are eligible to apply for funding as a prime recipient or subrecipient.

U.S. 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 subrecipient to all Topics.

DOE/NNSA FFRDCs are eligible to apply for funding as a prime recipient to *Subtopic 1.4 only*. AMO provided substantial funding through a competitive National Laboratory Call for Proposals in addition to non-competitive Annual Operating Plans (AOPs) to support R&D efforts at the National Laboratories. There is significant potential for other types of entities to advance R&D efforts in this technical space and these topic areas/subtopic areas will provide the opportunity for such entities to compete for Federal funds while allowing the National Laboratories to receive funding as subrecipients.

Non-DOE/NNSA FFRDCs are eligible to apply for funding as a subrecipient, but are not eligible to apply as a prime recipient.

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.

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.

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iii. Foreign Entities

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 domestic subsidiary or affiliate 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 C1. lists the necessary information that must be included in a Foreign Entity Participation waiver request. The applicant does not have the right to appeal EERE's decision concerning a waiver request.

iv. Incorporated Consortia

Domestic incorporated consortia are eligible to apply for funding as a prime recipient or subrecipient. Please refer to "Domestic Entities" above. For a foreign incorporated consortium, 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.

If the incorporated consortium includes foreign members, the applicant must submit a separate explicit written waiver request in the Full Application for each foreign member. Appendix C1. lists the necessary information that must be included in a waiver request.

v. Unincorporated Consortia

An unincorporated consortium 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. If the consortium includes foreign members, the applicant must submit a separate explicit written waiver request in the Full Application for each foreign

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member. Appendix C1. lists the necessary information that must be included in a waiver request.

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.

vi. Special Eligibility Requirements for Subtopic 2.2

Applicants to Subtopic 2.2: Thermal Process Intensification must propose a research partnership or consortia. A research partnership or consortium is a collaboration of two or more entities to conduct research with the objective of developing solutions to a problem or a challenge common to the entities by pooling their resources for achieving a common goal. The lead entity for the research partnership or consortia must qualify as an "Eligible Applicant" as defined in Section III.A. Further, the partners or consortia members must also meet the eligibility requirements for subrecipients. See Section III.A.

The funding for Subtopic 2.2 is drawn from FY18 and FY19 funds appropriated for "Advanced Manufacturing Research and Development Facilities" which funds various consortia including the Clean Energy Manufacturing Innovation Institutes (CEMI), the Manufacturing Demonstration Facility (MDF), and the Critical Materials Institute. The goal of Subtopic 2.2 is to fund the development of smaller consortia that leverage existing national lab assets to perform R&D in the area thermal process intensification.

B. Cost Sharing

Regardless of entity type, 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

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unless otherwise allowed by law. (See 2 CFR 200.306 and 2 CFR 910.130 for the applicable cost sharing requirements.)

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

i. Legal Responsibility

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

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

ii. Cost Share Allocation

Each project team is free to determine how best to allocate the cost share requirement among the team members. The amount contributed by individual project team members may vary, as long as the cost share requirement for the project as a whole is met.

iii. Cost Share Types and Allowability

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

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

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

In-kind contributions are those where a value of the contribution can be readily determined, verified and justified but where no actual cash is transacted in

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securing the good or service comprising the contribution. Allowable in-kind contributions include, but are not limited to: the donation of volunteer time or the donation of space or use of equipment.

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

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

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

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

Cost share contributions must be specified in the project budget, verifiable from the prime recipient's records, and necessary and reasonable for proper and efficient accomplishment of the project. As all sources of cost share are considered part of total project cost, the cost share dollars will be scrutinized under the same federal regulations as federal dollars to the project. Every cost share contribution must be reviewed and approved in advance by the 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 guidance on cost sharing.

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 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 due to server/connection congestion.

i. Compliance Criteria

1. Concept Papers

Concept Papers are deemed compliant if:

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- 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. Section I.C. of the FOA “Applications Specifically Not of Interest” describes the type of submissions that are deemed nonresponsive and are not eligible for further review or consideration.

E. Other Eligibility Requirements

i. 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

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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

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An entity may only submit one Concept Paper and one Full Application for each subtopic area of this FOA. If an entity submits more than one Concept Paper and one Full Application to the same subtopic 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 subtopic 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 subtopic area of this FOA.

G. Questions Regarding Eligibility

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

IV. Application and Submission Information

A. Application Process

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

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- 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 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.

Questions about this FOA? Email AMOMultitopicFOA@ee.doe.gov

Problems with EERE Exchange? Email EERE-ExchangeSupport@hq.doe.gov Include FOA name & number in subject line.

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.

Applicants that experience issues with submissions that result in late submissions: In the event that an applicant experiences technical difficulties so severe that they are unable to submit their application by the deadline, 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 the applicant in resolving all issues (including finalizing submission on behalf of and with the applicant's concurrence). Please note, network traffic is at its heaviest during the final hours and minutes prior to submittal deadline. Applicants who experience this during the final hours or minutes and are unsuccessful in uploading documents will not be able to use this process.

B. 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

C. Content and Form of the Concept Paper

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

i. Concept Paper Content Requirements

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.

Questions about this FOA? Email AMOMultitopicFOA@ee.doe.gov

Problems with EERE Exchange? Email EERE-ExchangeSupport@hq.doe.gov Include FOA name & number in subject line.

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 Topic/Subtopic Area being addressed, the 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 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>

Questions about this FOA? Email AMOMultitopicFOA@ee.doe.gov

Problems with EERE Exchange? Email EERE-ExchangeSupport@hq.doe.gov Include FOA name & number in subject line.

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.

D. 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:

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Submission	Components	File Name
Full Application (PDF, unless stated otherwise)	Technical Volume (PDF format. See Chart in Section IV.D.ii.)	ControlNumber_LeadOrganization_TechnicalVolume
	Statement of Project Objectives (SOPO) (Microsoft Word format, 20 page limit)	ControlNumber_LeadOrganization_SOPO
	SF-424 Application for Federal Assistance (PDF format)	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 (PDF format. 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 (PDF format. See DOE O 412.1A, Attachment 3)	ControlNumber_LeadOrganization_WP
	Authorization from cognizant Contracting Officer for FFRDC, if applicable (PDF format)	ControlNumber_LeadOrganization_FFRDCAuth
	SF-LLL Disclosure of Lobbying Activities (PDF format)	ControlNumber_LeadOrganization_SF-LLL
	Foreign Entity and Foreign Work waiver requests, if applicable (PDF format)	ControlNumber_LeadOrganization_Waiver
	U.S. Manufacturing Plan (PDF format)	ControlNumber_LeadOrganization_USMP
Data Management Plan (Microsoft Word format)	ControlNumber_LeadOrganization_DMP	

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.

Questions about this FOA? Email AMOMultitopicFOA@ee.doe.gov

Problems with EERE Exchange? Email EERE-ExchangeSupport@hq.doe.gov Include FOA name & number in subject line.

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 Topic/Suptopic 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 the critical success factors in achieving that goal. • DOE Impact: The applicant should discuss the impact that DOE funding would have on the proposed project. Applicants should specifically explain how DOE funding, relative to prior, current, or anticipated funding from other public and private sources, is necessary to achieve the project objectives.
<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.
<p>Workplan (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

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	<p>describe the specific expected end result of each performance period.</p> <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. 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 (See Section VI.B.xiii). 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. The applicant should also provide the specific technical criteria to be used to make the Go/No-Go decision. 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). Each project must have one SMART end of project goal. The summary provided should be consistent with the SOPO. • Project Schedule (Gantt Chart or similar): The applicant should provide a schedule for the entire project, including task and subtask durations, milestones, and Go/No-Go decision points. • 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
<p>Technical Qualifications and Resources (Approximately 20% of the Technical Volume)</p>	<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. • Describe the time commitment of the key team members to support the project. • Attach one-page resumes for key participating team members as an appendix. Resumes do not count towards the page limit. Multi-page resumes are not allowed. • Describe the technical services to be provided by DOE/NNSA FFRDCs, if applicable. • Attach letters of commitment from all subrecipient/third party cost share providers as an appendix. Letters of commitment do not count towards the page limit. • Attach any letters of commitment from partners/end users as an appendix (1 page maximum per letter). Letters of commitment do not count towards the page limit.

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	<ul style="list-style-type: none"> • 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; and ○ Communication plans
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iii. 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".

iv. 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 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".

v. 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

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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”.

vi. 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”.

vii. 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.

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viii. 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”.

ix. 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”.

x. 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”.

xi. 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.

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

xii. 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. 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”.

xiii. 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

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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".

xiv. 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 Data Management Plans 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

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digitally accessible at the time of publications. DOE Public Access Plan dated July 24, 2014 provides additional guidance and information on Data Management Plans.

For subtopic 1.1 applications, even with the selection of Option 1 or Option 2 below, the DMP must further (i) explain on how the applicant will incorporate best practices in HTEM data management; (ii) whether and how it will publish data and software in appropriate repositories in coordination with relevant standards organizations, consortia and working groups; and (iii) whether and how it will register published data, software, and other relevant resources in an appropriate resource registry in coordination with relevant standards organizations, consortia, and working groups as discussed in Section I.B under the subtopic 1.1 narrative.

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 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".

E. Content and Form of Replies to Reviewer Comments

EERE will provide applicants with reviewer comments following the evaluation of all eligible Full Applications. Applicants will have a brief opportunity to review the comments and to prepare a short Reply to Reviewer Comments responding to the

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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 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.

F. Post Selection Information Requests

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

- Data Management Plan;
- 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; and
- Environmental Questionnaire.

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G. 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.

H. 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.

I. Intergovernmental Review

Technology Office not subject to Executive Order 12372

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

J. Funding Restrictions

i. Allowable Costs

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

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

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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 costs can only be incurred if such costs would be reimbursable under the agreement if incurred after award.

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. Pre-Award Costs Related to National Environmental Policy Act (NEPA) Requirements

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 costs where the prime recipient incurred the costs prior to receiving written authorization from the Contracting Officer. If the applicant elects to undertake activities that 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 and such costs may not be recognized as allowable cost share. 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. 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.

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

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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 if 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 wavier.

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 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

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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. The rules for property disposition are set forth in 2 CFR 200.310 – 200.316 as amended by 2 CFR 910.360.

vii. 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.

viii. 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 this part; history of performance; reports and findings from audits; and the

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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.

ix. 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.

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 factors:

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- 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 factors:

Technical Merit and Innovation

- Extent to which the proposed technology or process is innovative;
- Degree to which the current state of the technology and the proposed advancement are clearly described;
- Extent to which the application specifically and convincingly demonstrates how the applicant will move the state-of-the-art to the proposed advancement; and
- Sufficiency of technical detail in the application to assess whether the proposed work is scientifically meritorious and revolutionary, including relevant data, calculations and discussion of prior work in the literature with analyses that support the viability of the proposed work.

Impact of Technology Advancement

- How the project supports the topic area objectives and target specifications and metrics; and
- The potential impact of the project on advancing the state-of-the-art.

Criterion 2: Project Research (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;

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- 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; and
- *Factor Applicable Only to Subtopic 1.1:* The extent the discussion of best practices guidelines in HTEM data management for data collection, reporting, sharing, and archiving is adequate and guidelines are incorporated early in the research effort.

Identification of Technical Risks

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

Baseline, Metrics, and Deliverables

- The level of clarity in the definition of the baseline, metrics, and milestones;
- 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; and
- *Factor Applicable Only to Subtopic 1.1:* Degree to which the experimental methodology carefully describes the three critical areas High Throughput Experimental Methods (HTEM); Data collection, reporting, sharing, and archiving; and Algorithm development and application) to be included in the final deliverable.

Criterion 3: Team and Resources (20%)

This criterion involves consideration of the following factors:

- The capability of the Principal Investigator(s) and the proposed team to address all aspects of the proposed work with a high probability of success.
- The qualifications, relevant expertise, and time commitment of the individuals on the team;
- The sufficiency of the facilities to support the work;
- The degree to which the proposed 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;
- The reasonableness and appropriateness of the budget and spend plan for the proposed project and objectives; and
- *Factor Applicable Only to Subtopic 2.2:* The strength of the proposed research partnership or consortium.

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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;
- 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).

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D. Evaluation and Selection Process

i. Overview

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

ii. Pre-Selection Clarification

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

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

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

iii. 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).

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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.

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.

iv. 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

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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.

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 was born outside the jurisdiction of the United States, is a citizen of a foreign government, and has not been naturalized under U.S. law. 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. 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.

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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 <http://nepa.energy.gov/>.

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 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

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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:

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1. EERE shares responsibility with the recipient for the management, control, direction, and performance of the project.
 2. EERE may intervene in the conduct or performance of work under this award for programmatic reasons. Intervention includes the interruption or modification of the conduct or performance of project activities.
 3. EERE may continue, redirect, place on hold 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 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, overall

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contribution to the EERE program goals and objectives, and deliverables to be achieved by the recipient in that budget period. Federal funding beyond the Go/No-Go decision point (continuation funding) is contingent upon (1) availability of federal funds appropriated by Congress for the purpose of this program; (2) the availability of future-year budget authority; (3) recipient's technical progress compared to the Milestone Summary Table stated in Attachment 1 of the award; (4) recipient's submittal of required reports; (5) recipient's compliance with the terms and conditions of the award; (6) 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, 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.

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. Export Control

Export control laws are in place to protect U.S. national security, foreign policy, and economic interests without imposing undue regulatory burdens on legitimate international trade. Some projects may be subject to export control restrictions per the applicable laws and regulations. It is the prime recipient's responsibility to determine applicability with export control laws and regulations and ensure compliance. Export control laws and regulations may apply to individual research projects, depending on the nature of the research tasks.

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.

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 3 business days prior to the application due date and time. Please note, feedback on individual concepts will not be provided through Q&A.

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

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

VIII. Other Information

A. FOA Modifications

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

B. Government Right to Reject or Negotiate

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

C. Commitment of Public Funds

The 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

In general, EERE will only use data and other information contained in applications for evaluation purposes, unless such information is generally available to the public or is already the property of the Government.

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.

The use of protective markings such as “Do Not Publicly Release – Trade Secret” or “Do Not Publicly Release – Confidential Business Information” is encouraged. However, applicants should be aware that the use of protective markings is not

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dispositive as to whether information will be publicly released pursuant to the Freedom of Information Act, 5 U.S.C. §552, et. seq., as amended by the OPEN Government Act of 2007, Pub. L. No. 110-175. (See Section I of this document, “Notice of Potential Disclosure Under the Freedom of Information Act (FOIA)” for additional information regarding the public release of information under FOIA.

Applicants are encouraged to employ protective markings in the following manner:

The cover sheet of the application must be marked as follows and identify the specific pages containing trade secrets or commercial or financial information that is privileged or confidential:

Notice of Restriction on Disclosure and Use of Data:

Pages [list applicable pages] of this document may contain trade secrets or commercial or financial information that is privileged or confidential, and 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 trade secrets or commercial or financial information that is privileged must be marked as follows: “May contain trade secrets or commercial or financial information that is privileged or confidential and exempt from public disclosure.”

In addition, each line or paragraph containing trade secrets or commercial or financial information that is privileged or confidential must be enclosed in brackets.

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 and non-disclosure acknowledgements (COI/NDA) prior to reviewing an application. Non-federal personnel conducting administrative activities must sign a COI/NDA.

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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. Notice of Potential Disclosure Under Freedom of Information Act (FOIA)

Under the FOIA, 5 U.S.C. §552, et. seq., as amended by the OPEN Government Act of 2007, Pub. L. No. 110-175, any information received from the applicant is considered to be an agency record, and as such, subject to public release under FOIA. The purpose of the FOIA is to afford the public the right to request and receive agency records unless those agency records are protected from disclosure under one or more of the nine FOIA exemptions. Decisions to disclose or withhold information received from the applicant are based upon the applicability of one or more of the nine FOIA exemptions, not on the existence or nonexistence of protective markings or designations. Only the agency's designated FOIA Officer may determine if information received from the applicant may be withheld pursuant to one of the nine FOIA exemptions. All FOIA requests received by DOE are processed in accordance with 10 C.F.R. Part 1004.

I. 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.

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J. 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.

K. Title to Subject Inventions

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

- Domestic Small Businesses, Educational Institutions, and Nonprofits: Under the Bayh-Dole Act (35 U.S.C. § 200 et seq.), domestic small businesses, educational institutions, and nonprofits may elect to retain title to their subject inventions;
- All other parties: The federal Non-Nuclear Energy Act of 1974, 42 U.S.C. 5908, provides that the Government obtains title to new inventions unless a waiver is granted (see below);
- Class Patent Waiver: DOE has issued a class waiver that applies to this FOA. Under this class waiver, domestic large businesses may elect title to their subject inventions similar to the right provided to the domestic small businesses, educational institutions, and nonprofits by law. In order to avail itself of the class waiver, a domestic large business must agree that any products embodying or produced through the use of a subject invention first created or reduced to practice under this program will be substantially manufactured in the United States, unless DOE agrees that the commitments proposed in the U.S. Manufacturing Plan are sufficient.
- Advance and Identified Waivers: Applicants may request a patent waiver that will cover subject inventions that may be invented under the award, in advance of or within 30 days after the effective date of the award. Even if an advance waiver is not requested or the request is denied, the recipient will have a continuing right under the award to request a waiver for identified inventions, i.e., individual subject inventions that are disclosed to EERE within the timeframes set forth in the award's intellectual property terms and conditions. Any patent waiver that may be granted is subject to certain terms and conditions in 10 CFR 784; and
- Determination of Exceptional Circumstances (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.

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Manufacturing Plan. Any Bayh-Dole entity (domestic small business or nonprofit organization) affected by this DEC has the right to appeal it.

L. 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.

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.

M. 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.

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“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.

N. 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.

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 personal emails. **Under no circumstances should Social Security Numbers (SSNs) be included in the application.** Federal Agencies are prohibited from the collecting,

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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:

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- 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.

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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

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)

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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., the prime recipient and subrecipients 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 place of business 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. Specific to the AMO Multitopic FOA, EERE seeks to stimulate technology innovation, improve the energy productivity of U.S. manufacturing, and enable the manufacture of cutting-edge products in the United States. To ensure that purpose is not frustrated by foreign involvement, foreign entities seeking to participate in awards under this FOA must demonstrate to the satisfaction of EERE that:

- a. Its participation is in the best interest of U.S. industry, and U.S. economic development;
- b. Adequate Intellectual Property (IP) and data protection protocols exist between the U.S. subsidiary and its foreign parent organization;
- c. The work is conducted within the U.S. and the entity acknowledges the U.S. Manufacturing Plan; and
- d. The foreign entity will satisfy other conditions that may be deemed necessary by the Institute or DOE 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, and the extent, if any, the entity is state owned or controlled;

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- 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)

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

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the work outside the United States. To seek a foreign work waiver, the applicant must submit an explicit waiver request in the Full Application. A separate waiver request must be submitted for each entity proposing to perform 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 for a foreign work waiver must include the following:

- a. The rationale for performing the work outside the U.S. (“foreign work”);
- b. A description of the work proposed to be performed outside the U.S.;
- c. An explanation as to how the foreign work is essential to the project;
- d. A description of the anticipated benefits to be realized by the proposed foreign work and the anticipated contributions to the U.S. 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 manufacturing of products and/or services;
- e. A description of the likelihood of Intellectual Property (IP) being created from the foreign work and the treatment of any such IP;
- f. The total estimated cost (DOE and recipient cost share) of the proposed foreign work;
- g. The countries in which the foreign work is proposed to be performed; and
- h. 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 where EERE will evaluate project performance, project schedule adherence, meeting milestone objectives, compliance with reporting requirements, overall contribution to the program goals and objectives, and deliverables to be achieved by the recipient in that budget period. As a result of EERE’s review, EERE may take one of 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.

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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)

AC	Alternating Current
AI	Artificial Intelligence
AMO	Advanced Manufacturing Office
CHP	Combined Heat and Power
COI	Conflict of Interest
DC	Direct Current
DE	District Energy
DEC	Determination of Exceptional Circumstances
DER	Distributed Energy Resources
DMP	Data Management Plan
DOE	Department of Energy
DOI	Digital Object Identifier
DTEC	Direct Thermal Energy Conversion
EERE	Energy Efficiency and Renewable Energy
EM	Electromagnetic
FAIR	Findable, Accessible, Interoperable, and Reusable
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
GDP	Gross Domestic Product
ICME	Integrated Computational Materials Engineering
HPC	High Performance Computing
HTEM	High Throughput Experimental Methods
LHV	Lower Heating Value
LTB	Lower Thermal Budget
M&O	Management and Operating
ML	Machine Learning
MPIN	Marketing Partner ID Number
MV	Medium-Voltage
MVA	Mega Volt Amp
MYPP	Multi-Year Program Plan
NDA	Non-Disclosure Acknowledgement
NEPA	National Environmental Policy Act
NNSA	National Nuclear Security Agency
OMB	Office of Management and Budget
OSTI	Office of Scientific and Technical Information
PCS	Power Conditioning Systems
P/H	Power to Heat

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PII	Personal Identifiable Information
QTR	Quadrennial Technology Review
Quads	Quadrillion BTUs (British Thermal Units)
R&D	Research and Development
R2R	Roll-to-Roll
RFI	Request for Information
RFP	Request for Proposal
SAM	System for Award Management
SiC	Silicon Carbide
SOPO	Statement of Project Objectives
SPOC	Single Point of Contact
TIA	Technology Investment Agreement
TRL	Technology Readiness Level
UCC	Uniform Commercial Code
WBG	Wide-Bandgap
WBS	Work Breakdown Structure
WP	Work Proposal

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