

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

**Buildings Energy Efficiency Frontiers & Innovation
Technologies (BENEFIT) – 2019**

Funding Opportunity Announcement (FOA) Number: DE-FOA-0002090

FOA Type: Initial

CFDA Number: 81.086

FOA Issue Date:	04/23/2019
Modification 000001:	06/17/2019
Submission Deadline for Concept Papers:	05/21/2019, 5:00pm ET
Anticipated Date of Concept Paper Notifications:	06/04/2019
Submission Deadline for Full Applications:	07/15/2019, 5:00pm ET
Anticipated Date for Distribution of Reviewer Comments:	08/28/2019
Expected Submission Deadline for Replies to Reviewer Comments:	09/03/2019, 5:00pm ET
Expected Timeframe for EERE Selection Notifications:	October-November 2019
Expected Timeframe for Award Negotiations:	January 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 cancelation of further award negotiations and rescission of the Selection.

Modifications

All modifications to the FOA are [HIGHLIGHTED] in the body of the FOA.

Mod. No.	Date	Description of Modification
000001	6/17/19	<p>The following modifications were made:</p> <ul style="list-style-type: none">• Broken reference links were updated (but not highlighted); and• Section IV.d.i. Required templates and forms for the full application have been updated and/or added to the Required Application Documents section of the FOA under Exchange.

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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) Building Technologies Office (BTO). This section describes the overall goals of BTO and the type of projects that are being solicited for funding support through this FOA.

The DOE mission is to ensure America's security and prosperity by addressing its energy, environmental and nuclear challenges through transformative science and technology solutions. Powering our homes, offices, schools, hospitals, restaurants, and stores consumes a lot of energy. Residential and commercial buildings account for approximately 40% of the nation's total energy demand – greater than that for either industry (32%) or transportation (29%) – and about 75% of all electricity use (and even more of peak power demand). The resulting annual national energy bill totals more than \$380 billion.

Improving the energy efficiency of buildings reduces energy costs in homes and commercial buildings. Many of the nation's more than 118 million homes and 5.6 million commercial buildings were constructed before 1980—prior to the existence of today's efficient products and building construction practices. By saving money on energy costs there is more money available to flow into other sectors of the economy. Unlocking the energy savings of these buildings through efficiency improvements represents a significant economic opportunity.

Improving the energy efficiency of buildings alleviates pressure on our electric grid and extends our energy resources as we diversify to greater use of an all-of-the-above energy supply strategy. This helps to ensure a reliable energy system well into the future.

BTO leads a network of national laboratory, university, small business, and industry partners to develop innovative, cost-effective energy saving solutions—better products, better new homes, better ways to improve older homes, and better buildings in which we live and work. The United States has made significant progress in improving building energy efficiency over the last 30 to 40 years, due in part to the successful efforts of BTO. The Office's funded research has contributed to significant improvement in building energy efficiency including new technologies in solid-state lighting (SSL), energy saving windows, heat pump water heaters, and high-efficiency furnaces and air conditioners.

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While BTO works to improve the energy efficiency of homes and buildings, BTO and successful applicants must take steps in their research and development (R&D) activities to ensure that energy-efficiency solutions do not sacrifice the comfort of building occupants or the performance of labor-saving household appliances, products, devices, and equipment. To do so, BTO focuses on accelerating the pace of innovation in technologies for both new and existing buildings. BTO invests in R&D to deliver cost effective products and solutions that will improve energy productivity and enhance the services provided to building occupants. BTO's research also includes early-stage R&D on [grid-interactive efficient building](#) (GEB) technologies and approaches. Through GEB R&D, BTO enables industry and others to develop and deploy truly "smart" buildings capable of connecting with the power grid in new and increasingly adaptive manners. This leads to overall energy system affordability, efficiency, reliability, and resiliency.

ii. Technology Space and Strategic Goals

BTO's overall goal is to improve the energy productivity of buildings without sacrificing occupant comfort or product performance. The goal is to use energy more productively and efficiently, not simply to use less energy. Progress towards achieving this goal will make building energy costs more affordable to the benefit of American families and businesses.

The efficiency and affordability of consumer products have improved in part due to DOE research and development, resulting in increased adoption of energy-efficient technologies. For example, from 2008 to 2015, total installations of residential light emitting diode (LED) lightbulbs increased from under 100,000 to nearly 202 million. Over the same time, LED costs dropped by nearly 90%. Today LEDs account for 20% of all general lighting applications, up from 1% in 2010. DOE projects that by 2030, LEDs will reach 80% of all lighting sales, saving Americans \$26 billion per year in electricity costs.

Other examples include refrigerators and windows. Today, more than 100 million refrigerators in homes across the country use an advanced compressor that can trace its roots to DOE's R&D activities in the late 1970s. In fact, today's average refrigerator is 20% larger, has more features, costs half the price, and uses one-quarter the energy than it did four decades ago. Similarly, windows today "use" less than one-third the energy compared to windows before the 1970s. The core technology driving these advances was sponsored by DOE.

BTO research is focused on reducing energy intensity for major segments of the sector with the most opportunity for energy savings, while balancing the need to

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maintain occupant comfort and productivity, and product performance. This includes both new and existing buildings, both residential and commercial, including their energy-consuming and labor-saving equipment. The development of next-generation building technologies, including building materials, components, equipment, energy models and systems, is critical to increasing energy productivity in a cost-effective manner.

BTO's Emerging Technologies (ET) program invests in the research and development to create the next-generation building technologies, tools and systems to enhance energy efficiency. The program focuses on the most energy-intensive technologies for residential buildings, shown in **Figure 1**, and in commercial buildings, where the opportunity for cost-effective energy savings is greatest. These technologies include air conditioning, space heating, water heating, lighting and sensors & controls, all of which are addressed in this FOA.

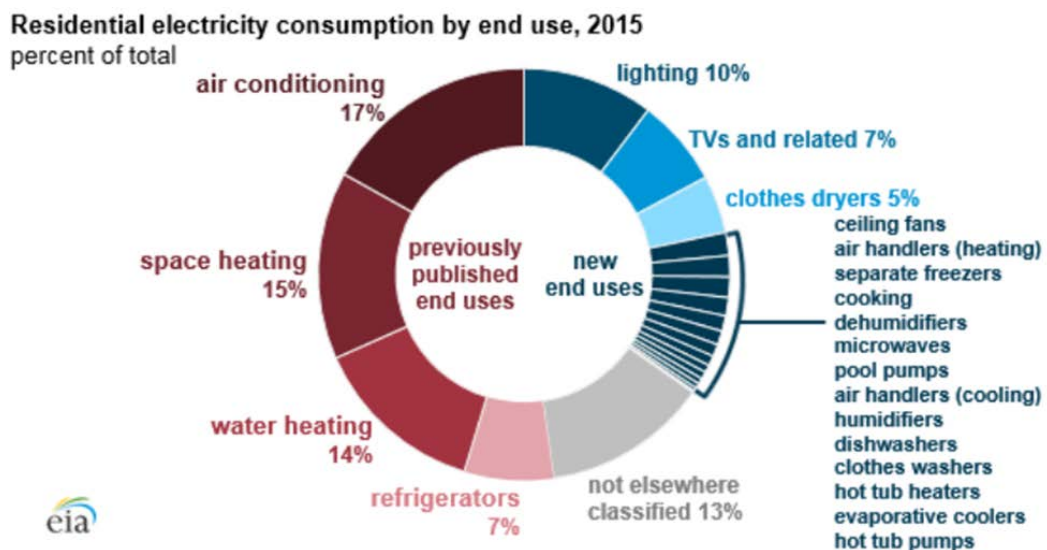


Figure 1: Source: U.S. Energy Information Administration, 2015 Residential Energy Consumption Survey

Improving the energy efficiency performance of the technologies in the ET program has the potential to provide significant energy savings on an annual basis compared to the Annual Energy Outlook (AEO) reference case, as show in **Figure 2**.

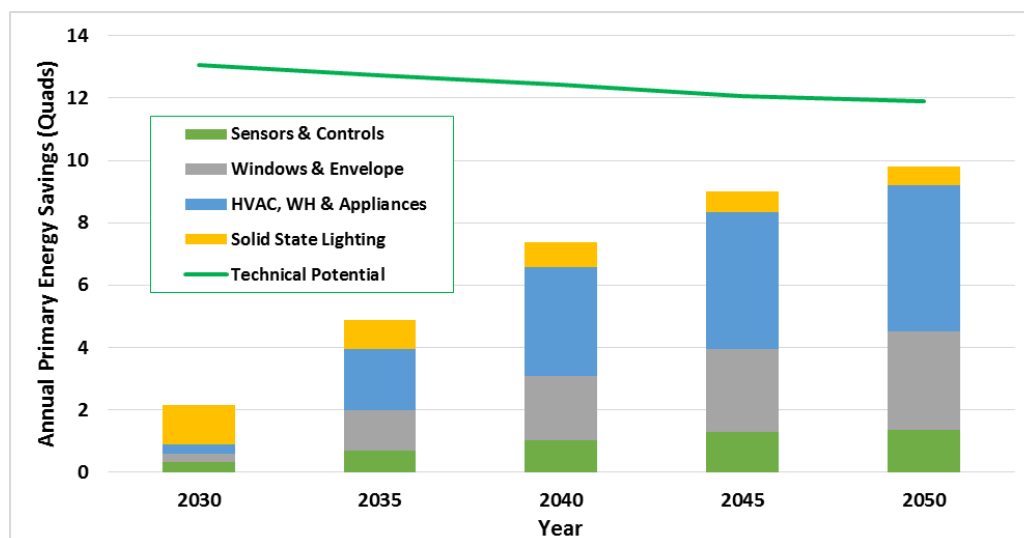


Figure 2: Annual Energy Savings, Compared to AEO Baseline, from Achievement of ET Goals by Technology Subprogram

Additional benefits can be provided through GEB. There are now almost 18 billion devices connected to the Internet globally, 7 billion of which are internet-of-things (IOT) devices and the market for these devices is accelerating rapidly. In 2015 this market was expected to grow by about 20% annually, it is now projected to grow by 39% annually.¹ BTO's GEB research will take advantage of the potential energy savings associated with these devices across the entire building sector, commercial and residential alike. The GEB vision will allow American businesses and families to save energy and reduce their utility bills automatically and without impacting comfort or productivity by allowing buildings to provide grid services through flexible building loads. BTO is an active participant in DOE's broader [Grid Modernization Initiative \(GMI\)](#), a comprehensive effort of different DOE offices and national laboratories with public and private partners to help shape the future of our nation's grid.

BTO has issued the BENEFIT FOA annually since 2014. The 2019 BENEFIT FOA will invest up to \$47 million, to allow all interested parties (universities, corporations, non-profits, national labs) to research and develop innovative technologies that will improve energy productivity, improve flexibility, security and resiliency, as well as lower energy costs. This year's BENEFIT FOA will also include funding for SSL R&D; BTO had issued the SSL FOA separately, each year since 2004.

B. Priority Research Areas

¹ IOT-Analytics, State of the IoT 2018: Number of IoT devices now at 7B – Market accelerating.

Achieving BTO's priorities across the building technology landscape requires sustained, multifaceted innovation. With this FOA, BTO intends to fund high-impact, early-stage research in the following areas:

Topic 1: Flexible Building Technologies

This topic supports early-stage R&D for dynamic energy efficiency technologies and techniques for existing and new, residential and commercial buildings. This work is aligned with BTO's demand flexibility strategy that integrates advanced sensing, controls and communication with flexible, energy efficiency technologies to advance the role buildings can play in the modernizing power grid. Research is focused on cybersecurity, advanced actuators and building controls, energy storage and performance verification for flexible building loads.

Topic 2: Heating, Ventilation and Air Conditioning (HVAC) Technologies

This topic supports the development of highly efficient technologies for thermal end-uses in buildings, including space conditioning, water-heating and refrigeration. These loads account for approximately half of the energy consumed in buildings, including 28% of the total amount of U.S. natural gas consumption.² Work is focused on early-stage R&D for non-vapor compression technologies and fuel-driven (including natural gas and propane and other alternative fuels) equipment, which have the potential to realize a step-change efficiency improvement over the current state-of-the-art technology. These alternatives to vapor compression can save energy through their improved scalability which allows them to be sized to better match load than can vapor compression technologies, thus greatly improving efficiency and lowering first cost. This topic also supports more mature absorption-based solutions for space conditioning, water heating and combination systems that optimize energy efficiency, reliability and energy affordability.

Topic 3: Solid-State Lighting (SSL) Technologies

This topic will support the development of highly efficient lighting technologies and systems to improve lighting energy efficiency. Research is focused on solving critical challenges in the efficiency of LEDs and organic light emitting diodes (OLEDs). In addition, the topic will address application-specific lighting efficiency. The topic will go beyond the efficiency of just the light source itself to provide the opportunity for the next generation of lighting systems to be developed. The goal is to generate light more efficiently but also more efficiently direct and control the use of light in buildings, without negatively impacting product performance.

Metrics, Current Status, Targets

BTO has provided detailed descriptions, performance metrics, and targets for each topic/sub-topic. Applicants must provide evidence or analysis as to how these targets can be met or exceeded by their proposed activities, without sacrificing the

² EIA Annual Energy Outlook 2019

comfort of building occupants or the performance of labor-saving products, devices, and equipment. BTO-provided descriptions, metrics, and targets are intended to be general representations and may not be relevant to all potential technology approaches. Accordingly, applicants must develop and present the proper metrics and targets specific to their proposed approach. Applicants must provide a detailed case as to how any applicant-provided metrics are meaningful towards technological advancement needed to meet the BTO- and EERE-set goals.

Priority will be given to approaches that demonstrate a pathway to exceeding the metric targets and goals identified within the FOA without compromising other aspects of performance. Certain sub-topics require applicants to report relevant performance metrics such as primary energy savings and cost effectiveness as measured by simple payback as described in Appendix F.

C. Topic Areas

Applications should clearly identify to which sub-topic they are applying. A single application should not submit to multiple sub-topics.

Topic Area 1: Flexible Building Technologies

Growing peak electricity demand, transmission and distribution infrastructure constraints,^{3,4} and an increasing share of variable renewable electricity generation are challenging the electrical grid.⁵ Flexible (and even, dispatchable) electricity loads can be used to address these issues, creating a more resilient and reliable grid while simultaneously making electricity cleaner and more affordable for consumers.

Operating an electricity grid is tantamount to balancing supply and demand at different time scales under the constraints of limited supply resources. Demand-side entities have traditionally contributed in limited ways; however, demand-side contributions may be just as viable. Buildings are a major potential source of cost-effective demand flexibility because building electricity use drives a significant amount of peak power demand in most of the country. With appropriate controls and communications equipment, buildings can manipulate flexible assets under

³ EIA, <https://www.eia.gov/todayinenergy/detail.php?id=15051>;
https://www.eia.gov/totalenergy/data/monthly/pdf/sec7_3.pdf;

⁴ DOE National Electric Transmission Congestion Study, 2015,
https://www.energy.gov/sites/prod/files/2015/09/f26/2015%20National%20Electric%20Transmission%20Congestion%20Study_0.pdf

⁵ DOE "A More Resilient Grid",
<https://www.energy.gov/sites/prod/files/2016/06/f32/A%20More%20Resilient%20Grid.pdf>

their control—e.g. lighting, water heating and HVAC.⁶ Today, these flexible assets, as well as other behind-the-meter distributed energy resources (DERs) such as photovoltaics, electric vehicles, and storage, are typically valued, scheduled, implemented, and managed separately. The vision of GEB is the integration and continual optimization of these resources for the benefit of the buildings’ owners and occupants, and the grid. **Table 1** provides a summary of how a range of GEB technologies can be used to provide integrated load management strategies and how these approaches differ from traditional energy efficiency and automated demand response.

Building Service	Energy Efficiency	Demand Response	GEB ⁷
Thermal Comfort Systems	<ul style="list-style-type: none"> • Building has insulated, tight envelope, and efficient HVAC system to provide occupant thermal comfort with low energy use. • Building has moderate amount of thermal mass to reduce heating/cooling needs. 	<ul style="list-style-type: none"> • Building changes temperature setpoint in response to grid signal. • Building can cycle HVAC systems in response to external demand response signals. 	<ul style="list-style-type: none"> • Building has significant amount of thermal mass, potentially using phase change materials, to support pre-cooling and coasting for long periods. • Building is aware of occupancy and occupant preferences and can raise cooling setpoints by varying amounts depending on electricity prices and grid signals. • Building integrates owner and occupant priorities for thermal comfort and other services and sheds load in priority order.
Lighting	<ul style="list-style-type: none"> • Building uses SSL along with daylighting and occupancy sensors to dynamically adjust lighting levels. 	<ul style="list-style-type: none"> • Building dims lighting by a preset amount in response to grid signals 	<ul style="list-style-type: none"> • Building incorporates occupants lighting preferences and can dim lighting by varying amounts in response to changing prices.
Water Heating	<ul style="list-style-type: none"> • Building has high efficiency heat pump or electric water heaters. 	<ul style="list-style-type: none"> • Building has connected water heaters that shift loads by pre-heating water during off-peak periods in response to grid signals. 	<ul style="list-style-type: none"> • Building has high efficiency and connected and controlled water heaters used to shift loads in response to external DR signals or to store excess energy from on-site generation.

Table 1: Strategies for Demand Flexibility: Integrated Energy Efficiency and Demand Response
Adapted from ACEEE⁸

⁶ There are three basic flexibility modes and these are referred to in shorthand as shed, shift, and modulate: Shed: The ability to reduce electricity use during the generation balancing area’s annual peak demand period(s) or during grid emergencies; Shift: The ability to change the timing of electricity use to minimize demand during peak events or to avoid renewable curtailment; Modulate: The ability to balance power demand or reactive power draw/supply automatically in response to a signal from the grid operator during the dispatch period.

⁷ Roth, K., Westphalen, D., Feng, M., Llana, P., Quartararo, L. (2005). “Energy Impact of Commercial Building Controls and Performance Diagnostics: Market Characterization, Energy Impact of Building Faults and Energy Savings Potential,” TIAX LLC.

⁸ K. E. Parmenter, P. Hurtado, G. Wikler, and C. W. Gellings, “Dynamic Energy Management,” 2008 Am. Council on Energy-Efficient Econ. Summer Study Energy Effic. Build., 2008.

In addition, two key capabilities are needed to enable integrated efficiency and demand response.

1. Individual devices, appliances, and equipment must be able to communicate, report on status, and respond to control commands.
2. The building, as a whole, must be able to intelligently monitor and coordinate these activities, with the preferences of occupants, and with changing conditions in the building and on the grid.

These capabilities, however, cannot be fully realized with traditional building controls because they are typically fragmented by end use and thus not holistic. Additionally, they are typically rule-based and designed to be reactive to only meet short-term occupant thermal and ventilation requirements. Unlike most traditional building control schemes that separately manage individual systems (e.g. lighting, thermal, ventilation), next-generation control systems must manage building loads in a coordinated, flexible manner to both meet energy-efficiency targets and for the benefit of the electric grid. To achieve this, advances in controls are focused on the ability to incorporate predictions (e.g., occupancy patterns, weather forecasts) in addition to current state information and execute optimization-based strategies across multiple building systems (e.g., HVAC, refrigeration, and lighting), as well as over longer time periods (e.g., hours and days rather than minutes) and multiple spatial scales (e.g., occupant, zone, whole-building, campus).

BTO's sensors and controls R&D sub-program aims to accelerate these transitions through a portfolio approach focused on the development of hierarchical, predictive and adaptive control approaches. In Figure 3, BTO analysis shows that at a portfolio-level, monitoring and control technologies are anticipated to save 1.4 quads in 2030 and 3.8 quads in 2050 through further technological advancements and increased sophistication of control strategies. This 2050 projection is equivalent to roughly 10% of the total energy consumption from the buildings sector in 2017.

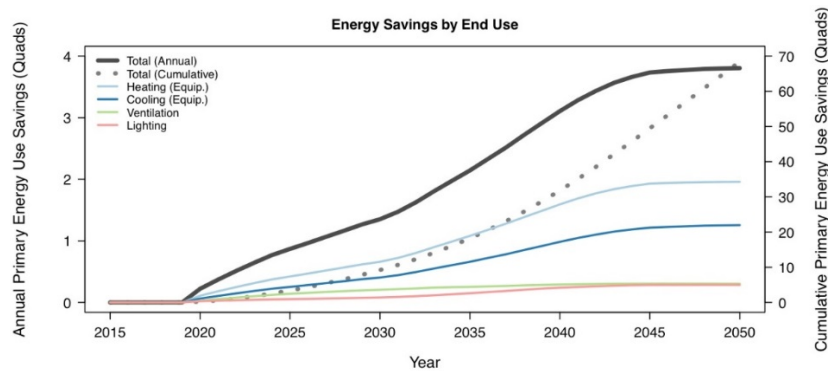


Figure 3: Maximum Adoption Energy Savings Potential in Total (Annual on the Left Axis and Cumulative on the Right Axis) and Across Applicable End Uses (Annual on the Left Axis) for Technological Innovations in Sensors and Controls for the Buildings Sector.

This topic includes early stage R&D and performance verification of efficient and flexible technologies for both existing and new residential and commercial buildings. This work is aligned with BTO's grid-interactive efficient buildings strategy that integrates advanced sensing, controls and communication with flexible, energy efficiency technologies to advance the role buildings can play in the modernizing power grid. Research is focused on cybersecurity, advanced actuators and building controls, energy storage, and performance verification for flexible building loads.

Topic Area 1 includes five sub-topics. Applications should clearly identify which sub-topic they are applying to and a single application should not submit to multiple sub-topics:

- Sub-topic 1a: Cybersecurity through Adaptive Building Controls
- Sub-topic 1b: Flexible Building Equipment Performance Verification
- Sub-topic 1c: Advanced Actuators
- Sub-topic 1d: Thermal Energy Storage Materials
- Sub-topic 1e: Embedded Energy Storage for Building Equipment

Applicants to this topic area are required to explain how their work will enable increased demand-side flexibility, integration and energy storage capabilities, without negatively impacting occupant comfort or product performance.

Sub-topic 1a: Cybersecurity through Adaptive Building Controls

BTO seeks applications to address the challenges of detecting anomalous behavior in building energy operating conditions originating from cyber- attacks and to develop effective responses to these types of risks through adaptive control strategies. Building energy management systems work by integrating sensing and actuation with computing and communications to monitor and control the physical world. These systems need to accommodate current state-of-the-art security practices and procedures that are regularly updated to mitigate potential attack scenarios and

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vulnerabilities that might pose a risk to, and ultimately compromise the performance of, these systems.

In addition to limited energy efficiency performance, traditional rule-based control methods are restricted in their ability to respond to cyber-attacks due to their reactive, *if-then* logic. Emerging control methods in buildings, such as model predictive control, are better suited to respond to anomalous behavior caused by cyber-attacks. Such methods can adapt and learn over time to update predicted system outputs and future control actions. These systems can incorporate security risks as a variable to optimize against.

The incorporation of automated and accurate techniques to detect and diagnose the root cause of faults, regardless of their source, is also important to achieving building energy efficiency goals. Faults in building operations in the commercial buildings sector alone lead to approximately 0.3-1.8 quads of wasted energy in the U.S. each year.⁹ A median energy savings of 17% is reported with the successful implementation of current state-of-the-art techniques for automated fault detection and diagnostics (AFDD).¹⁰ This is achieved when AFDD is used to determine the cause of and correct for differences between actual and optimal building performance using data collected from a building automation system. BTO has a goal of 30% energy savings by 2030 for HVAC loads in the commercial sector through the development and implementation of advanced controls that incorporate AFDD with a cost target of \$0.14/ft² floor.¹¹

Two of the main challenges with current state-of-the-art AFDD are implementing whole-building approaches and properly isolating and diagnosing the root cause of faults in an automated manner. Anomalous behavior can be caused by issues such as normal equipment wear and tear, operator error, or incorrect implementation of control logic along with software errors and glitches that manifest themselves in different ways. These conditions can also be the result of a cyber-related attack. Diagnosing the root cause of detected faults can be challenging because unique patterns or symptoms may not be present, and information provided from the monitoring of conditions is not always sufficient. This lack of information can limit the control system's response to anomalous behavior. It can also limit the development of resilient controls to automatically isolate attacks and maintain

⁹ Roth, K., Westphalen, D., Feng, M., Llana, P., Quartararo, L. (2005). "Energy Impact of Commercial Building Controls and Performance Diagnostics: Market Characterization, Energy Impact of Building Faults and Energy Savings Potential," TIAX LLC

¹⁰ Sofos, M., Langevin, J.T. (2018). "Laying Down the Foundation: An R&D Roadmap for Energy Savings through Advancements in Smart Building Technologies," 2018 ACEEE Summer Study on Energy Efficiency in Buildings.

¹¹ Roadmap to Achieve Energy Delivery Systems Cybersecurity.

https://www.energy.gov/sites/prod/files/Energy%20Delivery%20Systems%20Cybersecurity%20Roadmap_finalweb.pdf

continuity of operations with limited impact on delivery of energy services and occupant comfort.

This sub-topic addresses the further development of control capabilities at the building-level to detect and adapt to cyber-related threats. Proposed approaches should maximize the potential energy savings that advanced controls are designed to deliver by minimizing potential disruptions caused by cyber-related faults.

Acceptable approaches under this sub-topic include:

- Techniques to analyze anomalous network behavior and/or physical system responses that can properly identify faults originating from a cyber-attack or malicious activity to properly isolate the fault and respond to an attack.
- Optimization-based control strategies that incorporate and learn from cyber-related faults, attack strategies, and vulnerabilities to anticipate and respond to future attacks.
- Deceptive capabilities that can mislead the attacker and reveal its presence to the building control system.

Applicants can choose to address one, more than one, or all of these areas. Other approaches that advance the response, mitigation, and prevention of cyber-attacks through adaptive of building control schemes are also encouraged. Approaches which can be applied to other EERE technology areas in addition to buildings will be considered for co-funding with other offices.

Sub-topic 1b: Flexible Building Equipment Performance Verification

BTO's GEB research will enable buildings to harness the flexibility of their equipment and loads and deploy that flexibility in response to grid needs. Buildings will consider efficiency and grid needs simultaneously and co-optimize them while meeting the needs of their occupants. To achieve this, researchers and industry require high-resolution data sets about equipment performance. Today, there is limited availability of public data sets. BTO seeks the development of publicly available data sets that measure the performance of energy efficient building technologies and control systems to provide grid services using hardware-in-the-loop (HIL) test methods. Successful approaches will collect and share high-resolution performance data to verify the building equipment's ability to change the building's electric load. Suitable data sets must quantify the flexibility provided by individual components and systems, determine the ease of control, and evaluate the acceptance of change to the occupants; while providing grid services such as those identified in **Table 2**.

Flexibility Modes	Load Change Characteristics	Example Measures & Technologies	Technical Requirements for Grid Services	
			Description	Frequency of Events
Efficiency	Building technologies are installed that provide persistent reduction in the annual energy use to provide the same or improved function.	Building has insulated, tight envelope and efficient HVAC system to reduce heating/cooling energy needs. Bui	The building must sustain reduced energy use, as verified by metered energy use data.	Continuous
Shed load	Building reduces demand for a short time period during peak demand or emergency events.	Building dims lighting system by a preset amount in response to grid signals while maintaining occupant visual comfort levels.	To provide contingency reserves, the building must reduce a load within 10-30 min of receiving a signal and may need to sustain load reduction for up to 1 hour.	20 times/yr - continuous
Shift Load	Building changes the timing (and sometimes the amount) of energy use to minimize peak demand or to take advantage of renewable resources.	Connected water heaters pre-heat water during off-peak periods in response to grid signals.	To avoid renewable curtailment, the building must align energy use with times of cheapest electricity (using utility time-of-use pricing).	Daily
Modulate Load	Building automatically increases /decreases power demand or reactive power draw/supply in response to grid operator signals.	Batteries and inverters autonomously modulate power draw to help maintain grid frequency or control system voltage.	To provide power support and ramping services, the building must modulate power within seconds/ sub-seconds and receive automatic control signals. Advanced telemetry is required for output signal transmission to grid operator.	Continuous

Table 2: Flexibility Modes for Building Equipment

HIL methodologies are desired because they allow for the physical testing of hardware under simulated field conditions. This enables researchers to run equipment through an expanded range of test conditions and reduces the time and costs typically associated with fully deployed field studies. Testing schemes should leverage advanced simulation capabilities that incorporate verification of hardware to reflect and document actual and/or unanticipated hardware responses to efficiency and grid needs.¹² Such coupled hardware and simulation verification

¹² Lauss, G.F., Faruque, M.O., Schoder, K., Dufour, C., Viehweider, A., and Langston, J. (2016). Characteristics and design of power hardware-in-the-loop simulations for electrical power systems. IEEE Transactions on Industrial Equipment, 63, 406-417

methods offer a beneficial hybrid of lab-based and in situ test settings, enabling fine control over the range of test scenarios considered while accurately emulating device or system performance in the field. Resulting data sets should include high resolution, variable performance characteristics of building equipment and systems to ensure that simulation tools can produce more accurate and time-sensitive representations of flexible building thermal and electric loads.¹³

Example outcomes from this sub-topic include:

- Documenting the capabilities of, and collecting load profile data from, a single piece of equipment (such as a rooftop unit, residential water heater, variable refrigerant flow HVAC system, etc.) under a set of simulated zone conditions to provide a grid service or services while also handling building or zone-level requirements; and how this equipment responds in expanded scenarios based on new building types, climates, or energy pricing.
- Documenting the interaction of two or more integrated pieces of equipment as they respond to meet building energy, comfort, and service requirements, and a range of grid signals including peak shifting, smoothing, and baseload reduction.

Applicants are required to:

- Identify the behind-the-meter building equipment or systems to be evaluated. Approaches which incorporate energy storage and distributed generation technologies are acceptable; however, a successful approach must also incorporate an evaluation of at least one piece of major building equipment.
- Evaluate the capability of building equipment or systems to provide at least one of the flexibility modes, in addition to efficiency, such as those categorized in **Table 2**.
- Identify a specific HIL verification strategy which includes a description of how the hardware will be integrated with the simulation and how onboard device control will be leveraged or addressed.
- Describe the methodology to be used for accurately collecting high resolution data to validate simulation tools.
- Address occupant variables, integrated and additive performance across one or more devices (including interactions with on-board controls, trade-offs with devices at the zone, connectivity, response rate, interoperability, operation on failure, and autonomous learning and adaptation), and premature component failures.
- Identify a utility or distributor partner to contribute to the verification and assessment of the hardware potential.

The following approaches are discouraged from applying under this sub-topic area:

¹³ Lawrence, T., M. Boudreau, L. Helsen, G. Henze, J. Mohammadpour, D. Noonan, D. Patteeuw, S. Pless, R. Watson, (2016). *Ten questions concerning integrating smart buildings into the smart grid*. Building and Environment, 108, 273-283.

- Validation approaches which are based solely on simulation or demonstration in real buildings or do not incorporate testing of building equipment.
- Approaches which exclusively investigate building envelope, windows, or any building equipment/appliance outside of the context of benefits the equipment can provide to the grid.

Sub-topic 1c: Advanced Actuators

Accurate, reliable, and affordable actuators are necessary to execute control strategies that deliver energy efficiency and manage demand flexibility across building loads. BTO seeks applications that address current gaps in actuator performance compared to emerging sensors and control logic. Managing energy use in buildings relies on sensors that monitor operating conditions (e.g., temperature) and send collected measurements to controller devices and actuators that perform actions (e.g., valve adjustment) based on output signal control logic from the controller devices. BTO's sensors and controls goal is to achieve 10% total energy savings by 2030 compared to total 2017 primary energy consumption levels in the buildings sector. These savings are dependent on innovations in the intelligence and automation of sensor and control technologies to optimize building operating conditions. The achievement of these savings is also dependent on aggressive cost targets of \$29/node in the residential sector and \$57/node in the commercial sector by 2030. Achieving these cost targets will increase the pervasiveness of monitoring through innovations in sensing and wireless network infrastructure.¹⁴

Advancements in digital functionality can play a significant role in fully harnessing the capabilities of building controls systems. The lack of a complete shift to digital-based components has limited the full exploitation of intelligent operations. For example, many actuators are still pneumatic rather than digital-based electric. This results in common and difficult to diagnose faults (e.g., stuck dampers) or incompatibility with newer systems. While up-front component costs of electric actuators can be higher than their mechanical counterparts, long-term maintenance costs are generally lower. The higher component costs often deter the use of electric actuators.

BTO seeks innovative actuator technology development across the buildings sector spectrum. Acceptable approaches may include the conversion of pneumatic actuators to digital-based actuators. Also accepted are approaches with improved response rates that can match enhanced monitoring and data inputs (e.g., occupancy variables such as comfort, behavior) from innovations in sensors and networking. All proposed solutions should demonstrate integration into wireless-

¹⁴ Sofos, M., Langevin, J.T. (2018). "Laying Down the Foundation: An R&D Roadmap for Energy Savings through Advancements in Smart Building Technologies," 2018 ACEEE Summer Study on Energy Efficiency in Buildings.

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sensor networks and existing control systems with a payback period of less than 2 years. Payback calculations must be done using Appendix F.

Sub-topic 1d: Thermal Energy Storage Materials

BTO seeks the advancement of thermal energy storage materials and an understanding of the limitations, such as high cost and low energy density, which contribute to their underutilization in buildings. Approximately half of the energy consumed in buildings is for thermal end uses.¹⁵ Energy storage materials that increase a building's thermal mass provide the flexibility to time-shift demand on hourly or seasonal time scales. By time-shifting consumption, building owners and occupants can gain the ability to consume energy during more favorable periods. Time-shifting may be done to reduce demand charges, to take advantage of time-of-use (TOU) rates, to better match photovoltaic (PV) output, to improve the efficiency of the grid, or to gain resilience in the face of power outages or other disruptions.

Applications of interest include advanced chemistries that make thermal storage materials more suitable for building applications and encapsulation materials that mediate heat transfer and prevent contamination of the thermal storage material with the external environment. Novel sensible, latent, and thermochemical thermal energy storage advancements will be considered.

Tunable thermal storage technologies are highly desired. This includes materials with the ability to dynamically regulate their heat transfer rate (i.e., ramping speed) in and out of the storage medium and phase change materials (PCMs) with tunable phase transition temperatures (T_t). Of particular interest are PCMs with T_t that can be adjusted within the range of typical heating and cooling season temperature setpoints, though any thermal energy storage materials with $T_{t,max} - T_{t,min} \geq 2^\circ\text{C}$ that can, for instance, keep PCMs in a "cooled" state until deployed to shift/shed peak loads would be valued.

Paraffins are currently the most widely used PCMs in building applications, yet their high cost, low volumetric energy capacities, and high combustibility are major barriers to their widespread acceptance. These factors underline the need to shift the focus away from paraffinic PCMs. Two intriguing PCM classes are bio-based and inorganic salt hydrates. Bio-based PCMs are a renewable, cheap, and eco-friendly alternative to paraffins. Desired research for bio-based PCMs includes refining their phase transition properties and improving the manufacturing process. Inorganic salt hydrates and their eutectics have features that show great promise as primary PCMs for building applications. These features include high volumetric energy densities and suitable transition temperatures that can be achieved at low cost. However, technical challenges remain which include excessive subcooling effect, incongruent

¹⁵ EIA Annual Energy Outlook 2018

melting and phase segregation during transition, corrosiveness, and difficulty in efficiently microencapsulating. Overcoming these barriers with low-cost and stable (e.g., chemically, physically, thermally) salt hydrate PCMs and encapsulation materials offer great value.

Thermochemical energy storage technologies are promising because they have potentially high energy densities and display the possibility of storing energy for long periods of time with negligible self-discharge. Research in this field is nascent, though, leaving these technologies currently unavailable for building applications. As such, advances are needed to optimize their operating requirements including, but not limited to, operating temperatures, multi-cycling efficiency, material cost, and appropriate systems design for building applications.

Thermal storage technologies must be deployable in buildings and are therefore subject to several constraints. Preference will be given to non-toxic, non-combustible, low-odor materials with long lifetimes. Materials should aim for transition temperatures that can be safely deployed in building contexts. BTO is specifically interested in materials that can address the size and weight constraints that make some thermal storage technologies impractical for typical buildings.

Future research activities should be focused on validating and improving the performance of materials with the highest potential to possess characteristics outlined in **Figure 4** and **Table 3**. While proposed approaches are not required to meet all the listed characteristics, they should demonstrate a path towards meeting the performance targets and characteristics laid out in **Table 3**. Approaches should also address any system integration considerations and other important process parameters specific to the material being proposed. All research should be on the highest caliber materials to yield the clearest possible results and potential for building applications.

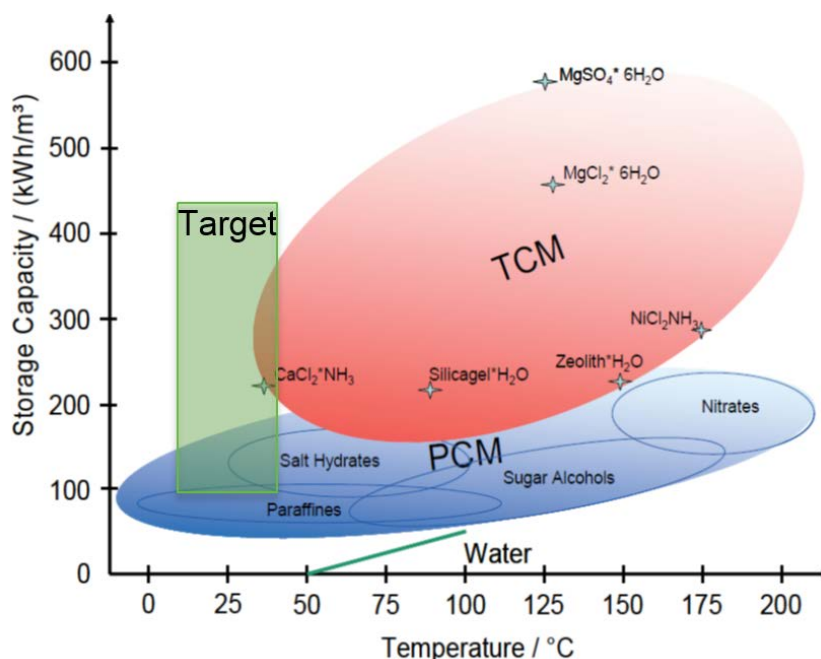


Figure 4: Target for Next Generation Thermal Storage Materials¹⁶
(TCM = Thermo-Chemical Material; PCM = Phase Change Material)

Metric Description	Metric	Clarifying Details
Phase Change Temperature	Achievable range of transition temperatures	Operating temperatures need to be appropriate for building applications. Each application group has different temperature requirements.
Large-scale availability and low price	<\$15/kWh _{thermal}	The price of the raw material and the encapsulation process determine the cost of the thermal energy storage product. Materials should be low cost and abundant for scalability.
Energy density	>100 kWh/m ³	
Thermal conductivity	>1 W/m·K	Impacts charging/discharging time. A suitable heat exchange is required.
Thermal reliability (Efficiency after thermal cycles and aging)	>90% after >5000 cycles	Performance over several thermal cycles. Minimum of 5000 cycles are required for approximately 13-14 years.
Non-toxic, non-flammable, non-	Requirement	Safety requirement for building applications

¹⁶ Laevemann E, Energiespeicher Thermische. *Theoretische Grenzen und Beurteilungskriterien*, presented at the Experten-Workshop Thermische Speicher: Potentiale und Grenzen der Steigerung der Energiespeicherdichten, Berlin, Germany; June 2010.

explosive and non-reactive		
Non-corrosiveness	None or minimized	Compatibility with other materials, such as encapsulation materials
Volume variations during phase transition	Minimized	
No phase segregation or separation	Minimized	Assure a long lifetime
Subcooling/supercooling	Minimized; <2°C	To assure that melting and solidification (or phase change transition) can proceed in a narrow temperature range.
Round-trip efficiency	Maximized	Ratio of thermal energy retained in the charging-discharging process.
Self-discharge	Minimized	Rate at which stored thermal energy is depleted as a function of time.

Table 3: Targets and Characteristics for Next Generation Thermal Storage Materials

All applicants under this sub-topic are required to report relevant performance metrics such as primary energy savings and cost effectiveness as measured by simple payback, as described in Appendix F.

Sub-topic 1e: Embedded Energy Storage for Building Equipment

BTO seeks the development of new equipment and technologies that seamlessly integrate energy efficiency and energy storage (electrical and/or thermal) into a single piece of equipment to reduce demand loads and increase demand-side flexibility while maintaining occupant comfort.

Technological advancements have allowed for higher efficiency building equipment, but new technologies and approaches are needed that go “beyond batteries” and simple operational efficiency. The need exists to integrate building equipment synergistically into a seamless system. The emphasis of this sub-topic is on the integration of the energy storage technology into the equipment rather than a building scale energy storage system. System performance targets, not energy storage targets, are shown in **Table 4**. These technical requirements have been developed to reduce the load of the equipment by 50% during peak periods over a 4-hour time period and should be compared against equivalent energy efficiency rated equipment. While approaches are not required to meet all the characteristics in **Table 4**, approaches should demonstrate a path toward meeting the performance targets and characteristics laid out in the table. They should also address any system integration considerations specific to the application.

System Metric Description	System Metric	Details
Demand reduction	50%	During periods of peak demand.
Time Period	4 hours	If the equipment only performs a function/feature infrequently (e.g. once a day), a more appropriate time

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		or cycle can be used as defined by DOE's method of test for that equipment. If the waste thermal energy is captured and used for the following duty cycle, the steady state cycle can be used in the calculation, a typical usage pattern for that equipment, e.g. daily, weekly, etc.
Volume	Less than or equal to 10% increase	This is with respect to the baseline unit, same energy efficiency rating as used in DOE's standard methods of test.
Weight	Less than or equal to 20% increase	This is with respect to the baseline unit, same energy efficiency rating as used in DOE's standard methods of test.
Simple payback period	Less than 5 years	The system cost includes all part for operation, including all energy storage parts and subcomponents.
Ability to start and stop multiple times per day without as required for the equipment lifetime	Requirement	
Lifetime for equipment including energy storage	Same as baseline unit	
Service and installation requirements	Same as baseline unit	

Table 4: Targets for Embedded/Integrated Energy Storage for HVAC, Water Heating and Appliances

All applicants under this sub-topic are required to report relevant performance metrics such as primary energy savings and cost effectiveness as measured by simple payback, as described in Appendix F.

Topic Area 2: Heating, Ventilation and Air Conditioning (HVAC) and Related Technologies

Thermal end uses – HVAC, refrigeration, water heating, and appliances – accounted for nearly 22 quads of primary energy consumed in the United States in 2018.¹⁷ This is the largest residential and commercial end-use of energy for U.S. buildings. About one-third of that energy comes from natural gas; nearly half of American homes use gas as their predominant heating fuel¹⁸. In the U.S. natural gas is a secure fuel that provides energy independence since nearly all natural gas consumed is produced domestically.

¹⁷ Annual Energy Outlook, U.S. Energy Information Administration, Table A4 Residential Sector Key Indicators and Consumption and Table A5 Commercial Sector Key Indicators and Consumption, <http://www.eia.gov/forecasts/aeo/>, accessed 2/07/2019

¹⁸ EIA. 2015. "Residential Energy Consumption Survey." U.S. Energy Information Agency. Accessed October 2, 2018: <https://www.eia.gov/consumption/residential/data/2015/hc/php/hc1.9.php>

This topic supports the development of highly efficient technologies for thermal end-uses in buildings, including space conditioning, water-heating, and refrigeration. Work is focused on early-stage R&D for non-vapor compression technologies and fuel-driven (including natural gas and propane and other alternative fuels) equipment. This topic also supports more mature absorption-based solutions for space conditioning, water heating, and combination systems that optimize energy efficiency, reliability, and energy affordability.

Most space conditioning systems and water heating appliances rely on old technologies: vapor-compression and heat-of-combustion systems. These approaches have effectively and efficiently served building needs for some 100 years or longer. Vapor compression and fuel-fired technologies remain dominant due to their low first cost, high reliability, and other attractive attributes.

BTO seeks transformative non-vapor compression and thermal heat pump technologies with a coefficient of performance (COP) greater than 2. This increase in performance could achieve a 10-fold improvement in annual energy savings compared to the 2018 performance guidelines (covering minimum federal standards and other requirements). It represents an energy efficiency potential improvement greater than 50% compared to BTO's baseline and a paradigm shift in technology.

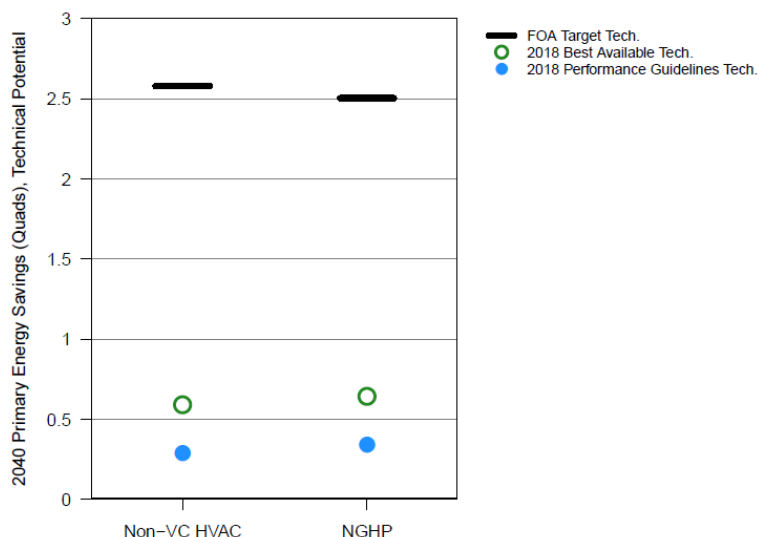


Figure 5: HVAC Technologies Annual Energy Savings Potential

Air conditioning (A/C) and refrigeration are responsible for a rapidly growing share of worldwide energy consumption. A/C equipment and systems today represent close to a \$100 billion per year global market. While adoption of A/C in developed countries increased rapidly in the 20th century, the 21st century will see much greater adoption in developing countries. This is especially true in hot climate locations with large and growing populations. This presents a global energy challenge. However, it also presents an opportunity to grow U.S. exports. The

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International Energy Agency (IEA) projects that, by 2050, A/C energy consumption will increase 4.5 times over 2010 levels for non-Organization of Economic Coordination and Development (OECD) countries while OECD countries will increase 1.3 times. These growth markets have enhanced dehumidification requirements that are similar to those in the U.S. Technology innovations developed under this FOA will help enable U.S. manufacturers to enhance their competitiveness and increase exports of HVAC equipment to major growth markets.^{19,20}

Building equipment driven by natural gas and other fuels²¹ has the potential for significant energy savings. Most currently installed fuel-driven devices have a COP_{heating} of less than 1 because conventional fuel-driven technologies use heat derived directly from the combustion of fossil fuels. They are efficiency- and performance-limited since heat is generated without taking advantage of existing thermal energy in the ambient environment. While some advanced natural gas systems are available, existing systems are currently too expensive and may not be sufficiently reliable to achieve widespread adoption. This FOA topic seeks to move the industry beyond condensing technologies and into the next generation of fuel-fired equipment through the development of fuel-driven solutions with a COP_{heating} greater than 2. To achieve this performance target, technologies must leverage advances in material science and novel thermodynamic cycles. Compact heat exchange in high-temperature (greater than 450°C) applications and/or with unconventional working fluids will play an important role.

Topic Area 2 includes two sub-topics. Applications should clearly identify to which sub-topic they are applying to and a single application should not submit to both sub-topics:

Sub-topic 2a: Non-Vapor Compression Heating, Ventilation and Air Conditioning (HVAC) technologies

Sub-topic 2b: Fuel-Driven Building Equipment

Sub-topic 2a: Non-Vapor Compression Heating, Ventilation and Air Conditioning (HVAC) Technologies

BTO is seeking transformational non-vapor compression HVAC technologies to move beyond refrigerants. BTO has published a technical report on the *Energy Savings Potential and Research, Development and Demonstration Opportunities for Non-Vapor-Compression HVAC Technologies*²² to identify promising non-vapor

¹⁹ Goetzler, W., et al. 2016. "The Future of Air Conditioning for Buildings." U.S. Department of Energy Report DOE/EE-1394, July. <https://www.energy.gov/eere/buildings/downloads/future-air-conditioning-buildings-report>

²⁰ University of Birmingham, 2015. "Doing Cold Smarter." Birmingham Energy Institute. <http://www.birmingham.ac.uk/Documents/college-eps/energy/policy/Doing-Cold-Smarter-Report.pdf>

²¹ Includes propane and other fuels

²² <http://energy.gov/eere/buildings/downloads/non-vapor-compression-hvac-technologies-report>

compression technologies. These technologies include magnetocaloric, thermoacoustic, and thermoelectric cooling. Each of these has been explored for many years with very limited commercial success. The goal of this sub-topic is to support early-stage R&D that will enable the commercial success of these, and other, technologies for both residential and commercial buildings by 2030. Successful approaches should address the desirable characteristics listed below but are not required to address all of them. Successful approaches must also demonstrate a path to achieving the required system performance targets.

Included in this topic are hybrid technologies that are not purely based on vapor compression technologies. Separate Sensible and Latent Cooling (SSLC) A/C systems, specifically technologies that have high performance under extreme conditions (i.e., above 60% relative humidity), are also encouraged. SSLC systems have potential to save 30% of energy when compared with a conventional baseline system.²³ BTO is also interested in enhanced dehumidification capabilities that can operate at partial load or at lower cooling set points.

Required system performance targets:

- Seasonal COP_{cooling} = 12.3
- Installed cost per unit in 2019\$ = \$2,630
- Installed cost per kBtu/h cooling in 2019\$ = \$12

Desirable characteristics:

- Part-load performance
- Flexible performance to provide grid services, such as those listed in sub-topic 1b
- Net zero water consumption
- Reduced size and/or weight relative to today's high efficiency units
- Readily available materials

All applicants under this sub-topic are required to report relevant performance metrics such as primary energy savings and cost effectiveness as measured by simple payback, as described in Appendix F.

Fuel-fired solutions should be submitted sub-topic 2b of this FOA and are not acceptable to this sub-topic.

Sub-topic 2b: Fuel-Driven Building Equipment

BTO seeks the development of technologies that can enable transformative change to fuel-driven (including natural gas, propane and other alternative fuels) building

²³ Ling, Jiazhen; Hwang, Yunho; and Radermacher, Reinhard, "Theoretical Study on Separate Sensible and Latent Cooling Air Conditioning System" (2008). International Refrigeration and Air Conditioning Conference. Paper 902. <http://docs.lib.purdue.edu/iracc/902>

equipment (HVAC, water heating and appliances) with a COP_{heating} greater than 2. This sub-topic also includes all associated sub-components that directly or indirectly impact the performance and cost of fuel-driven equipment. It includes the development of new technologies and practices that radically change installation, operation, maintenance, and service. This sub-topic also includes compact heat exchange for high-temperature (greater than 450°C) applications.

Conventional fuel-driven technologies using heat derived directly from the combustion of fossil fuels are efficiency- and performance-limited since heat is generated from the fuel directly without taking advantage of existing thermal energy in the ambient environment. Advanced fuel-driven technologies are currently too expensive and unreliable to achieve widespread use. The goal of this sub-topic is to support early-stage R&D that will enable the commercial success of advanced fuel-driven technologies over today's state-of-the-art systems using the same fuel. Successful approaches should address the desirable characteristics listed below but are not required to address all of them. Successful approaches must also demonstrate a path to achieving the required system performance targets. Applicants are required to identify the projected system performance ($COP_{\text{heating}} > 2.0$) and support this calculation in the discussion.




Required system performance targets:

- Seasonal $COP_{\text{heating}} = 2$
- Installed Cost per Unit in 2019\$ = \$3,930
- Installed cost per \$/kBtu/h cooling in 2019\$ = \$21

Desirable characteristics:

- Acceptable reliabilities, maintenance intervals, and life expectancies
- Similar levels of product safety
- Low cost, on both first and life cycle bases

A recent BTO report on Natural Gas R&D Opportunities²⁴ identified key research technology gaps as shown in **Table 5**.

Rank		Category	Initiative Description	Score
1		Gas heat pumps	Development of reversible cycle absorption heat pump (GAHP) appliances with high efficiency cooling (to enable year-round use and better competition with electric A/C)	3.6
2		Combined Heat and Power (CHP)	Development of grid-responsive CHP systems (~100-500 kW) to enable performance optimization (including electrical and thermal storage for rapid-response controls).	3.5
3		Boilers & Furnaces	Development of energy recovery solutions to boost natural gas equipment efficiencies and resiliency through electric generation.	3.5

²⁴ <https://www.energy.gov/sites/prod/files/2018/08/f55/bto-Natural-Gas-RD-Opportunities-082918.pdf>








Rank		Category	Initiative Description	Score
4		Manufacturing	Development of equipment designs and/or manufacturing methods for cheaper manufacturing of NG equipment (e.g. gas fired HP heat exchanger mfg.).	3.45
5		CHP	Development of improved and/or lower cost combined cooling, heat, and power (CCHP) systems (aka Trigenation)	3.45
6		Materials	Development of novel materials or processes to improve cost-effectiveness of regenerating desiccants using natural gas	3.4
7		Gas heat pumps	Development of new or improved gas HP absorption cycles to improve efficiency in cold climates	3.4
8		Boilers & Furnaces	Development of improved multi-fuel/hybrid systems that optimize for cost and emissions	3.3
9		Heat & heat/mass exchange	Development of membrane-based heat and mass exchangers with higher throughput of fluid	3.1
10		CHP	Improve performance of small natural gas engines for microCHP and small gas heat pump (GHP) applications (improved efficiency, longer useful life, and fewer servicing requirements)	3.1

Table 5: Priority Research Needs for Natural Gas Technologies in Building Applications

Also include under this sub-topic are approaches that directly align with congressional direction, “for [the] research, development, and market transformation ... related to the direct use of natural gas in residential applications, including gas heat pump heating and water heating, on-site combined heat and power, and natural gas appliance venting.”²⁵ This includes nearer-term absorption-based solutions for space conditioning, water heating, and combination systems that optimize the efficiency, reliability, affordability, and cost-effectiveness of energy.

All applicants under this sub-topic are required to report relevant performance metrics such as primary energy savings and cost effectiveness as measured by simple payback, as described in Appendix F.

Topic Area 3: Solid-State Lighting (SSL) Technologies

BTO’s SSL program was created in response to Congressional direction described in Section 912 of the Energy Policy Act (EPACT) of 2005. EPACT directs DOE to “Support research, development, demonstration, and commercial application activities related to advanced solid-state lighting technologies based on white light

²⁵ H.R. 5895, Energy and Water, Legislative Branch, and Military Construction and Veterans Affairs Appropriations Act, 2019

emitting diodes.”²⁶ Lighting accounts for roughly 10% of the electricity use in the building sector and 8% of total U.S. electricity use.²⁷ The specific goal of the SSL program is: By 2030, develop advanced SSL technologies that – compared to conventional lighting technologies – are much more energy efficient, longer lasting, and cost competitive, by targeting a product system efficiency of 50% with appropriate application spectrum.

BTO supports foundational R&D topics with benefits that apply across the value chain and that are not typically undertaken within the lighting industry. This early-stage R&D advances the understanding of underlying physical phenomena, explores new technical and fabrication approaches, and develops an understanding of application requirements that improve lighting effectiveness. BTO-supported R&D reduces the development risk with new technologies while simultaneously improving efficiency and maximizing energy savings. Despite rapid progress in SSL technologies, significant advancements in performance and scientific understanding remain. Advancements in SSL technology have highlighted gaps in understanding at not only the material-device level, but also at the lighting science level. Research in these areas will enable the next level of performance advancements for SSL. Ongoing innovation and breakthroughs in materials, devices, advanced fabrication processes, and integration are needed to realize the full potential of the technology. In addition, at the lighting science level, the SSL technology platform raises new questions as to the effectiveness of the quality, delivery, and control of lighting.

SSL, particularly LED-technology, is on course to become the dominant technology across all lighting applications. The luminous efficacy, as measured in lumens per watt (lm/W), of SSL continues to advance toward the practical limit of 255 lm/W for phosphor-converted LED architectures and the ultimate theoretical limit of 325 lm/W for direct emitting architectures, as shown in **Figure 6**.

²⁶ The Energy Policy Act of 2005 (Pub.L. 109–58), Section 912

²⁷ Based on EIA data; <https://www.eia.gov/tools/faqs/faq.php?id=99&t=3>

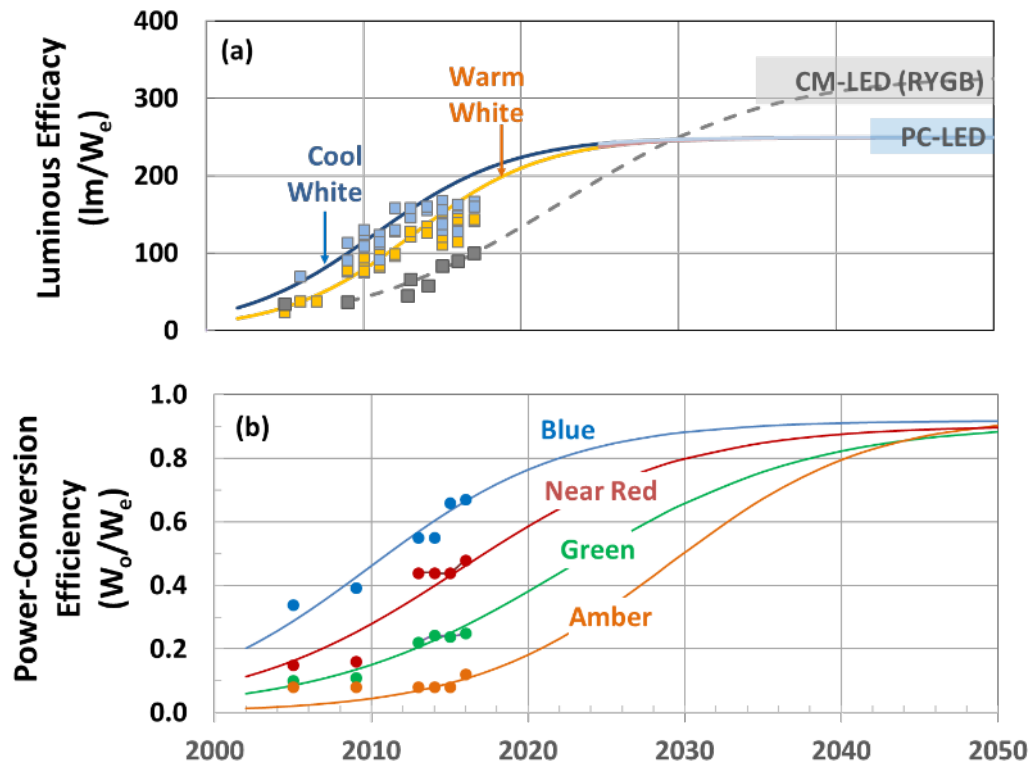


Figure 6: Lighting Efficacy and Efficiency Status and Projections over Time to Targets

Beyond LEDs, advancements in OLEDs are also needed to achieve efficiency targets. OLED lighting offers an intriguing performance and production counter-point to LED lighting. By its very nature, OLED lighting is diffuse. Every other lighting technology, including LEDs, requires optical diffusion to protect occupants from the bright light source's glare. Significant performance and cost barriers remain for OLED lighting. OLED efficacy greatly lags LED efficacy at approximately 90 lm/W with a target of 190 lm/W . However, there may be application-specific energy efficiency advantages. OLED lighting technology needs ongoing R&D to improve efficiency at the material, device, and light extraction levels. Additionally, these advancements in efficiency will have a direct impact on affordability and reliability.

LEDs and OLEDs can also be used in combination with daylighting and other lighting technologies to provide the most efficient lighting application. This FOA topic goes beyond source efficiency to develop first-of-a-kind lighting systems that provide the right quality of light, at the right intensity, at the right time for the lighting application.

Topic Area 3 includes five sub-topics. Applications should clearly identify to which sub-topic they are applying and a single application should not submit to multiple sub-topics:

Sub-topic 3a: Green Gap and Droop in LEDs

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Sub-topic 3b: Quantum Dot Optical Down-Converters
 Sub-topic 3c: Stable, Efficient White LEDs
 Sub-topic 3d: Light Extraction and Utilization for LEDs
 Sub-topic 3e: Advanced Lighting Systems

Sub-topic 3a: Green Gap and Droop in LEDs

BTO seeks to address the underlying science for LED technology in two related key areas:

1. Increased efficiency of green-yellow direct emission to address “green gap”, and
2. Increased efficiency at higher current densities and temperatures to address current and thermal “droop”.

To achieve these challenging technical hurdles, BTO envisions a partnership of cross-functional teams involving multiple organizations and capabilities. Broad expertise ranging from combinatorial analysis and design to chip fabrication techniques are highly desired. Applications should include multiple approaches with down selects scheduled throughout the project. BTO expects to make one award under this sub-topic.

“Green gap” describes the current technology status of LEDs in which the efficiency of green direct emitters is significantly lower than that of blue or red (each obtained from different material systems). This is depicted in Figure 8 below. Solving the green gap is a critical challenge to meeting the theoretical efficiency for white LEDs based on a color mixing approach. To achieve optimal color quality, a green LED with a wavelength around 540 nanometers (nm) is required.

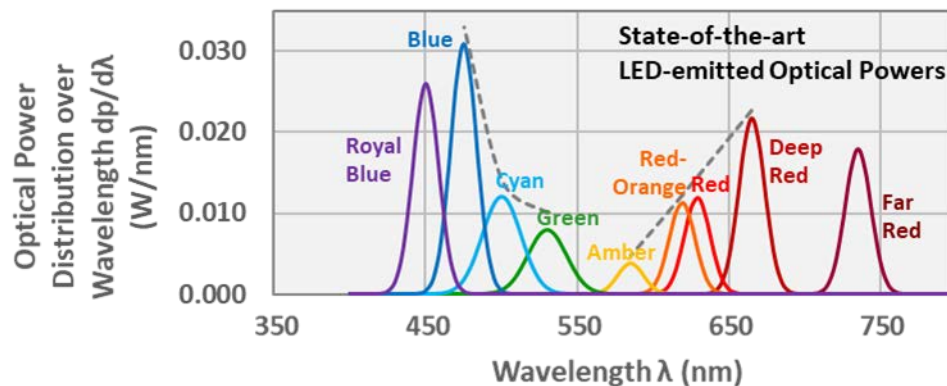


Figure 7: Spectral Power Densities of State-of-the-Art Commercial LEDs vs. Wavelength²⁸

“Droop” refers to the phenomena in which the efficiency of LED emission begins to roll-off or decrease at increased currents and temperatures. Different non-radiative

²⁸ Figure from DOE BTO SSL Program, “2018 Solid-State Lighting R&D Opportunities,” edited by James Brodrick, Ph.D.

mechanisms dominate droop at different current densities. This includes Shockley-Read-Hall and Auger recombination. Resolving droop allows LEDs to be driven “harder” to provide greater lumen output per unit chip area. Improved material quality and structural design a necessary to overcome these challenges.

Applicants must demonstrate a path toward meeting 2035 performance targets and the ultimate DOE SSL performance targets listed in **Table 6**. All research should be on highest caliber materials and devices to yield clearest possible results.

Emitter Materials ^{29,30}			
Metrics	2017 Status	Interim 2025 Targets	2035 Targets
External Quantum Efficiency (EQE) (peak value)	80% (Blue) 44% (Green) 63% (Near Red) 18% (Amber)	88% (Blue) 60% (Green) 69% (Near Red) 33% (Amber)	93% (Blue) 75% (Green) 80% (Near Red) 60% (Amber)
Power Conversion Efficiency (PCE) - 35A/cm ² , 25°C	67% (Blue) 27% (Green) 50% (Near Red) 16% (Amber)	84% (Blue) 50% (Green) 70% (Near Red) 30% (Amber)	90% (Blue) 75% (Green) 85% (Near Red) 70% (Amber)
PCE - 100A/cm ² , 85°C	54% (Blue) 13% (Green) 18% (Near Red) 7% (Amber)	65% (Blue) 30% (Green) 45% (Near Red) 19% (Amber)	83% (Blue) 60% (Green) 70% (Near Red) 55% (Amber)

Table 6: Targets for Emitter Materials

Sub-topic 3b: Quantum Dot Optical Down-Converters

BTO seeks the advancement of high efficiency, on-chip quantum dot (QD) down converters to match or exceed performance of conventional on-chip phosphor materials for application in general illumination. QD down converters have the potential to be more efficient than traditional phosphor down conversion materials and can more readily achieve the desired emission wavelength compared to their counterparts. QDs are engineered materials that convert light through a different process than conventional phosphors. Unlike their conventional counterparts, QDs re-emit light as a function of their size. The ability to develop specific sizes of QDs gives them the potential for greater spectral control. Research is needed to improve the efficiency and lifetime of on-chip QDs and develop successful fabrication techniques.

²⁹ The status of red and amber emitters is based on commercial AlInGaP LEDs. However, there is the possibility of developing InGaN or other material system-based LEDs that emit at these wavelengths. LEDs in novel materials systems would currently have lower performance levels but may represent the path to simultaneously meeting all the ultimate performance targets. Research on novel emitter materials is not expected to meet shorter term performance targets but should demonstrate a clear path to meeting all 2025 performance targets.

³⁰ PCE is the optical power out divided by electrical power in for the LED package.

Successful approaches should include QD architectures, degradation mechanisms, synthesis techniques, and/or functionalization approaches. Approaches should demonstrate advancements in on-chip LED performance at multiple emission wavelengths relevant to high efficiency LEDs. Alternatively, research may identify fundamental limitations for QD in LED lighting applications. Research in QDs that do not contain heavy metals or scarce materials is encouraged.

Metrics in **Table 7** describe the state-of-the-art phosphors used for LEDs and include targets for QD optical down-converter performance. Approaches must demonstrate a path towards meeting 2035 performance targets of **Table 7** and the ultimate DOE SSL performance targets described above. All research should be on highest caliber materials and devices to yield clearest possible results.

Quantum Dot Optical Down-Converters			
Metrics	2017 Status	Interim 2025 Targets	2035 Targets
Quantum yield (QY) at 150°C across the visible spectrum and at 1 W/mm ²	88% (Green) 81% (Red)	91% (Green) 88% (Red)	99% (Green) 95% (Red)
Spectral full width at half maximum (FWHM)	110 nm (Green) 75 nm (Red)	70 nm (Green) 30 nm (Red)	30 nm (at all wavelengths)
On-chip reliability: Color shift Depreciation Failure	$\Delta u'v' < 0.007$ at 6,000 hours	$\Delta u'v' < 0.002$ over life	$\Delta u'v' < 0.002$ over life

Table 7: Targets for Quantum Dot Down-Converters

Sub-topic 3c: Stable, Efficient White Organic Light Emitting Diodes

BTO seeks development of novel materials and structures that can help create highly efficient, stable, white OLED devices for general illumination purposes. Device should have desirable color qualities, long lifetime, and high efficiency, even at high brightness. Approaches may include development of highly efficient blue emitter materials and hosts such as graded doping approaches. Or they may comprise a device architecture leading to longer lifetime such as tandem structures with improved charge generation layers to maximize internal quantum efficiency. Materials/structures should be demonstrated in OLED devices that are characterized to ascertain the performance as compared to the metrics in **Table 8**. Novel materials/structures should demonstrate high stability while maintaining or improving other applicable metrics.

Applicants must demonstrate a path toward meeting 2035 performance targets in **Table 8** and the ultimate DOE SSL performance targets described above. All research should be on highest caliber materials and devices to yield clearest possible results.

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Stable, Efficient White OLED Devices			
Metrics	2017 Status	Interim 2025 Targets	2035 Targets
Internal Quantum Efficiency (IQE)	62%	80%	85%
Voltage per stack @ 10,000 lm/m ²	2.83 V	2.75 V	2.7 V
Stability	L70: 40,000 hours at 10,000 lm/m ² Catastrophic failure rates Color shift	L70: 50,000 Hours at 10,000 lm/m ²	L70: 50,000 Hours at 10,000 lm/m ²

Table 8: Targets for White OLEDs

Sub-topic 3d: Light Extraction and Utilization for OLEDs

BTO seeks development of new optical and device designs for improving OLED light extraction while retaining the thin profile and state-of-the-art performance of OLED panels. Applicants should detail how their approach integrates and operates in state-of-the-art structures and should include modeling or quantitative analysis that supports the proposed approach. Acceptable approaches should define a path for low-cost, scalable, and high-yield manufacturing. The proposed approach may also explore light-shaping techniques that can be integrated with the proposed light extraction technology to attain increased utilization efficiency of the generated light. Such methods should allow some control of the angular distribution of intensity but minimize the variation of color with angle.

Applicants must demonstrate a path toward meeting 2035 performance targets in **Table 9** and the ultimate DOE SSL performance targets described above. Applicants are required to report the projected energy savings and system performance as described in Appendix F. All research should be on highest caliber materials and devices to yield clearest possible results.

OLED Light Extraction and Utilization			
Metrics	2017 Status	Interim 2025 Targets	2035 Targets
Extraction efficiency (EQE/IQE)	55%	60%	75%
Color variation with angle ($\Delta u'v'$)	< ± 0.003	< ± 0.002	< ± 0.002
Light delivery efficiency	Lambertian	20% improvement of optical delivery efficiency	50% improvement of optical delivery efficiency

Table 9: Targets for OLED Light Extraction and Utilization

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Sub-topic 3e: Advanced Lighting Systems

BTO seeks applications that leverage SSL advances to achieve significant gains in overall lighting application efficiency. Innovative concepts and application-specific lighting-system level methodologies are encouraged to leverage daylighting, building design, and controls in combination with advanced SSL. Development and testing of first-of-a-kind systems to take advantage of connected lighting and integration of multiple light sources are desired.

This sub-topic targets the development of lighting system architectures that leverage the unique properties of SSL technologies to produce improved lighting application efficiency and performance. The sub-topic includes added benefits such as providing positive physiological impacts or increasing agricultural yields while lowering lighting system energy use. Advanced lighting concepts that demonstrate improvements to lighting application efficiency should address the relevant lighting application efficiency metrics described below in addition to delivering the right quality of light, at the right intensity, at the right time for the lighting application under real world conditions.

Applicants must demonstrate a path toward meeting 2035 performance targets in **Table 10** and the ultimate DOE SSL performance targets described above, where relevant.

Advanced SSL Lighting Concepts ³¹			
Metrics	2017 Status	Interim 2025 Targets	2035 Targets
Color mixed luminaire efficiency, efficacy, and performance across operational range (depends on application – user may define metrics for specific use case)	100 lm/W (3000-4000 K, color rendering index (CRI) 80, ANSI Quadrangle)	150 lm/W (warm white and cool white)	250 lm/W (warm white and cool white)
Lighting application efficiency (depends on application – user may define metrics for specific use cases)	Luminaire efficiency: 150 lm/W	Luminaire efficiency: 180 lm/W	Luminaire efficiency: 225 lm/W
	Task optical delivery efficiency: depends on application	Task optical delivery efficiency: applicant discuss and describe improvement	Task optical delivery efficiency: applicant discuss and describe improvement
	Spectral efficiency: depends on application	Spectral efficiency: 90%	Spectral efficiency: 95%
	Intensity control: none or remote at dimmer switch	Intensity control: active and automatic	Intensity control: active and automatic

³¹ Spectral efficiency refers to the overlap of the emitted spectrum with the spectrum appropriate to the activity or desired visual or non-visual response.

Table 10: Targets for Advanced SSL Concepts

All applicants under this sub-topic are required to report relevant performance metrics such as primary energy savings and cost effectiveness as measured by simple payback, as described in Appendix F.

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

D. Applications Specifically Not of Interest

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

- Applications that fall outside the technical parameters specified in Section I.A and I.B of the FOA
- Applications that are focused on deployment.
- Applications for proposed technologies that are not based on sound scientific principles (e.g., violates the laws of thermodynamics).

E. Teaming Partner List

EERE is compiling a Teaming Partner List to facilitate the widest possible national participation for this FOA. The list allows organizations who may wish to participate in an application, but do not wish to apply as the Prime applicant, to express their interest to potential applicants and to explore potential partners.

The Teaming Partner List will be available on EERE Exchange at <https://eere-Exchange.energy.gov> under DE-FOA-0002090 during the time of its release through its closing. The Teaming Partner List will be updated at least weekly until the close of the Full Application period, to reflect new Teaming Partners who have provided their information. Any organization that would like to be included on this list should submit the following information to BENEFIT-FOA0002090@netl.doe.gov, with the subject line "Teaming Partner Information":

Organization Name, Contact Name, Contact Address, Contact Email, Contact Phone, Organization Type, Topic Area(s) to which the organization would like to participate, Area of Technical Expertise, and Brief (approximately 200 words or less) Description of Capabilities.

By submitting a request to be included on the Teaming Partner List, the requesting organization consents to the publication of the above-referenced information. By facilitating this Teaming Partner List, EERE does not endorse or otherwise evaluate the qualifications of the entities that self-identify themselves for placement on the

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Teaming Partner List. EERE will not pay for the provision of any information, nor will it compensate any applicants or requesting organizations for the development of such information.

F. Authorizing Statutes

The programmatic authorizing statute includes EPLaw 2005 911(a)(2)(B) and EPLaw 2005 – Subtitle A, Section 912.

Awards made under this announcement will fall under the purview of the Code of Federal Regulations (CFR), Title 2, 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 \$47M of federal funding available for new awards under this FOA, subject to the availability of appropriated funds. EERE anticipates making approximately 18-40 awards under this FOA. EERE may issue one, multiple, or no awards. Individual awards may vary between \$1 million and \$6 million.

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

Topic 1: Dynamic Buildings and Communities. EERE may issue approximately 7-16 awards in this topic area, with awards in the amount of \$1,000,000 - \$3,000,000.

Topic 2: Heating Ventilation and Air Conditioning Technologies. EERE may issue approximately 6-18 awards in this topic area, with awards in the amount of \$1,500,000 - \$2,500,000.

Topic 3: Solid-State Lighting. EERE may issue approximately 5-10 awards in this topic area, with awards in the amount of \$1,500,000 - \$6,000,000.

The maximum award size and duration by sub-topic area is provided in the **Table 11**:

Sub-topic	Maximum Award Size	Maximum Duration
1a: Cybersecurity through Adaptive Building Controls	\$3 million	36 months

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1b: Flexible Building Equipment Performance Verification	\$2.5 million	36 months
1c: Advanced Actuators	\$1 million	24 months
1d: Thermal Energy Storage Materials	\$3 million	36 months
1e: Embedded Energy Storage for Building Equipment	\$3 million	36 months
2a: Non-Vapor Compression Heating, Ventilation and Air Conditioning	\$2.5 million	36 months
2b: Fuel-Driven Building Equipment	\$2.5 million	36 months
3a: Green Gap and Droop in LEDs	\$6 million	60 months
3b: Quantum Dot Optical Down-Converters	\$2 million	36 months
3c: Stable, Efficient White OLEDs	\$1.5 million	36 months
3d: Light Extraction and Utilization for OLEDs	\$1.5 million	36 months
3e: Advanced Lighting Systems	\$4 million	36 months

Table 11: Maximum Award Size and Duration

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. Before the expiration of the initial budget period(s), EERE may perform a down-select among different recipients and provide additional funding only to a subset of recipients.

ii. Period of Performance

EERE anticipates making awards that will run up to 60 months in length, comprised of one or more budget periods. Project continuation will be contingent upon satisfactory performance and Go/No-Go decision review. At the Go/No-Go decision points, EERE will evaluate project performance, project schedule adherence, meeting milestone objectives, compliance with reporting requirements, and overall contribution to the program goals and objectives. As a result of this evaluation, EERE will make a determination to continue to fund the project, recommend re-direction of work under the project, place a hold on federal funding for the project, or discontinue funding the project.

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.

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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. Grants

Although EERE has the authority to provide financial support to prime recipients through Grants, EERE generally does not fund projects through Grants. EERE may fund a limited number of projects through Grants, as appropriate.

iv. Technology Investment Agreements (TIAs)

In rare cases and if determined appropriate, EERE will consider awarding a TIA to a non-FFRDC applicant. TIAs, governed by 10 CFR Part 603, are assistance instruments used to increase the involvement of commercial entities in the Department's research, development, and demonstration programs. A TIA may be either a type of cooperative agreement or an assistance transaction other than a cooperative agreement, depending on the intellectual property provisions. In both cases, TIAs are not necessarily subject to all of the requirements of 2 CFR Part 200 as amended by 2 CFR Part 910.

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In a TIA, EERE may modify the standard Government terms and conditions, including but not limited to:

- Intellectual Property Provisions: EERE may negotiate special arrangements with recipients to avoid the encumbrance of existing intellectual property rights or to facilitate the commercial deployment of inventions conceived or first actually reduced to practice under the EERE funding agreement.
- Accounting Provisions: EERE may authorize the use of Generally Accepted Accounting Principles (GAAP) where recipients do not have accounting systems that comply with Government recordkeeping and reporting requirements.

EERE will be more amenable to awarding a TIA in support of an application from a consortium or a team arrangement that includes cost sharing with the private sector, as opposed to an application from a single organization. Such a consortium or teaming arrangement could include a FFRDC. If a DOE/NNSA FFRDC is a part of the consortium or teaming arrangement, the value of, and funding for the DOE/NNSA FFRDC portion of the work will be authorized and funded under the DOE field work authorization system and performed under the laboratory's Management and Operating (M&O) contract. Funding for a non-DOE/NNSA FFRDC would be through an interagency agreement under the Economy Act or other statutory authority. Other appropriate contractual accommodations, such as those involving intellectual property, may be made through a "funds in" agreement to facilitate the FFRDCs' participation in the consortium or teaming arrangement. If a TIA is awarded, certain types of information described in 10 CFR 603.420(b) are exempt from disclosure under the Freedom of Information Act (FOIA) for five years after DOE receives the information.

An applicant may request a TIA if it believes that using a TIA could benefit the RD&D objectives of the program (see section 603.225) and can document these benefits. If an applicant is seeking to negotiate a TIA, the applicant must include an explicit request in its Full Application. After an applicant is selected for award negotiation, the Contracting Officer will determine if awarding a TIA would benefit the RD&D objectives of the program in ways that likely would not happen if another type of assistance agreement (e.g., cooperative agreement subject to the requirements of 2 CFR Part 200 as amended by 2 CFR Part 910). The Contracting Officer will use the criteria in 10 CFR 603, Subpart B, to make this determination.

III. Eligibility Information

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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

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. 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.

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 prime recipient or subrecipient.

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.

NETL is not eligible for award under this announcement and may not be proposed as a sub-recipient on another entity's application. An application that includes NETL as a prime recipient or sub-recipient will be considered non-responsive.

iii. Foreign Entities

Foreign entities, whether for-profit or otherwise, are eligible to apply for funding under this FOA. Other than as provided in the "Individuals" or "Domestic Entities" sections above, 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 and have a physical location for business operations in the United States. If a foreign entity applies for funding as a prime

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recipient, it must designate in the Full Application a subsidiary or affiliate incorporated (or otherwise formed) under the laws of a State or territory of the United States to be the prime recipient. The Full Application must state the nature of the corporate relationship between the foreign entity and domestic subsidiary or affiliate.

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

In the waiver request, the applicant 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 have a foreign entity serve as the prime recipient. EERE may require additional information before considering the waiver request.

A foreign entity may receive funding as a subrecipient.

iv. Incorporated Consortia

Incorporated consortia, which may include domestic and/or foreign entities, are eligible to apply for funding as a prime recipient or subrecipient. For consortia incorporated (or otherwise formed) under the laws of a State or territory of the United States, please refer to "Domestic Entities" above. For consortia incorporated in foreign countries, please refer to the requirements in "Foreign Entities" above.

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

v. Unincorporated Consortia

Unincorporated Consortia, which may include domestic and foreign entities, must designate one member of the consortium to serve as the prime recipient/consortium representative. The prime recipient/consortium representative must be incorporated (or otherwise formed) under the laws of a State or territory of the United States. The eligibility of the consortium will be determined by the eligibility of the prime recipient/consortium representative under Section III.A. of the FOA.

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

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

B. Cost Sharing

The cost share must be at least 20% of the total allowable costs for research and development projects (i.e., the sum of the Government share, including FFRDC costs if applicable, and the recipient share of allowable costs equals the total allowable cost of the project) and must come from non-federal sources unless otherwise allowed by law.

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.

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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.1 of the FOA. In addition, cost share must be verifiable upon submission of the Full Application.

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

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

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

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

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

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

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

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

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share contribution must be reviewed and approved in advance by the Contracting Officer and incorporated into the project budget before the expenditures are incurred.

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

iv. Cost Share Contributions by FFRDCs

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

v. Cost Share Verification

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

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

vi. Cost Share Payment

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

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

complied with its cost share obligations to date. The Contracting Officer must approve all such requests before they go into effect.

C. Compliance Criteria

Concept Papers, Full Applications and Replies to Reviewer Comments must meet all compliance criteria listed below or they will be considered noncompliant. EERE will not review or consider noncompliant submissions, including Concept Papers, Full Applications, and Replies to Reviewer Comments that were: submitted through means other than EERE Exchange; submitted after the applicable deadline; and/or submitted incomplete. EERE will not extend the submission deadline for applicants that fail to submit required information by the application deadline due to server/connection congestion.

i. Compliance Criteria

1. *Concept Papers*

Concept Papers are deemed compliant if:

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

2. *Full Applications*

Full Applications are deemed compliant if:

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

3. *Replies to Reviewer Comments*

Replies to Reviewer Comments are deemed compliant if:

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

D. Responsiveness Criteria

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

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E. Other Eligibility Requirements

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

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

The following wording is acceptable for the authorization:

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

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

NETL is not eligible for award under this announcement and may not be proposed as a sub-recipient on another entity's application. An application that includes NETL as a prime recipient or sub-recipient will be considered non-responsive.

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

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

1. *Authorization for non-DOE/NNSA FFRDCs*

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

2. *Authorization for DOE/NNSA FFRDCs*

The cognizant Contracting Officer for the FFRDC must authorize in writing the use of the FFRDC on the proposed project and this authorization must be

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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.

NETL is not eligible for award under this announcement and may not be proposed as a sub-recipient on another entity's application. An application that includes NETL as a prime recipient or sub-recipient will be considered non-responsive.

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

An entity may submit more than one Concept Paper and Full Application to this FOA, provided that each application describes a unique, scientifically distinct project and provided that an eligible Concept Paper was submitted for each Full Application.

G. Questions Regarding Eligibility

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

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IV. Application and Submission Information

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;
- 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.

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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.

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

B. Application Forms

The application forms and instructions are available 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

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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.

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/Sub-topic Area being addressed (if applicable), both the technical and business points of contact, names of all team member organizations, and any statements regarding confidentiality.
Technical Description and Impacts	2 pages maximum	Applicants are required to describe succinctly: <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	Applicants are required to describe succinctly the qualifications, experience, and capabilities of the proposed Project Team, including: <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;

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		<ul style="list-style-type: none"> • 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 also use the Addendum section to provide photographs, maps, references, graphs, charts, or other data to supplement their Technology Description. However, the Addendum section, inclusive of any supplemental photograph, maps, references, graphs, charts, or other data, may not exceed the maximum page limit for the section specified in the preceding column.</p>
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EERE makes an independent assessment of each Concept Paper based on the criteria in Section V.A.i. of the FOA. EERE will encourage a subset of applicants to submit Full Applications. Other applicants will be discouraged from submitting a Full Application. An applicant who receives a “discouraged” notification may still submit a Full Application. EERE will review all eligible Full Applications. However, by discouraging the submission of a Full Application, EERE intends to convey its lack of programmatic interest in the proposed project in an effort to save the applicant the time and expense of preparing an application that is unlikely to be selected for award negotiations.

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

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.

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All Full Application documents must be marked with the Control Number issued to the applicant. Applicants will receive a control number upon clicking the “Create Concept Paper” button in EERE Exchange, and should include that control number in the file name of their Full Application submission (i.e., *Control number_Applicant Name_Full Application*).

i. Full Application Content Requirements

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

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

Submission	Components	File Name
Full Application (PDF, unless stated otherwise)	Technical Volume (PDF format. See Chart in Section IV.D.ii.)	ControlNumber_LeadOrganization_TechnicalVolume
	Statement of Project Objectives (SOPO) (Microsoft Word format. 10 page limit; template available in EERE Exchange)	ControlNumber_LeadOrganization_SOPO
	SF-424 Application for Federal Assistance (PDF format; template available in EERE Exchange)	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; template available in EERE Exchange)	ControlNumber_LeadOrganization_SF-LLL
	Foreign Entity and Performance of Work in the United States waiver requests, if applicable (PDF format)	ControlNumber_LeadOrganization_Waiver

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	U.S. Manufacturing Plan (PDF format)	ControlNumber_LeadOrganization_USMP
	Technical Potential and Payback Calculation	ControlNumber_LeadOrganization_TPP

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.

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.

Except for enabling technologies and design tools, one performance metric used to evaluate applications is the primary energy savings technical potential. Sub-topics requiring the energy savings calculation are identified in the sub-topic description. Applications to these sub-topics will be required to use the BTO Baseline Energy Calculator (<https://scout.energy.gov/baseline-energy-calculator.html>) to compute the total market size in TBtu in 2030. Each applicant will enter the relevant building type (residential single-family, commercial food sales, etc.), end use (heating, cooling, lighting, cooking, refrigeration, etc.), climate zone(s) (1—5), and other information, from which the web tool will

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return the energy market size in TBtu. The applicants will also need to provide an estimate of the percent energy savings applicable to this market for their proposed technology innovation, with supporting analysis as described in Appendix F. The applicant will present the primary energy savings technical potential: the product of the percent energy savings and the energy market size as calculated by the Baseline Energy Calculator.

A second performance metric used to evaluate some applications is the cost effectiveness, as measured by the simple payback. This too will be applicable to technology development applications, and not to other applications such as design tools or enabling technologies for which primary energy savings and/or payback are difficult to directly quantify. Sub-topics requiring the simple payback calculation are identified in the sub-topic description. Simple payback should be calculated using the approach described in Appendix F.

Applications to all other sub-topics will be required to provide an estimate of primary energy savings, potentially resulting from their approach, without the use of Appendix F. Such approaches must provide their own analysis of primary energy savings technical potential and an analysis of their cost effectiveness. Applicants are strongly encouraged to provide references that support their analysis.

The Technical Volume to the Full Application may not be more than 15 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/Sub-topic Area being addressed (if applicable), 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 are required to report two performance metrics: primary energy savings and cost effectiveness and provide supporting rationale for the calculations when applying to sub-topics for which they are required. 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: The applicant should describe the current state of the art in the applicable field, the specific innovation of the proposed technology, and the advantages of proposed technology over current and emerging technologies. • Impacts: The applicant should discuss the overall impact on advancing the state of the art/technical and impacts, positive or negative, on occupant comfort, occupant productivity, or product performance, if the project is successful.
<p>Workplan and Market Transformation Plan (This section should constitute approximately 40% of the Technical Volume)</p>	<p>The Workplan should include a summary of the Project Objectives, Technical Scope, Work Breakdown Structure (WBS), Milestones, Go/No-Go Decision Points, and Project Schedule. A detailed SOPO is separately requested. The Workplan should contain the following information:</p> <ul style="list-style-type: none"> • Project Objectives: The applicant should provide a clear and concise (high-level) statement of the goals and objectives of the project as well as the expected outcomes. • Technical Scope Summary: The applicant should provide a summary description of the overall work scope and approach to

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	<p>achieve the objective(s). The overall work scope is to be divided by performance periods that are separated by discrete, approximately annual decision points (see below for more information on Go/No-Go decision points). The applicant should describe the specific expected end result of each performance period.</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. Unless otherwise specified in the FOA, the minimum requirement is that 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
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	<p>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.</p> <ul style="list-style-type: none"> • End of Project Goal: The applicant should provide a summary of the end of project goal(s). Unless otherwise specified in the FOA, the minimum requirement is that 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 • Market Transformation Plan: The applicant should provide a market transformation plan, including the following: <ul style="list-style-type: none"> ○ Identification of target market, competitors, and distribution channels for proposed technology along with known or perceived barriers to market penetration, including a mitigation plan ○ Identification of a product development and/or service plan, commercialization timeline, financing, product marketing, legal/regulatory considerations including intellectual property, infrastructure requirements, data dissemination, U.S. manufacturing plan, and product distribution.
<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.

	<ul style="list-style-type: none"> • 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. • 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 under the respective FOA found on EERE Exchange at <https://eere-exchange.energy.gov/>. The SOPO, including the Milestone Table, must not exceed 10 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 **that is provided in EERE Exchange**. 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

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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 under the respective FOA on EERE Exchange at <https://eere-Exchange.energy.gov/>.
- Prime recipients must complete each tab of the Budget Justification Workbook for the project as a whole, including all work to be performed by the prime recipient and its subrecipients and contractors.
- Applicants should include costs associated with required annual audits and incurred cost proposals in their proposed budget documents. The “Instructions and Summary” included with the Budget Justification Workbook will auto-populate as the applicant enters information into the Workbook.
- Applicants must carefully read the “Instructions and Summary” tab provided within the Budget Justification Workbook.
- Save the Budget Justification Workbook in a single Microsoft Excel file using the following convention for the title “ControlNumber_LeadOrganization_Budget_Justification”.

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”.

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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.

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" (document is available in EERE Exchange) to

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

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

-
- An officer or employee of Congress; or
- An employee of a Member of Congress.

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

xii. Waiver Requests: Foreign Entities and Performance of Work in the United States (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

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 request to waive the Performance of Work in the United States requirement.

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

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any subawardee and any assignee or licensee or any entity otherwise acquiring rights to any subject invention, including subsequent assignees or licensees. A subject invention is any invention conceived of or first actually reduced to practice under an award.

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

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

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

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

xiv. Data Management Plan (DMP)

Applicants whose full applications are selected for award negotiations will be required to submit a DMP during the award negotiations phase.

An applicant may select one of the template DMP listed below. Alternatively, instead of selecting one of the template DMPs below, an applicant may submit another DMP provided that the DMP, at a minimum, (1) describes how data sharing and preservation will enable validation of the results from the proposed work, how the results could be validated if data are not shared or preserved and (2) has a plan for making all research data displayed in publications resulting

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from the proposed work digitally accessible at the time of publications. DOE Public Access Plan dated July 24, 2014 provides additional guidance and information on DMPs.

Option 1 (when protected data is allowed): 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.

xv. Open Source Software Distribution Plan

Applicants whose full applications are selected for award negotiations, and whose technical approach includes development of software, will be required to submit an Open Source Software Distribution Plan during the award negotiations phase. This plan describes how software produced under this resulting project will be distributed. Guidance for preparing an Open Source Software Distribution Plan is included in Appendix D of the FOA.

xvi. Technical Potential and Payback Calculation

All applicants proposing a technology, except for enabling technologies and design tools, will need to provide an estimate of the percent energy savings applicable to this market for their proposed technology innovation, with supporting analysis as described in Appendix F. The applicant will present the primary energy savings technical potential: the product of the percent energy savings and the energy market size as calculated by the Baseline Energy Calculator.

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A second performance metric used to evaluate applications will be the cost effectiveness, as measured by the simple payback. Again, this will be applicable only to technology development applications, and not to other applications such as design tools or enabling technologies for which primary energy savings and/or payback are difficult to directly quantify. An explicit approach is described in Appendix F, which applicants should follow to compute the payback for their proposed technology. An acceptable maximum payback (in years) will not be specified, since that can vary significantly depending on the end use.

E. Content and Form of Replies to Reviewer Comments

EERE will provide applicants with reviewer comments following 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 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.

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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):

- 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;
- Environmental Questionnaire;
- Data Management Plan; and
- Open Source Software Distribution Plan, if applicable.

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

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 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

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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

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 waiver of the Performance of Work in the United States requirement, the applicant must submit a written waiver request to EERE. Appendix C lists the necessary information that must be included in a request to waive the Performance of Work in the United States requirement.

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

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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

Foreign travel costs are not allowable under this FOA.

vi. Equipment and Supplies

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

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

vii. 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."

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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 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 and Market Transformation Plan (30%)

This criterion involves consideration of the following factors:

Research Approach, Workplan and SOPO

- Degree to which the approach and critical path have been clearly described and thoughtfully considered; and

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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.

Identification of Technical Risks

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

Baseline, Metrics, and Deliverables

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

Market Transformation Plan

- Identification of target market, competitors, and distribution channels for proposed technology along with known or perceived barriers to market penetration, including mitigation plan; and
- Comprehensiveness of market transformation plan including but not limited to product development and/or service plan, commercialization timeline, financing, product marketing, legal/regulatory considerations including intellectual property, infrastructure requirements, Open Source Software Distribution Plan (as applicable), U.S. Manufacturing Plan, and product distribution.

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 consortia/team demonstrates the ability to facilitate and expedite further development and commercial deployment of the proposed technologies;
- The level of participation by project participants as evidenced by letter(s) of commitment and how well they are integrated into the Workplan; and
- The reasonableness of the budget and spend plan for the proposed project and objectives.

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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).

D. Evaluation and Selection Process

i. Overview

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

ii. Pre-Selection Interviews

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

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

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

EERE may obtain additional information through Pre-Selection Interviews that will be used to make a final selection determination. EERE may select applications for funding and make awards without Pre-Selection Interviews. Participation in Pre-Selection Interviews with EERE does not signify that applicants have been selected for award negotiations.

iii. Pre-Selection Clarification

EERE may determine that pre-selection clarifications are necessary from one or more applicants. Pre-selection clarifications are distinct from and less formal than pre-selection interviews. These pre-selection clarifications will solely be for the purposes of clarifying the application, 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

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process. Information provided by an applicant that is not necessary to address the pre-selection clarification question will not be reviewed or considered. Typically, a pre-selection clarification will be carried out through either written responses to EERE's written clarification questions or video or conference calls with EERE representatives.

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

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

iv. Recipient Integrity and Performance Matters

DOE, prior to making a federal award with a total amount of federal share greater than the simplified acquisition threshold, is required to review and consider any information about the applicant that is in the designated integrity and performance system accessible through SAM (currently FAPIIS) (see 41 U.S.C. 2313).

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

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.

v. Selection

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

E. Anticipated Notice of Selection and Award Negotiation Dates

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

VI. Award Administration Information

A. Award Notices

i. Ineligible Submissions

Ineligible Concept Papers and Full Applications will not be further reviewed or considered for award. The 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.

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iv. Successful Applicants

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

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

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

v. Alternate Selection Determinations

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

vi. Unsuccessful Applicants

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

B. Administrative and National Policy Requirements

i. Registration Requirements

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

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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 an 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

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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 to DOE Sites

All applicants that ultimately enter into an award resulting from this FOA will be subject to the following requirement concerning foreign national involvement. Upon DOE's request, prime recipients must provide information to facilitate DOE's responsibilities associated with foreign national access to DOE sites, information, technologies, and equipment. 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 the prime recipient or subrecipients, contractors or vendors under the award, anticipate utilizing a foreign national person in the performance of an award, the prime recipient is responsible for providing to the Contracting Officer specific information of the foreign national(s) to satisfy compliance with all of the requirements for access approval.

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 USC 4321, *et seq.*). NEPA requires federal agencies to integrate environmental values into their decision-making processes by considering the potential environmental impacts of their proposed actions. For additional background on NEPA, please see DOE's NEPA website, at <http://nepa.energy.gov/>.

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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

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:

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- 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 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.

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viii. Statement of Federal Stewardship

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

ix. Statement of Substantial Involvement

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

1. EERE shares responsibility with the recipient for the management, control, direction, and performance of the project.
2. EERE may intervene in the conduct or performance of work under this award for programmatic reasons. Intervention includes the interruption or modification of the conduct or performance of project activities.
3. EERE may redirect or discontinue funding the project based on the outcome of EERE's evaluation of the project at the Go/No-Go decision point(s).
4. EERE participates in major project decision-making processes.
5. EERE promotes and facilitates technology transfer activities, including disseminating Technology Office results through presentations and publications.
6. EERE participates in project management planning activities, including risk analysis, to ensure EERE Technology Office requirements or limitations are considered in performance of the work elements.

x. Intellectual Property Management Plan (IPMP)

As a quarter 1 milestone if selected for award, applicants must submit an executed IPMP between the members of the consortia or team.

The award will set forth the treatment of and obligations related to intellectual property rights between EERE and the individual members. The IPMP should

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describe how the members will handle intellectual property rights and issues between themselves while ensuring compliance with federal intellectual property laws, regulations, and policies (see Sections VIII.K-VIII.N of this FOA for more details on applicable federal intellectual property laws and regulations). Guidance regarding the contents of IPMP is available from EERE upon request.

The following is a non-exhaustive list of examples of items that the IPMP may cover:

- The treatment of confidential information between members (e.g., the use of non-disclosure acknowledgements (NDAs));
- The treatment of background intellectual property (e.g., any requirements for identifying it or making it available);
- The treatment of inventions made under the award (e.g., any requirements for disclosing to the other members on an application, filing patent applications, paying for patent prosecution, and cross-licensing or other licensing arrangements between the members);
- The treatment of data produced, including software, under the award (e.g., any publication process or other dissemination strategies, copyrighting strategy or arrangement between members);
- Any technology transfer and commercialization requirements or arrangements between the members;
- The treatment of any intellectual property issues that may arise due to a change in membership of the consortia or team; and
- The handling of disputes related to intellectual property between the members.

xi. 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.

xii. 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>.

xiii. 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. In addition, all awarded projects will be required to submit data for analysis using the [BTO Scout software program](http://scout-bto.readthedocs.io/en/latest/) (<http://scout-bto.readthedocs.io/en/latest/>), to consist of the following for the proposed technology: baseline market, anticipated market entry year, absolute performance (e.g., COP, U-value) or, if appropriate, relative efficiency improvement compared to the baseline technology it replaces, total installed cost, expected service lifetime, and other ancillary descriptive information, as well as supporting reference information for these data, if available. Awardees are encouraged to use the [Scout ECM Definition Reference](http://scout-bto.readthedocs.io/en/latest/ecm_reference.html#ecm-definition-reference) (http://scout-bto.readthedocs.io/en/latest/ecm_reference.html#ecm-definition-reference) to understand the requested data format. Following review by BTO, these data may be made publicly available via the Scout [energy conservation measure \(ECM\) database on GitHub](#) (https://github.com/trynthink/scout/tree/master/ecm_definitions), although they will be presented in an anonymous manner without identifying the applicant.

xiv. Go/No-Go Review

Each project selected under this FOA will be subject to a periodic project evaluation referred to as a Go/No-Go Review. At the Go/No-Go decision points, EERE will evaluate project performance, project schedule adherence, meeting milestone objectives, compliance with reporting requirements, and overall contribution to the EERE program goals and objectives. Federal funding beyond the Go/No-Go decision point (continuation funding) is contingent upon (1) availability of federal funds appropriated by Congress for the purpose of this program; (2) the availability of future-year budget authority; (3) recipient's technical progress compared to the Milestone Summary Table stated in Attachment 1 of the award; (4) recipient's submittal of required reports; (5) recipient's compliance with the terms and conditions of the award; (6) EERE's Go/No-Go decision; (7) the recipient's submission of a continuation application; and (8) written approval of the continuation application by the Contracting Officer.

As a result of the Go/No-Go Review, DOE may, at its discretion, authorize the following actions: (1) continue to fund the project, contingent upon the availability of funds appropriated by Congress for the purpose of this program and the availability of future-year budget authority; (2) recommend redirection

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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.

xv. 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.

xvi. 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.

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: BENEFIT-FOA0002090@netl.doe.gov. Questions must be submitted not later than 3 business days prior to the application due date and time. Please note, feedback on individual concepts will not be provided through Q&A.

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

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

VIII. Other Information

A. FOA Modifications

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

B. Government Right to Reject or Negotiate

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

C. Commitment of Public Funds

The 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 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.

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E. Evaluation and Administration by Non-Federal Personnel

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

F. Notice Regarding Eligible/Ineligible Activities

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

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

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

H. 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:

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- 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.

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

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

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

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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.

“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. In addition, for those awards requiring distribution of software as Open-Source Software (OSS), the additional information in Appendix D must be addressed in the application.

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

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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, 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, and 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.

Q. 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 the Department of Energy (DOE) in order to satisfy requirements for foreign nationals' access to DOE sites, information, technologies, equipment, programs, and personnel. A foreign national is any person who was born outside 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 or subcontractors) anticipates involving foreign nationals in the performance of its award, the selected applicant may be required to provide to 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](#)

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[Terrorism](#) must receive final approval authority from the Secretary of Energy before they can commence any work under the award.

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.

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 AS THE PRIME RECIPIENT; AND 2. PERFORMANCE OF WORK IN THE UNITED STATES (FOREIGN WORK WAIVER)

1. Waiver for Foreign Entity Participation as the Prime Recipient

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 and have a physical location for business operations in the United States. To request a waiver of this requirement, an applicant must submit an explicit waiver request in the Full Application.

Overall, the applicant 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 have a foreign entity serve as the prime recipient. A request to waive the *Foreign Entity Participation as the prime recipient* requirement must include the following:

- Entity name;
- The rationale for proposing a foreign entity to serve as the prime recipient;
- Country of incorporation;
- A description of the project’s anticipated contributions to the US economy;
- How the project 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 project will promote domestic American manufacturing of products and/or services;
- A description of how the foreign entity’s participation as the prime recipient is essential to the project;
- A description of the likelihood of Intellectual Property (IP) being created from the work and the treatment of any such IP; and
- 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 waiver of the Performance of Work in the United States requirement).

EERE may require additional information before considering the waiver request.

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

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

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As set forth in Section IV.J.iii., all work under EERE funding agreements must be performed in the United States. This requirement does not apply to the purchase of supplies and equipment, so a waiver is not required for foreign purchases of these items. However, the prime recipient should make every effort to purchase supplies and equipment within the United States. There may be limited circumstances where it is in the interest of the project to perform a portion of the work outside the United States. To seek a waiver of the Performance of Work in the United States requirement, the applicant must submit an explicit waiver request in the Full Application. A separate waiver request must be submitted for each entity proposing performance of work outside of the United States.

Overall, a waiver request must demonstrate to the satisfaction of EERE that it would further the purposes of this FOA and is otherwise in the economic interests of the United States to perform work outside of the United States. A request to waive the *Performance of Work in the United States* requirement must include the following:

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

EERE may require additional information before considering the waiver request.

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

APPENDIX D – OPEN SOURCE SOFTWARE

Open Source Software Distribution Plan.

Applicants that are applying to one or more Topic Areas for which open source software distribution is required must submit a plan describing how software produced under this FOA will be distributed. For a DOE National Laboratory or a FFRDC, the data rights clause, including rights and requirements pertaining to computer software, in its M&O Contract shall apply and shall take precedence over any requirement set forth in this Appendix. The plan must include the following elements:

1. A complete description of any existing software that will be modified or incorporated into software produced under this FOA, including a description of the license rights. The license rights must allow the modified or incorporated software to be distributed as open source.
2. A discussion of the open source license that the applicant plans to use for the software it plans to produce under the FOA, and how that choice furthers the goals of this FOA. The discussion must also address how the license conforms to the conditions listed below.
3. A method for depositing the software in a source code repository.
4. A method for sharing and disseminating the software and other information to team members or others when multiple parties will contribute to the development of the software or the FOA requires that the software or other information be shared or disseminated to others.

Open Source Definition: Open source licenses must conform to all of the following conditions:

Free Redistribution

The license shall not restrict any party from selling or giving away the software as a component of an aggregate software distribution containing programs from several different sources. The license shall not require a royalty or other fee for such sale. The rights attached to the software must apply to all to whom the software is redistributed without the need for execution of an additional license by those parties.

Source Code

The program must include source code, and must allow distribution in source code as well as compiled form. Where some form of a product is not distributed with source code, there must be a well-publicized means of obtaining the source code for no more than a reasonable reproduction cost preferably, i.e., downloading via the Internet without charge. The source code must be the preferred form in which a programmer would modify the program.

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Deliberately obfuscated source code and intermediate forms such as the output of a preprocessor or translator are not allowed.

Derived Works

The license must allow modifications and derived works, and permit the option of distributing the modifications and derived works under the same terms as the license of the original software.

Integrity of the Author's Source Code

The license may restrict source-code from being distributed in modified form only if the license allows the distribution of "patch files" with the source code for the purpose of modifying the program at build time. The license must explicitly permit distribution of software built from modified source code. The license may require derived works to carry a different name or version number from the original software.

No Restriction Against Fields of Endeavor

The license must not restrict anyone from making use of the program in a specific field of endeavor. For example, it may not restrict the program from being used in a business, or from being used for genetic research.

License Must Not Be Specific to a Product or Technology

The rights attached to the program must not depend on the program's being part of a particular software distribution. If the program is extracted from that distribution and used or distributed within the terms of the program's license, all parties to whom the program is redistributed should have the same rights as those that are granted in conjunction with the original software distribution. No provision of the license may be predicated on any individual technology or style of interface.

License Must Not Restrict Other Software

The license must not place restrictions on other software that is distributed along with the licensed software. For example, the license must not insist that all other programs distributed on the same medium must be open-source software.

Examples of Acceptable Licenses

Apache License, 2.0

<http://www.apache.org/licenses>

The 2.0 version of the Apache License was approved by the Apache Software Foundation (ASF) in 2004. The goals of this license revision were to reduce the number of frequently asked questions, to allow the license to be reusable without modification by any project (including non-ASF projects), to allow the license to be included by reference instead of listed in every file, to clarify the license on submission of contributions, to require a patent license on contributions that necessarily infringe the contributor's own patents, and to move comments regarding Apache and other inherited attribution notices to a location outside the license terms

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The result is a license that is compatible with other open source licenses, while remaining true to and supportive of collaborative development across both nonprofit and commercial organizations.

All packages produced by the ASF are implicitly licensed under the Apache License, Version 2.0, unless otherwise explicitly stated.

GNU General or Public License (GPLv3)

<http://www.gnu.org/licenses/gpl.html>

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The GPL is the first copyleft license for general use, which means that derived works must be distributed under the same license terms. Under this philosophy, the GPL grants the recipients of a computer program the rights of the free software definition and uses copyleft to ensure the freedoms are preserved, even when the work is changed or additions are made. This aspect distinguishes the GPL from permissive free software licenses, including the BSD licenses. The license's copyright disallows modification of the license. Copying and distributing the license is allowed because the GPL requires recipients to get "a copy of this License along with the Program". According to the GPL FAQ, anyone can make a new license using a modified version of the GPL as long as he or she uses a different name for the license, does not mention "GNU", and removes the preamble, though the preamble can be used in a modified license if permission to use it is obtained from the Free Software Foundation (FSF).

GNU Library or "Lesser" General Public License (LGPLv3) <http://www.gnu.org/licenses/lgpl.html>

The GNU Lesser General Public License (formerly the GNU Library General Public License) or LGPL is a free software license published by the Free Software Foundation (FSF). It was designed as a compromise between the strong-copyleft GNU General Public License or GPL and permissive licenses such as the BSD licenses and the MIT License. The GNU Library General Public License (as the LGPL was originally named) was published in 1991, and adopted the version number 2 for parity with GPL version 2. The LGPL was revised in minor ways in the 2.1 point release, published in 1999, when it was renamed the GNU Lesser General Public License to reflect the FSF's position that not all libraries should use it. Version 3 of the LGPL was published in 2007 as a list of additional permissions applied to GPL version 3.

The LGPL places copyleft restrictions on the program governed under it but does not apply these restrictions to other software that merely link with the program. There are, however, certain other restrictions on this software.

The LGPL is primarily used for software libraries, although it is also used by some stand-alone applications, most notably Mozilla and OpenOffice.org.

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Software packages that use one of the versions of the MIT License include Expat, PuTTY, the Mono development platform class libraries, Ruby on Rails, Lua (from version 5.0 onwards), and the X Window System, for which the license was written.

Mozilla Public License 2.0 (MPL-2.0)

<http://www.mozilla.org/MPL/2.0/>

The Mozilla Public License (MPL) is a free and open source software license. Version 1.0 was developed by Mitchell Baker when she worked as a lawyer at Netscape Communications Corporation and version 1.1 at the Mozilla Foundation. Version 2.0 was developed in the open, overseen by Baker and led by Louis Villa. The MPL is characterized as a hybridization of the modified BSD license and GNU General Public License.

The MPL is the license for the Mozilla Application Suite, Mozilla Firefox, Mozilla Thunderbird and other Mozilla software. The MPL has been adapted by others as a license for their software, most notably Sun Microsystems, as the Common Development and Distribution License for OpenSolaris, the open source version of the Solaris 10 operating system, and by Adobe, as the license for its Flex product line.

APPENDIX E – GLOSSARY

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

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

- i. A report on the Recipient's progress towards meeting the objectives of the project, including any significant findings, conclusions, or developments, and an estimate of any unobligated balances remaining at the end of the budget period. If the remaining unobligated balance is estimated to exceed 20 percent of the funds available for the budget period, explain why the excess funds have not been obligated and how they will be used in the next budget period.
- ii. A detailed budget and supporting justification if there are changes to the negotiated budget, or a budget for the upcoming budget period was not approved at the time of award.
- iii. A description of any planned changes from the negotiated Statement of Project Objectives and/or Milestone Summary Table.

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

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

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

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

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

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

APPENDIX F – TECHNICAL POTENTIAL AND PAYBACK CALCULATION

Applicants are required to provide detailed, and if possible, quantitative justification for the energy and cost benefits for their applications. Applicants that are proposing energy efficiency technologies are strongly encouraged to use the methodologies described below to provide the expected energy and cost savings. Applicants proposing non-technological solutions, e.g., modeling approaches, and/or solutions that will allow for building technologies to provide grid services are required to provide the other expected benefits, as well as an analysis of their cost effectiveness. The approaches used in these analyses need to be appropriately justified.

Technical Potential Calculation

One performance metric used to evaluate applications will be the 2030 primary energy savings technical potential. Applicants proposing energy efficiency technologies should provide the *Primary Energy Savings Technical Potential* (TBtu). The *Primary Energy Savings Technical Potential* is calculated from Eq. F1:

$$\left[\begin{array}{c} \text{Primary Energy Savings} \\ \text{Technical Potential} \\ \text{(TBtu)} \end{array} \right] = \left[\begin{array}{c} \% \text{ Energy Savings} \\ \text{Over Typical New} \\ \text{Technology} \end{array} \right] \times \left[\begin{array}{c} \text{2030 Energy Market} \\ \text{Size} \\ \text{(TBtu)} \end{array} \right] \quad (\text{F1})$$

The *2030 Energy Market Size* (TBtu) can be determined from the building type addressed by the technology (residential or commercial), the end use (cooling, lighting, cooking, refrigeration, etc.), the climate zone (1 – 5), and other information. The [BTO Baseline Energy Calculator](#) tool facilitates the determination of the *2030 Energy Market Size*. If a proposed technology or approach affects energy use in multiple end uses (e.g. an HVAC technology that operates in both heating and cooling modes), the Baseline Energy Calculator will need to be run multiple times to obtain the market size for each affected end use. Detailed instructions on how to use the Baseline Energy Calculator are provided on the website.

The “Typical New Technology” in Eq. F1 is the technology that is being replaced. For “covered” technologies, that is, technologies subject to minimum efficiency standards,³² Applicants should assume the efficiency of the “Typical New Technology” to be greater than or equal to the applicable efficiency standard. For “covered” and other technologies, Table F1 presents the projected 2030 stock and average stock efficiency for a variety of residential equipment that may be used in this calculation. Corresponding 2030 average stock efficiencies for commercial units are provided in Table F2. In all cases applicants should ensure that if a “covered”

³² http://www1.eere.energy.gov/buildings/appliance_standards/standards_test_procedures.html

technology is being replaced, the efficiency of the “Typical New Technology” is equal to or greater than the applicable efficiency standard.

Table F1 2030 Residential equipment stock and average efficiency³³

Equipment Class	Stock (million units)	Stock Average Efficiency
Main Space Heaters		
Electric Heat Pumps (HSPF)	15.74	9.85
Natural Gas Heat Pumps (GCOP)	0.38	1.30
Geothermal Heat Pumps (COP)	1.52	3.78
Natural Gas Furnace (AFUE)	67.57	0.86
Distillate Furnace (AFUE)	5.60	0.88
Space Cooling		
Electric Heat Pumps (SEER)	15.75	17.19
Natural Gas Heat Pumps (GCOP)	0.38	0.67
Geothermal Heat Pumps (EER)	1.52	19.14
Central Air Conditioners (SEER)	77.46	14.54
Room Air Conditioners (EER)	47.16	11.20
Water Heaters		
Electric (EF)	60.02	0.99
Natural Gas (EF)	65.94	0.63
Distillate Fuel Oil (EF)	1.66	0.65
Propane (EF)	2.63	0.62
Refrigeration		
Refrigerators (kW.hr/yr.)	167.35	466.89
Freezers (kW.hr/yr.)	43.63	409.36

³³ Residential Sector Equipment Stock and Efficiency, AEO 2017 Reference case:

<https://www.eia.gov/outlooks/aeo/data/browser/-/?id=30-AEO2017&cases=ref2017&sourcekey=0>

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Table F2 2030 Commercial equipment average efficiency³⁴

Equipment Class	Stock Average Efficiency ³⁵
Space Heating	
Electricity	1.79
Natural Gas	0.79
Distillate Fuel Oil	0.81
Space Cooling	
Electricity	3.90
Natural Gas	0.80
Water Heating	
Electricity	1.09
Natural Gas	0.87
Distillate Fuel Oil	0.79
Ventilation (cfm/Btu)	0.71
Refrigeration	3.10

If the provided information is not used to calculate the *Energy Market Size* (TBtu), then a comparable approach can be applied, with corresponding justification.

Simple Payback

A second performance metric used to evaluate applications will be the cost effectiveness, as measured by the *Simple Payback*. This will be applicable only to technology innovations, and not to other innovations such as design tools or enabling technologies for which primary energy savings and/or payback are difficult to describe. Proposers should compute the *Simple Payback* for their proposed technology innovation per Eq. F2:

³⁴ Commercial Sector Energy Consumption, Floorspace, and Equipment Efficiency, AEO 2017 Reference case: <https://www.eia.gov/outlooks/aeo/data/browser/#/?id=32-AEO2017&cases=ref2017&sourcekey=0>. Note that the stock (millions of units) are not available from this source.

³⁵ Unless noted otherwise, efficiencies are in units of Btu of energy output divided by Btu of energy input.

$$\left[\begin{array}{c} \text{Simple} \\ \text{Payback} \\ (\text{Yr}) \end{array} \right] = \frac{\left[\begin{array}{c} \text{Incremental Initial} \\ \text{Cost of Proposed} \\ \text{Technology at Scale (\$)} \end{array} \right]}{\left[\begin{array}{c} \text{Cost} \left(\frac{\$}{\text{Yr}} \right) \\ \text{Savings} \end{array} \right]} \quad (F2)$$

$$= \frac{\left[\begin{array}{c} \text{Incremental Initial} \\ \text{Cost of Proposed} \\ \text{Technology at Scale (\$)} \end{array} \right]}{\left[\begin{array}{c} \text{Unit Energy Consumed by} \\ \text{Typical New Technology} \\ \text{Per Year (kWh/Yr)} \end{array} \right] \left[\begin{array}{c} \text{Energy} \left(\frac{\$}{\text{kWh}} \right) \\ \text{Cost} \end{array} \right] \left[\begin{array}{c} \% \text{ Energy Savings} \\ \text{Over Typical New} \\ \text{Technology} \end{array} \right]}$$

where the *Incremental Initial Cost of Proposed Technology at Scale (\$)* is computed from

$$\left[\begin{array}{c} \text{Incremental Initial} \\ \text{Cost of Proposed} \\ \text{Technology at Scale (\$)} \end{array} \right] = \left[\begin{array}{c} \text{Unit Cost of} \\ \text{Proposed Technology} \\ \text{at Scale (\$)} \end{array} \right] - \left[\begin{array}{c} \text{Unit Cost of} \\ \text{Typical New} \\ \text{Technology (\$)} \end{array} \right] \quad (F3)$$

Note that the *% Energy Savings Over Typical New Technology* term in Eq. F2 is the same as that in Eq. F1. The “Energy Cost” can be specified alternatively in \$/MMBtu (i.e., for natural-gas-fired systems), or in whatever units are most appropriate. The nationally averaged energy costs specified in Table F3 *must* be used for this calculation. The proposer should describe, and provide supporting documentation, what they consider to be an acceptable maximum payback (in years), which can vary significantly depending on the end use.

Table F3 Retail energy 2015 pricing (year-to-date)

Sector	Electricity, ¢/kWh ³⁶	Natural Gas	
		\$/Thousand Cubic Feet ³⁷	\$/MMBTU ³⁸
Residential	12.64	12.36	12.02
Commercial	10.65	8.15	7.93

³⁶ http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_3

³⁷ http://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PCS_DMcf_a.htm

³⁸ <http://www.eia.gov/tools/faqs/faq.cfm?id=45&t=8>

APPENDIX G – LIST OF ACRONYMS

A/C	Air Conditioning
AEO	Annual Energy Outlook
AFDD	Automated Fault Detection Diagnostics
AGC	Automatic Generation Control
ANSI	American National Standards Institute
BEM	Building Energy Modeling
BENEFIT	Buildings Energy Efficiency Frontiers & Innovation Technologies
BTO	Building Technologies Office
CFR	Code of Federal Regulations
CHP	Combined Heat and Power
COI	Conflict of Interest
COP	Coefficient of Performance
CRI	Color Rendering Index
DEC	Determination of Exceptional Circumstances
DER	Distributed Energy Resources
DMP	Data Management Plan
DOE	Department of Energy
DUNS	Dun and Bradstreet Universal Numbering System
EERE	Energy Efficiency and Renewable Energy
EPACT	Energy Policy Act
EQE	External Quantum Efficiency
ET	Emerging Technologies
EUI	Energy Use Intensity
FAR	Federal Acquisition Regulation
FFATA	Federal Funding and Transparency Act of 2006
FFRDC	Federally Funded Research and Development Center
FOA	Funding Opportunity Announcement
FOIA	Freedom of Information Act
FWHM	Full Width at Half Maximum
GAAP	Generally Accepted Accounting Principles
GAHP	Gas Absorption Heat Pump
GEB	Grid-Interactive Efficient Building
GHP	Gas Heat Pump
GMI	Grid Modernization Initiative
HIL	Hardware-in-the-Loop
HVAC	Heating, Ventilation, and Air-Conditioning
IEA	International Energy Agency
IOT	Internet-of-Things
IP	Intellectual Property
IPMP	Intellectual Property Management Plan
IQE	Internal Quantum Efficiency
IT	Information Technology

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LED	Light Emitting Diode
M&O	Management and Operating
MPIN	Marketing Partner ID Number
M&V	Measurement and Verification
NDA	Non-Disclosure Acknowledgement
NEPA	National Environmental Policy Act
NNSA	National Nuclear Security Agency
OECD	Organization of Economic Coordination and Development
OLED	Organic Light Emitting Diode
OMB	Office of Management and Budget
OSS	Open-Source Software
OSTI	Office of Scientific and Technical Information
PCE	Power Conversion Efficiency
PCM	Phase Change Material
PII	Personally Identifiable Information
PV	Photovoltaic
QD	Quantum Dot
QY	Quantum Yield
R&D	Research and Development
RIA	Research and Innovation Act
SAM	System for Award Management
SOPO	Statement of Project Objectives
SSL	Solid-state Lighting
SSLC	Separate Sensible and Latent Cooling
TIA	Technology Investment Agreement
TOU	Time-of-Use
UCC	Uniform Commercial Code
VFD	Variable Frequency Drive
WBS	Work Breakdown Structure
WP	Work Proposal

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