DEPARTMENT OF ENERGY (DOE)
OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY (EERE)

BUILDINGS ENERGY EFFICIENCY FRONTIERS & INNOVATION TECHNOLOGIES (BENEFIT) – 2016

Funding Opportunity Announcement (FOA) Number: DE-FOA-0001383
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FOA Issue Date:	12/15/2015
First Informational Webinar:	12/21/2015, 2:00pm ET
Submission Deadline for Concept Papers:	2/5/2016, 5:00pm ET
Second Informational Webinar:	3/17/2016, 2:00pm ET
Submission Deadline for Full Applications:	4/19/2016, 5:00pm ET
Expected Submission Deadline for Replies to Reviewer Comments:	5/27/2016, 5:00pm ET
Expected Date for EERE Selection Notifications:	Summer 2016
Expected Timeframe for Award Negotiations	Late Summer 2016

- 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.

- FOA Webinar links:

  12/21/2015 – Informational Webinar
  https://attendee.gotowebinar.com/register/8715391438828356098

  03/17/2016 – Informational Webinar
  https://attendee.gotowebinar.com/register/9049947538484352769

- 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 Funding Opportunity Announcement are highlighted in yellow in the body of the FOA.

Mod. No.	Date	Description of Modification
000001	01/11/2016	1. Total available federal funding has increased from $8 million to $20 million. 2. The number of anticipated awards has increased to approximately 17-25. 3. The schedule has been altered to allow an additional week for submission of Concept Papers. The new submission date for Concept Papers is 2/5/2016 4. The 2nd Webinar has been rescheduled to 3/17/2016. 5. Additional detail regarding building/grid interaction has been added for Topic Areas 1, 2 and 4. 6. Extend the submission date for Full Applications to 4/19/2016.

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I. FUNDING OPPORTUNITY DESCRIPTION

A. DESCRIPTION/BACKGROUND

Buildings accounted for 40% (38.5 Quadrillion Units of BTUs, or Quads) of the primary energy consumption in the United States (US) in 2014, greater than that attributable to either industry (33%) or transportation (27%). Building energy consumption represents a cost of approximately $416 billion in 2012 dollars. This leads to buildings being responsible for 38% of the energy-related carbon dioxide emissions in the USA [2014 Annual Energy Outlook, http://www.eia.gov/forecasts/aeo/]. It is clear that energy efficiency measures in the buildings sector provide a tremendous opportunity to reduce energy consumption and costs, and to reduce greenhouse gas (GHG) emissions.

The Emerging Technologies (ET) Program of the Building Technologies Office (BTO) supports applied research and development (R&D) for technologies and systems that contribute to reductions in building energy consumption. The goal of the ET Program is to enable the development of cost-effective technologies that can reduce building energy use intensity by 30 percent by 2020, and 45 percent by 2030, relative to the consumption of 2010 energy-efficient technologies. The ET Program strives to meet this goal by researching and developing cost-effective, energy-efficient technologies for residential and/or commercial buildings that are to be introduced into the marketplace. A portion of the ET budget provides support for the Department of Energy (DOE) national laboratories in five areas; solid-state lighting, heating, ventilation, and air conditioning (HVAC) (includes water heating and appliances), sensors & controls, windows & envelope, and modeling & tools. The majority of the remaining budget is distributed through competitive solicitations, including Funding Opportunity Announcements (FOAs) like this one, to allow all interested parties (corporations, universities, non-profits, as well as the national labs) to help advance technologies that lead to reduced primary energy consumption in buildings.

This FOA combines early-stage topics (Innovations) with later-stage, roadmap-driven topics (Frontiers) that complement the core funding provided by the program. Because of their different focuses (Innovations: early-stage; Frontier: later-stage, roadmap-driven), this FOA is divided into two sections; an Innovations and a Frontiers section with an additional optional Buildings University Innovators and Leaders Development (BUILD) supplement.

Applications for a BUILD Supplement cannot be submitted as standalone applications.

Below is a summary of the 5 topic areas and optional BUILD supplements:

INNOVATIONS section:

Topic 1: Open Topic for Energy Efficiency Solutions for Residential and Commercial Buildings

The Building Technologies Office (BTO) seeks to develop technologies, techniques, and tools for making buildings more energy efficient. Currently supported technologies include heating,

ventilating, and air conditioning (HVAC), water heating, lighting, building envelope (including windows), and sensors and controls, as well as building energy modeling.

BTO specifically encourages submissions that augments our existing portfolio. Any innovative energy-efficiency technologies, approaches, or design tools which show a clear application to residential and/or commercial buildings with significant primary energy savings potential that are neither (a) already supported by BTO (see http://energy.gov/eere/buildings/emerging-technologies), nor (b) described explicitly in a BTO R&D roadmap (see http://energy.gov/eere/buildings/listings/technology-roadmaps), are eligible to apply under Topic 1, including technologies that enable more effective integration between buildings and the electricity grid.

The following subtopics are of particular interest to BTO:

a) HVAC&R (Heating, Ventilation, Air Conditioning, and Refrigeration) Materials Joining Technologies[1]
b) Technologies to Reduce the Balance-of-System Cost for Energy Efficient Windows & Envelope Retrofits

Note that BTO will consider other submissions within Topic 1, besides these subtopics.

Topic 2: Human-in-the-Loop Sensor & Control Systems

BTO seeks to develop novel hardware and software solutions for real-time occupant-centered control of the HVAC, lighting, and/or plug load end uses, which represent 13.5, 4.4, and 2.4 quads of primary building energy use, respectively.[2] The primary goal of this subtopic is to move building control schemes beyond the typically over-simplified representation of occupant comfort and actions (e.g., static group-level occupancy schedules and comfort proxies)[3] to enable real-time feedback on individual-level occupant presence and/or comfort via a local sensing infrastructure. Such occupant-centered control schemes can save energy by reducing unneeded space conditioning and lighting during unoccupied periods and by avoiding overly conservative operational settings when occupants are present in the space.

Topic 3: Infiltration Diagnostic Technologies

BTO seeks applications to develop novel infiltration diagnostic technologies that can be used to identify the location and quantify the extent of infiltration/exfiltration through the building envelope, which represented 4% of total U.S. primary energy use in 2010.[4] Of particular interest are technologies that reduce variability in test results, reduce the complexity and effort

[1] http://energy.gov/eere/buildings/downloads/research-development-opportunities-joining-technologies-hvacr
[2] U.S. Energy Information Administration. (2014). *2014 Annual Energy Outlook*. Washington, D.C.: U.S. Energy Information Administration. http://www.eia.gov/forecasts/aeo/pdf/0383(2014).pdf.
[3] Friere, R.Z., Oliveira, G.H., and Mendes, N. (2008). *Predictive controllers for thermal comfort optimization and energy savings.* Energy and Buildings, 40, 1353-1365.
[4] U.S. Department of Energy. (2014). *Windows and Building Envelope Research and Development: Roadmap for Emerging Technologies.* Washington, D.C.: U.S. Department of Energy. http://energy.gov/sites/prod/files/2014/02/f8/BTO_windows_and_envelope_report_3.pdf

required to test medium and large commercial buildings, do not disrupt building occupants during testing, and/or enable evaluation of façades under construction for air sealing quality assurance. Novel infiltration diagnostic technologies are a key enabler of advanced air-sealing products that address the energy savings opportunity associated with infiltration. Approaches using either or both direct measurement of air infiltration and indirect measurement (i.e., virtual sensing) using building sensor systems are of interest.

FRONTIERS section:

Topic 4: Plug and Play Sensor Systems

The objective of this topic is to improve the power performance, self-calibration and automatic recognition of sensor nodes in building applications with the goal of enabling true plug-and-play solutions at ≤$10/node that optimally interface with building management systems (BMS) and control schemes. Through innovations in both sensing hardware and open-source software, these solutions will accelerate sensor deployment and improve data collection capabilities for building operation, including HVAC, lighting, windows/window attachments, plug loads, and occupancy, that can be utilized in both existing and new controls systems. As an enabling technology within buildings, advancements in sensor and controls strategies can improve the efficiency of other buildings technologies, i.e. heating, ventilating, and air conditioning (HVAC), water heating, lighting, and windows/window attachments, as well as improve transaction-based capabilities and integration with the electricity grid.[5] Energy savings of up to 30% are estimated in buildings through improvements in climate, air quality, and occupancy sensors.[6]

Topic 5: Advanced Air-Sealing Technologies for Existing Buildings

BTO seeks applications for the development of advanced, cost-effective air-sealing technologies designed specifically for use in existing buildings, which comprise more than 98% of the current building stock. When integrated into the envelope, air-sealing technologies act as a barrier to infiltration or exfiltration of air and other flows. A next-generation air-sealing methodology will require new thought processes on how heat, air, and moisture flow are interrelated and how to best regulate them in order to improve overall building-level system performance, as opposed to a more traditional strategy that focuses on component improvements. Most importantly, to be suitable and cost-effective for existing buildings, these technologies should minimize envelope disassembly and installation complexity, and thus occupant disruption. Current air-sealing systems capable of controlling heat, air and moisture, for both residential and commercial buildings, are complicated and costly because three separate technologies, and often separate trades, are needed. One integrated technology system, allowing vertical integration of trades and installation steps would reduce the costs associated with high performance air sealing technologies. Existing systems also have inadequate quality control and verification of completeness during application, which reduces the efficacy of the sealing technology and leads to lower realized energy savings.

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[5] Nguyen, T.A. and Aiello, M. (2013). *Energy intelligent buildings based on user activity: A survey*. Energy and Buildings, 56, 244-257.

[6] Siemens, 2012, "Building Automation – impact on energy efficiency," [Online], Available: http://www.hqt.sbt.siemens.com/gip/general/dlc/data/assets/hq/Building-automation---impact-on-energy-efficiency_A6V10258635_hq-en.pdf.

BUILD Supplements section

BUILD = Buildings University Innovators and Leaders Development

The BUILD effort makes available optional supplements to applications submitted in response to any of the topics described in this FOA. The BUILD Supplements are for a maximum of $100K/year for each year of a project, not to exceed $300K for a 3-year project for example. Prime recipients that are for-profit companies may apply for a BUILD Supplement to partner with a university. Equivalently, university prime recipients may apply for a BUILD Supplement to partner with a for-profit company. The BUILD Supplement cannot be submitted as a stand-alone application, and must describe technical work that supplements the work described in the primary application. The BUILD Supplement will be evaluated separately such that the primary application may be selected for an award with or without the BUILD Supplement.

B. TOPIC AREAS/TECHNICAL AREAS OF INTEREST

INNOVATIONS Section:

Topic 1: Open Topic for Energy Efficiency Solutions for Residential and Commercial Buildings

The Building Technologies Office (BTO) seeks to develop technologies, techniques, and tools for making buildings more energy efficient. Currently supported technologies include heating, ventilating, and air conditioning (HVAC), water heating, lighting, building envelope (including windows), and sensors and controls, as well as building energy modeling. Any innovative energy-efficiency technologies, approaches, or design tools which show a clear application to residential and/or commercial buildings with significant primary energy savings potential that are neither (a) already supported by BTO (see http://energy.gov/eere/buildings/emerging-technologies), nor (b) described explicitly in a BTO R&D roadmap (see http://energy.gov/eere/buildings/listings/technology-roadmaps), are eligible to apply under Topic 1, including technologies that enable more effective integration between buildings and the electricity grid.

Within this topic, the following subtopics are of particular interest. BTO will consider other proposals within Topic 1, besides these subtopics.

a) HVAC&R Materials Joining Technologies[1]

Vapor-compression systems have effectively and efficiently served HVAC needs for residential and commercial buildings for close to 100 years. Vapor compression technologies are currently the dominant HVAC technology due to their scalability, relatively compact size, high reliability, and other attributes. Vapor-compression systems move heat from one location to another through a closed-loop cycle by compressing, condensing, expanding, and evaporating a refrigerant fluid. Depending on the configuration and operating mode, vapor-compression systems can supply space cooling and/or space heating to maintain a comfortable building environment. However, refrigerants have detrimental effects on the global environment when released into the atmosphere. The objective of this topic is to unlock new technologies pushing energy efficiency while developing new joining techniques that maintain the integrity of these

sealed systems. The joining of materials is a critical requirement not limited just to metals but also includes the joining of membranes, plastic and hybrid joints between metals and non-metals. The main culprit that causes refrigerant leaks in most systems is via leaks in the metal tubing and their joints. These leaks are a combination of defects in field connections, defects in manufacturing, new connections and thinner wall structures, and are exacerbated as we move towards different refrigerant systems like CO_2 systems, higher pressure systems, or new low-GWP (global warming potential) refrigerants with flammability (or toxicity) issues.

This effort would focus on new techniques and methods for the joining of tubes, compressors, heat exchangers and other HVAC components with the goal of enabling and facilitating the development of new technologies like better heat exchangers and better joints in the factory and field. Better joints are defined as those with lower leak rates and enhanced throughput at the factory and final field installations. The anticipated commitment to reduce HFC consumption has stimulated interest in alternative refrigerants with low-GWP but addressing the issue of refrigerant leaks in existing equipment is critical to the US.

b) Technologies to Reduce the Balance-of-System Cost for Energy Efficient Windows & Envelope Retrofits

The single biggest mass-market barrier to retrofitting the envelope (windows or opaque components) for existing buildings is the high installed cost. BTO internal analysis shows that the return on investment, based on the installed cost rather than the component cost, for these technologies is often far longer than would be market acceptable and in some cases can be longer than the life of the product. Sensitivity analysis performed by BTO for the Windows & Envelope R&D roadmap[7] clearly shows that for both highly insulating windows and walls, the payback period is far more heavily dependent on the installed cost of the product than its insulating performance. For example, to add insulation to existing walls, the labor costs for traditional interior or exterior insulation is \$0.40 to \$0.50/ft^2 (at least 50% of the total cost depending on the insulation type), not accounting for associated construction such as moving windows or electrical outlets that is necessary for the state-of-the-art insulation materials.[8,9] However, the only way to get a payback period below 10 years for adding high performance (R6 to R12/in) wall insulation to either the interior or exterior surface of existing buildings is for the installed cost of the added insulation to be less than \$0.25/ft^2. These numbers will vary substantially by the project and path to market.

For this subtopic, BTO is interested in hardware, software and/or other enabling tools that reduce the balance-of-system costs associated with retrofitting windows and the opaque envelope, particularly walls and flat roofs, and other components of residential and/or

[7] http://energy.gov/eere/buildings/downloads/research-and-development-roadmap-windows-and-building-envelope

[8] Kosny, Jan; Fallahi, Ali; Shukla, Nitin. (January 2013). *Cold Climate Building Enclosure Solutions*. Washington, DC: U.S. Department of Energy. cse.fraunhofer.org/Portals/55819/docs/ba_cold_climate_enclosure_solutions.pdf.

[9] "Checklist." Consumers Checkbook. (2013). Accessed July 13, 2013: checkbook.org/interactive/window/other/w/article.cfm.

commercial buildings with high-performance insulating materials. BTO is not interested in techniques exclusively used to replace static building components with dynamic components (e.g. electrochromic windows or Phase Change Materials (PCMs)).

Topic 2: Human-in-the-Loop Sensor & Control Systems

Energy efficient building operations must balance the two key objectives of minimizing energy consumption and maintaining acceptable comfort conditions for building occupants. While various means exist for achieving energy objectives, a lack of real-time feedback on the presence and environmental preferences of building occupants precludes the realization of occupant comfort objectives. In practice, this limits the savings potential of energy efficiency measures, leading to unexpected operational challenges and eventual discrepancies between expected and measured energy consumption.[10] Moreover, the lack of information about actual occupancy and comfort responses yields energy waste via unneeded space conditioning and lighting during unoccupied periods and overly conservative operational settings when occupants are present in the space.[11]

Recent literature suggests significant energy savings and comfort improvements are possible from strategies that bring humans into the building controls loop. For example, a recent literature review of occupancy-based controls reports up to 40% simulated lighting and HVAC savings across residential and commercial building types.[12] Another study employs human-in-the-loop control of plug loads, reporting up to 80% computer power savings from a strategy that puts computers to sleep through an early occupant distraction-recognition scheme.[13] Multiple studies identify further energy savings from tuning operational strategies to real-time occupant preferences and behavior. For example, one lighting study shows up to a 79% reduction in energy consumption from employing a control strategy that allows occupant lighting adjustment over a baseline of constant lighting control.[14] In the case of HVAC, 10–40% savings are reportedly possible from tuning thermostat set points to the real-time individual

[10] Turner, C. (2008). *Energy Performance of LEED for New Construction Buildings*. Washington, D.C.: New Buildings Institute. http://www.usgbc.org/Docs/Archive/General/Docs3930.pdf.

[11] Ghahramani, A., Jazizadeh, F., Becerik-Gerber, B. (2014). *A knowledge based approach for selecting energy aware and comfort-driven HVAC temperature set points.* Energy and Buildings, 85, 536-548.

[12] Nguyen, T.A. and Aiello, M. (2013). *Energy intelligent buildings based on user activity: A survey*. Energy and Buildings, 56, 244-257.

[13] Munir, S., Stankovic, J.A., Liang, C.J.M., and Lin, S. (2014). *Reducing Energy Waste for Computers by Human-in-the-Loop Control.* Emerging Topics in Computing, IEEE Transactions, 2(4), 448-460.

[14] Bourgeois, D., Reinhart, C., and Macdonald, I. (2006). *Adding advanced behavioural models in whole building energy simulation: A study on the total energy impact of manual and automated lighting control*. Energy and Buildings, 38, 814-823.

comfort preferences;[15,16,17] another study finds further HVAC energy reductions by including energy use alongside learned occupant comfort ranges in a multi-objective optimization scheme.[18] In each of these studies, it is noted that real-time occupant feedback enables savings without adverse comfort effects, and comfort is improved in some cases. This is important because comfort is associated with productivity outcomes,[19] which are valued up to thirteen times greater than energy costs.[20]

Beyond these direct energy savings and comfort benefits, human-in-the-loop control schemes may also offer opportunities to collect local-level data on occupant presence and adaptive behavior that can be used to improve the representation of occupants in building energy simulation tools. Occupant behavior is a key source of uncertainty in building energy models, as previous studies have reported up to a +90%/-50% change in simulated energy consumption due to variations in behavior-related model inputs.[21]

BTO seeks novel occupant-centered building sensor hardware and/or software that can be integrated cost effectively with building control schemes, including but not limited to transaction-based controls that integrate with the electricity grid, to satisfy the multiple objectives of minimizing energy use and individual occupant discomfort. Solutions for incorporating occupants in the building controls loop may focus on real-time occupancy, occupant actions, and/or occupant comfort preferences, and must demonstrate the technical potential to save at least 250 TBtus annually of primary HVAC, lighting, and/or plug load energy consumption for residential and/or commercial U.S. buildings in 2030. Approaches that achieve energy savings via integration of occupancy and occupant preference feedback across multiple end uses are encouraged.

Local occupant sensing may be passive (using proxy occupant sensors without requiring direct human input); active (requiring direct occupant participation); or a hybrid of these options.[22] Where modeled proxies for occupant parameters are proposed, the predictive accuracy of these models should be reported. Examples of currently available passive occupancy sensing technologies that may be leveraged include infrared sensors, radio frequency identification

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[15] Erickson, V.L. and Cerpa, A.E. (2012). Thermovote: Participatory Sensing for Efficient Building HVAC Conditioning. In: Proceedings of Buildsys '12, Nov. 6, 2012, Toronto, CAN.

[16] Murakami, Y., Terano, M., Mizutani, K., Harada, M., Kuno, S. (2007). *Field experiments on energy consumption and thermal comfort in the office environment controlled by occupants' requirements from PC terminal.* Building and Environment, 42, 4022-4027.

[17] Feldmeier, M., Paradiso, J.A. (2010). *Personalized HVAC Control System.* In Proceedings of Internet of Things (IOT), Nov. 29-Dec. 1, 2010, Tokyo, JP.

[18] Ghahramani et al, 2013.

[19] Lan, L., Wargocki, P., and Lian, Z. (2011). *Quantitative measurement of productivity loss due to thermal discomfort.* Energy and Buildings, 43(5), 1057-1062.

[20] Lippiatt, B.C. and Weber, S.F. (1992). *Productivity Impacts in Building Life Cycle Cost Analysis.* Gaithersburg, MD: National Institute of Standards and Technology.

[21] Hong, T. and Lin, H.W. (2013). *Occupant Behavior: Impact on Energy Use in Private Offices.* Berkeley, CA: Lawrence Berkeley National Lab. http://eande.lbl.gov/sites/all/files/lbnl-6128e.pdf

[22] Munir, S., Liang, C.J.M., Lin, S. (2013). *Cyber Physical System Challenges for Human-in-the-Loop Control.* In: Proceedings of the 8th International Workshop on Feedback Computing, June 25, 2013, San Jose, CA.

(RFID), and CO_2 sensors; devices for active occupant feedback include smart phones, tablets, or desktop/laptop computers. Proposals that build upon such existing technologies or leverage emerging technologies like wearable sensors must address key barriers to their adoption in buildings, including high initial cost, difficulty of integration with existing BMS systems, occupant reporting fatigue over time, and privacy concerns.[9,23]

By 2030, all proposed solutions should meet a 2-5 year payback period[24] or else should demonstrate quantifiable non-energy benefits that are sufficient to justify a higher payback period (e.g., improved occupant comfort). Cost reductions are particularly desirable for projects that are leveraging the multitude of occupant feedback devices already available on the residential market.[25]

Finally, where applicable, applications should demonstrate clear strategies for aggregating real-time data across multiple occupants, incorporating the data into existing and new building management and control schemes, and learning from the data to enable greater automation of occupant-centered control schemes over time. Approaches should also be described for securely storing or transmitting collected data to external repositories to inform improved representation of occupant behavior in building energy modeling and control algorithms.

BTO is not interested in applications that focus on other aspects of building operations — such as operator behavior or fault detection and diagnosis — without incorporating direct or indirect feedback from individual building occupants. While software-focused solutions are welcome, control algorithms for multiple occupant spaces that rely solely on group-level representations of comfort (e.g., using zone-level environmental parameters or group comfort models like the Predicted Mean Vote (PMV)) are also not of interest.

Topic 3: Infiltration Diagnostic Technologies

Infiltration diagnostic technologies are used to measure the infiltration of air through the windows and opaque envelope elements of building enclosures. Of the approximately 40 quads of primary energy used by U.S. residential and commercial buildings in 2010, nearly 4 quads are associated with air infiltration alone. While infiltration diagnostic technologies do not themselves correct infiltration problems in buildings and thus save energy, they are a valuable tool for characterizing infiltration issues in a given building, and the test results can be used to estimate the energy savings potential of an infiltration remediation effort.

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[23] Klein, L., Kwak, J., Kavulya, G., Jazizadeh, F., Becerik-Gerber, B., Varakantham, P., and Tambe, M. (2012). Coordinating occupant behavior for building energy and comfort management using multi-agent systems. Automation in Construction, 22, 525-536.

[24] This payback period range is consistent with that typically demanded of energy efficient technologies by potential residential and commercial adopters. See: McKinsey Global Institute. (2009). "Unlocking energy efficiency in the U.S. economy." Accessed November 22, 2015: http://www.mckinsey.com/~/media/mckinsey/dotcom/client_service/epng/pdfs/unlocking%20energy%20efficiency/us_energy_efficiency_full_report.ashx

[25] In particular, smart thermostats, which typically sell at a $250 price point. See: "Smart Thermostats." Lowe's. (2015). Accessed July 10, 2015: http://www.lowes.com/Heating-Cooling/Thermostats/Smart-Thermostats/_/N-1z0yryw/pl#!

Novel infiltration diagnostic techniques are needed to be able to achieve the higher performance air-sealing targets in the BTO Windows and Envelope Technologies roadmap.[4] For example, BTO considered the opportunity for reducing the national average tightness of commercial buildings from 1.38 CFM75/ft^2 to 0.25 CFM75/ft^2, an 83% reduction.[26] Sealing large, readily-identified leaks yields an estimated average reduction in infiltration of only 10% (0.14 CFM75/ft^2). The remaining reduction, from an average 1.24 CFM75/ft^2 to 0.25 CFM75/ft^2, requires sealing more dispersed and difficult-to-find leaks. Current infiltration diagnostic technologies are not always suitable to locating and quantifying these more dispersed leaks, thus making them difficult to address.

Ideally, an infiltration diagnostic technology would:

- provide quantitative location *and* extent of infiltration,
- yield results for the whole building or sections of the envelope,
- require minimal setup and tear-down effort,
- be accurate regardless of outdoor weather conditions, and
- not be disruptive to building occupants.

Currently commercialized infiltration diagnostics, such as blower door tests and tracer gas methods, can meet no more than three of these criteria. Available diagnostic technologies often involve significant test setup and teardown time and effort, especially for larger buildings. For many diagnostic technologies, accuracy and repeatability of test results requires extensive knowledge and experience with a particular set of test conditions. Additionally, incomplete façades and façade sections generally cannot be tested, since existing methods require a complete enclosure.

BTO seeks applications to develop technologies *or* combinations of technologies that can meet at least three of the (above) specified criteria. Of particular interest are technologies that can also reduce variability in test results, reduce the complexity and effort required for medium/large commercial buildings, reduce disruption to building occupants from testing, and/or enable testing of incomplete façades for quality assurance.

Technical approaches for advanced infiltration diagnostic methods are highly varied, but can be grouped into two major types: direct and indirect methods. Direct methods involve measuring air flows through the envelope, typically as a single event. Blower door testing is an example of a direct method for infiltration diagnostics. Indirect methods involve measuring other parameters, such as CO_2 or VOCs, and estimating infiltration based on their concentrations or changes over time. Generally, indirect methods could be characterized as virtual sensing. Novel methods of either type are of interest to BTO.

[26] Emmerich, Steve; Persily, Andrew. (2011). "U.S. Commercial Building Airtightness Requirements and Measurements." Accessed December 4, 2013: nist.gov/customcf/get_pdf.cfm?pub_id=909521

FRONTIERS section:

Topic 4: Plug and Play Sensor Systems

BTO seeks applications for innovative hardware and/or open-source software solutions for wireless, multi-functional sensor nodes or packages with the goal of enabling true plug-and-play solutions at ≤$10/node in building applications. This goal will be accomplished by improvements to power performance in order to increase operational lifetime and reduce maintenance costs, as well as improvements to self-calibration and automatic recognition properties in order to ease the cost of installing, commissioning, and configuring a sensor node to communicate with a centralized system. Increased adoption of and improvements in advanced sensor solutions will enable energy savings in building energy management and controls strategies, including transaction-based controls that integrate with the electricity grid. Specifically, building commissioning (0.5-1.8 Quads technical potential), damper fault detection and diagnosis (0.02-0.1 Quads technical potential), demand-controlled ventilation (0.2-0.3 Quads technical potential), duct leakage diagnostics (0.15-0.4 Quads technical potential), optimal whole-building control (≥ 0.4 Quads technical potential) can all be improved through low cost and easily installed sensors (i.e. plug and play).[27] While commercially available sensor components exist today, the costs of current platforms are still high (typically >$100/node)[28] and further development of wireless solutions and systems-level integration are necessary.

Wireless sensing has become an attractive and cost-effective approach for monitoring in building system applications, especially in retrofits, due to the elimination of wiring, which makes up approximately 75% of the installed cost (labor and materials), and power cables, as well as the flexibility of sensor placement and monitoring from remote locations, and ability for automated reconfiguration of the system.[29,30,31,32] Wireless sensor nodes consist of four units, as depicted in Figure 4.1: the sensor unit composed of the sensor(s) or transducer(s) themselves that take measurements, the power supply and management device that monitors and regulates power from the source, the micro-controller or processing unit, and the communication hardware that consists of the wireless transceiver that transmits data for further processing by a central unit or gateway.[33,34]

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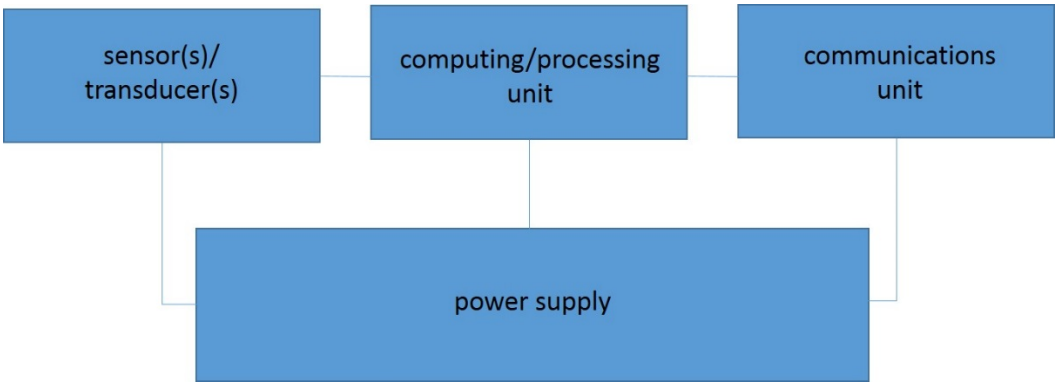
[27] Roth, K.W. et al., 2005, "Energy Impact of Commercial Building Controls and Performance Diagnostics: Market Characterization, Energy Impact of Building Faults and Energy Savings Potential."
[28] Survey of 15 commercially available sensor node packages with an average price of $105.22/sensor node.
[29] Malkawi, A. et al., 2005, "A new paradigm for human-building interaction: the use of CDF and augmented reality," Automation in Construction 14(1), 71-84.
[30] Rodrigues, F. et al., 2010, "The Impact of Wireless Sensors in Buildings Automation," Ibersensor, Lisbon Portugal.
[31] Wang, Y. et al., 2005, "Validation of an integrated network system for system for real-time wireless monitoring of civil structures," Proceedings of the 5th International Workshop on Structural Health Monitoring, 275-282.
[32] Osterlind, F. et al., 2007, "Integrating Building Automation Systems and Wireless Sensor Networks," Proceedings of IEEE Conference on Emerging Technologies and Factory Automation, 1376-1379.
[33] Puccinelli, D. et al, 2005, "Wireless Sensor Networks: Applications and Challenges to Ubiquitous Sensing," IEEE Circuits and Systems Magazine, 19-29.
[34] Akyildiz, I. F. et al., 2002, "A Survey on Sensor Networks," IEEE Communications Magazine, 102-114.

Figure 4.1. Sensor Node Block Diagram



Current state of the art wireless sensor nodes, which must communicate over a network, are typically designed to utilize wireless communication protocols adopted by the IEEE 1451.5 standard within the IEEE 802 family, including WiFi, Bluetooth, ZigBee, and 6LoWPAN.[35] In building automation systems, wireless sensor networks must operate efficiently with low energy consumption and reliably with a low error rate of data delivery and low delay, as well as be scalable, mobile, and safe.[36] Advanced versions of wireless sensors may deploy and communicate over a mesh network that extends coverage without significant range limitations.[37,38]

Because they are self-powered, wireless sensor nodes have limited energy storage capacity and the lifetime of a sensor node is typically dictated by its power supply. Since battery energy densities have not improved at the same rate as wireless sensor technology, limited-life batteries require replacement, which can be difficult depending on the placement of the sensor node and added labor and maintenance costs. To address this challenge, a rechargeable storage element can be utilized to supplement the battery or the battery can be supplemented or replaced with an energy harvester, such as a photovoltaic, thermoelectric generator, or piezoelectric, together with an energy storage element. In addition to batteries, other forms of energy storage include capacitors and fuel cells. As a result, reducing the power consumption

[35] IEEE 1451.5: Standard for a Smart Transducer Interface for Sensors and Actuator -- Wireless Communication Protocols and Transducer Electronic Data Sheet (TEDS) Formats. 2007. N.Y.: The Institute of Electrical and Electronic Engineers.
[36] Burrati, C. et al., 2009, "An Overview on Wireless Sensor Networks Technology and Evolution," Sensors 9, 6869-6896.
[37] Grindvoll, H. et al., 2012, "A Wireless Sensor Network for Intelligent Building Energy Management Based on Multi-Communication Standards – A Case Study," Journal of Information Technology in Construction 17, 43-61.
[38] Rodenas-Harraiz, D. et al., 2013, "Current Trends in Wireless Mesh Sensor Networks: A Review of Competing Approaches," Sensors 13, 5958-5995.

and extending the lifetime of the power source of wireless sensor nodes continues to be a key R&D task for researchers and manufacturers.[39,40,41,42,43]

Furthermore, the effective lifetime of the sensor node is limited if the energy consumption of the node is not optimized.[44] The power consumption of a sensor node is dictated by the frequency of sensor measurements (samples/unit time) and efficiency of data transmission to the rest of the sensor network which depend on the performance requirements for a specific sensing application. To reduce power consumption, systems, for example, can employ data filtering on the node so that only sensor readings of interest are communicated.[45,46] Power is further consumed by the processor and communication hardware; indeed, the communications unit is typically the primary source of consumption in the sensor node in which activities such as idle listening or redundant communication, where multiple sensors within a similar distance generate and transmit the same data, need to be minimized due to the resulting energy loss.[47,48,49,50] Effective low power design of the wireless sensor network and management of communications to overcome the constraints and meet the requirements of building applications, therefore, is an active area of research which includes utilizing appropriate routing

[39] Gholamzadeh, B. et al., 2008, "Concepts for Designing Low Power Wireless Sensor Network," International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering 2(9) 1869-1875.
[40] Fafoutis, X. et al., 2014, "Energy Harvesting – Wireless Sensor Networks for Indoor Applications using IEEE 802.11." Procedia Computer Science 32, 991-996.
[41] Zahid Kausar, A.S.M. et al., 2014, "Energizing Wireless Sensor Networks by Energy Harvesting Systems: Scopes, Challenges, and Approaches," Renewable and Sustainable Energy Reviews 38, 973-989.
[42] Knight, C. et al., 2008 "Energy Options for Wireless Sensor Nodes," Sensors 8, 8037.8066.
[43] Tan, Y.K. et al., 2010, "Review of Energy Harvesting Technologies for Sustainable WSN," Sustainable Wireless Sensor Networks, Yen Kheng Tan (Ed.) 14-43.
[44] Rault, T. et al., 2014, "Energy Efficiency in Wireless Sensor Networks: A Top-Down Survey," Computer Networks 67, 104-122.
[45] Hempstead, M. et al., 2008, "Survey of Hardware Systems for Wireless Sensor Networks," Journal of Low Power Electronics 4, 1-10.
[46] Yick, J. et al., 2008, "Wireless Sensor Network Survey," Computer Networks 52, 2292-2330.
[47] Ye, W. et al., 2004, "Medium access control with coordinated adaptive sleeping for wireless sensor networks," IEEE/ACM Trans. Networking 12(3), 493-506.
[48] Demirkol, I. et al., 2006, "MAC protocols for wireless sensor networks: a survey," IEEE Communications Magazine 44(4), 115-121.
[49] Gholamzadeh, B. et al., 2008, "Concepts for Designing Low Power Wireless Sensor Network," International Journal of Electrical, Computer, Energetic, Electronic and Communication Engineering 2(9) 1869-1875.
[50] Mohammed, A. et al., 2010, "A Survey on Routing Protocols for Wireless Sensor Networks," Sustainable Wireless Sensor Networks, Yen Kheng Tan (Ed.) 3-14.

protocols, reducing network traffic, and optimally placing sensor nodes to save power.[51,52,53,54,55,56,57,58]

Currently size is one of the significant limitations in designing wireless sensor nodes. Effective sizing of the energy storage and harvesting units can further reduce manufacturing costs. Depending on the source, either energy density or power density is the metric for characterization (e.g., energy storage for the former metric, energy harvester for the latter metric). Power sources must be as small and efficient as possible with power efficiency an important performance metric in achieving long lasting power sources and reducing maintenance costs.[59,60] Table 4.1 provides the technical targets for this topic. In order to achieve Technical Target 4.1.1 (mean time between replacement or recharge, depending on the power source configuration utilized), applicants are encouraged to optimize any or all four of the units comprising a sensor node, including but not limited to improvements to the density and performance of the power supply selected; optimizing the design of the application space, architecture and circuitry to achieve lower power processors and systems; enhancing the communication or transmission range; and optimally handling data streams for the designated application. A calculated baseline energy consumption for the current state of the art for the sensor node configuration selected and estimate of the percentage improvement (i.e. energy savings) for the solution proposed for 72 hours of operation should be included by applicants.

Another ongoing challenge is automating sensor calibration to the greatest extent possible.[61,62] This is especially important in a network that consists of multiple nodes and in a multi-functional node that consists of multiple sensors. Sensor calibration includes correcting for

[51] Shu, F. et al., 2009, "Building Automation Systems Using Wireless Sensor Networks: Radio Characteristics and Energy Efficient Communication Protocols." Electronic Journal of Structural Engineering 66-73.
[52] Guo, W. et al., 2011, "Wireless Mesh Networks in Intelligent Building Automation Control: A Survey." International Journal of Intelligent Control and Systems 16(1), 28-36.
[53] Osterlind, F. et al., 2007, "Integrating Building Automation Systems and Wireless Sensor Networks," Proceedings of IEEE Conference on Emerging Technologies and Factory Automation, 1376-1379.
[54] Grindvoll, H. et al., 2012, "A Wireless Sensor Network for Intelligent Building Energy Management Based on Multi-Communication Standards – A Case Study," Journal of Information Technology in Construction 17, 43-61.
[55] Fafoutis, X. et al., 2014, "Energy Harvesting – Wireless Sensor Networks for Indoor Applications using IEEE 802.11." Procedia Computer Science 32, 991-996.
[56] Rodrigues, F. et al., 2010, "The Impact of Wireless Sensors in Buildings Automation," Ibersensor, Lisbon Portugal.
[57] Dong, Q.F. et al., 2010, "Design of Building Monitoring System Based on Wireless Sensor Networks,"Wireless Sensor Network 2, 703-709.
[58] Jang, W.S. et al., 2010, "Wireless Sensor Network Performance Metrics for Building Applications," Energy and Building, 42(6), 862-868.
[59] Knight, C. et al., 2008 "Energy Options for Wireless Sensor Nodes," Sensors 8, 8037.8066.
[60] Cree, J. et al., 2013, "Sensor Characteristics Reference Guide," Pacific Northwest National Laboratory, PNNL-22484.
[61] Whitehouse, K. et al., 2002, "Calibration as a parameter estimation in sensor networks." Proceedings of the 1st ACM International Workshop on Wireless Sensor Networks and Applications.
[62] Bychkovskiy, V. et al., 2003, "A Collaborative Approach to In-Place Sensor Calibration." Information Processing in Sensor Networks 2634, 301-316.

errors of: (1) the sensing unit itself after manufacturing, (2) the sensor node after the sensors and other units are mounted, and (3) the change or drift in sensor characteristics over time due to age or damage. In order to enable plug-and-play functionality and further reduce installation and maintenance costs, proposed sensor node solutions should be self-calibrating and achieve Technical Target 4.1.2 for lifetime duration of accurate sensor operation without the need for manual re-calibration. Applications should include and justify the baseline calibration being improved.

Finally, the commissioning process and performance of buildings controls and transactions will improve by automating point mapping (i.e. automatically provide identity, state, and power use). An implicit way of locating sensors with a unique identifier, fault tolerance, and secure communications is desired.[63,64] New devices or nodes that come into the range of a wireless network can offer their services to the network and have new tasks allocated automatically and transparently without requiring a physical connection. Automated planning will also enable correct sensor placement to capture desired measurements, ensure sufficient energy harvesting and wireless signal strength for uninterrupted operation, and auto-configure with location, operational parameters, and other semantic information. Technical Targets 4.1.3-4.1.4 describe automated recognition characteristics that should be demonstrated by the end of the project period, including the positional accuracy or distance from the true node location, as well as the accuracy or percentage of sensors correctly mapped to position on a building schematic.

While standalone solutions or discrete nodes for specific sensing applications (i.e. HVAC, lighting, occupancy, etc.) will be considered, BTO is particularly interested in the development and optimization of wireless sensor nodes that are multi-functional (i.e. sense multiple parameters), as noted in Table 4.1 (Technical Target 4.1.5), as a pathway to achieving the goal of cost-reduction. The incorporation of multiple sensing parameters onto a single platform, however, also results in additional constraints on power consumption and operational lifetime, as well as potential added complexity in calibration and performance, which need to be considered and solved in order to successfully deploy in building applications. While the focus of this topic is on innovative sensing parameters for applications within the building, applications are encouraged but not limited to solutions that also improve transaction-based controls and optimally integrate building controls schemes with the electricity grid.

[63] Curran, K. et al., 2011 "An Evaluation of Indoor Location Determination Technologies," Journal of Location Based Services 5(2).
[64] Cree, J. et al., 2013, "Sensor Characteristics Reference Guide," Pacific Northwest National Laboratory, PNNL-22484.

Table 4.1. Technical Targets

ID	Category	Value
4.1.1	Operational lifetime of power source	
	(a) Mean time to replacement (for batteries)	≥ 10 years
	(b) Mean time between charging (for energy harvesters)	≥ 72 hours
4.1.2	Calibration (lifetime duration of accurate sensor operation)	≥ 5 years
4.1.3	Positional Accuracy (distance from true node location)	≤ 2 feet
4.1.4	Nodes Correctly Located	≥ 90 %
4.1.5	# of Sensed Variables/Node	≥ 1

Proposed solutions for multi-component sensor packages that are comprised of sensor nodes, power, logic, and communication configurations to sense building system states, energy usage, and environmental conditions (i.e. temperature, humidity, etc.) can either focus on hardware, software, or a combination thereof, but must include secure and non-proprietary communication protocols, as indicated in Section IV.D.2. In order to further enable the cost reduction goals, applications are encouraged that not only develop solutions to enhance the power efficiency and operational lifetime, self-calibration and automated recognition of wireless sensor packages, but that also include improvements to the manufacturing, design, and installation of the sensor node. In particular, peel and stick installation approaches and modular designs with easily reconfigurable hardware and common interfaces for all peripherals are all potentially of interest.

Topic 5: Advanced Air-Sealing Technologies for Existing Buildings

Of the 40 quads of primary energy used by U.S. residential and commercial buildings in 2010, approximately 16 quads can be attributed to losses through the building envelope, via heat transfer and air infiltration. More than 25% of that energy, or 10% of total energy use in buildings, is lost due to air infiltration alone. In 2010, infiltration accounted for greater energy losses than any other component related to the building envelope, including fenestration; 2035 projections show similar trends. As a result, air-sealing technologies are one of the top priority Building Envelope R&D areas. For example, BTO internal analysis of residential buildings shows that the total technical potential for envelope air-sealing ranges from 1,237 to 1,679 TBtu, depending on the air-sealing system's performance. For new (post-2010) residential buildings, the technical potential ranges from 507 to 633 TBtu, illustrating that the greatest energy-savings opportunities for air-sealing systems are in existing buildings.[4] Furthermore, it is expected that the technical potential for a next-generation technology that can *simultaneously* control heat, air, and moisture flow will be greater than the baseline numbers presented here.

BTO internal analysis presented in the Windows & Envelope roadmap shows that while sealing buildings with existing technologies is economically attractive, there is a relatively small energy savings potential. Applying existing cost-effective air-sealing technologies, such as foam sealing of wall/roof joints and exterior weather-stripping, leads to an average leakage reduction of 10% in commercial buildings (26,927 to 246,365 ft^2) in cold climates.[65] These measures are most impactful for leaky buildings with large, concentrated leaks that are inexpensive to seal. The technical potential and unstaged maximum adoption potential of achieving this level of leakage reduction (from 1.38 to 1.24 CFM75/ft^2) with existing technologies is only 44 TBtu. Bohac's analysis shows that the cost of sealing these large, concentrated leaks is $0.17 per 5-sided envelope, leading to a simple payback of approximately 6 years.[65] By contrast, to achieve an 83% infiltration reduction, it is necessary to seal more dispersed and difficult-to-find leaks. The technical and unstaged maximum potential for this level of infiltration reduction is 805 TBtu. However, no technology exists today to achieve this level of infiltration reduction at a market-acceptable price-point.

BTO seeks applications for the development of advanced air-sealing technologies designed specifically for use in existing buildings, which comprise more than 98% of the current building stock. When integrated into the envelope, air-sealing technologies act as a barrier to infiltration or exfiltration of air and other flows. A next-generation air-sealing methodology will require new thought processes on how heat, air, and moisture flow are interrelated and how to best regulate them in order to improve overall building-level system performance, as opposed to a more traditional strategy that focuses on component improvements. Most importantly, to be suitable and cost-effective for existing buildings, these technologies should minimize envelope disassembly and installation complexity, and thus, occupant disruption. Current air-sealing systems are complicated and costly because three separate technologies, and often separate trades, are needed. One integrated technology system, allowing vertical integration of trades and installation steps would reduce the costs associated with high performance air sealing technologies. Existing systems also have inadequate quality control and verification of completeness during application, which reduces the efficacy of the sealing technology and leads to lower realized energy savings. The cost and performance targets (including mechanical ventilation) for this topic are detailed in Table 5.1 below. The proposed technologies must meet or exceed durability (existing or proposed fire, structure, moisture, and acoustic) requirements. BTO is also particularly interested in technologies that are responsive to the Environmental Protection Agency Significant New Alternatives Policy (SNAP) policy that will phase out high-GWP blowing agents by 2021.[66]

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[65] Bohac, D. et al. (2013). *Leakage Reductions for Large Building Air Sealing and HVAC System Pressure Effects*. Minneapolis, MN: Center for Energy and Environment. Accessed July 17, 2013: mncee.org/getattachment/3fb02fdf-6654-4276-b1a2-1294574f482a/.

[66] Environmental Protection Agency Fact Sheet: Final Rule - Protection of Stratospheric Ozone: Change of Listing Status for Certain Substitutes under the Significant New Alternatives Policy Program http://www3.epa.gov/ozone/snap/download/SNAP_Regulatory_Factsheet_July20_2015_revised_508.pdf

Table 5.1. Cost and Performance Targets for Advanced Air-Sealing Technologies for Existing Buildings

ID	Category	Value
5.1.1	Performance Target	
	(a) Residential	≤ 1 ACH50 (air changes per hour at 50 Pa of pressure)
	(b) Commercial	< 0.25 CFM75/ft^2 (cubic feet of air per minute per square foot sealed surface area at 75 Pa of pressure)
5.1.2	Cost Target	< $0.5/ft^2 finished floor

Note that the infiltration performance target for the residential sector is not significantly tighter than some existing high performance home requirements, such as the DOE Challenge Home and the Passive House.[67] BTO's sensitivity analysis results show that the marginal benefit of setting a goal below 1 ACH50 is more than offset by the costs to achieve this level of air sealing. This target was thus set to 1 ACH50 in order to result in a target with a more economically viable solution. Similarly, the target for the commercial sector is in line with high performance targets for new construction. For example, the ASHRAE 189.1 (American Society of Heating, Refrigeration and Air Conditioning Engineers) standard requirement is 0.4 CFM75/ft^2,[68] and the Army Corps of Engineers recently set a maximum building envelope air leakage requirement of 0.25 CFM75/ft^2.[69]

BUILD Supplements section

BUILD: Buildings University Innovators and Leaders Development

To date, universities have been relatively underrepresented in terms of their share of BTO Emerging Technologies FOA awards. For example, in fiscal year 2014 universities submitted 32% of the concept papers, and 27% of the full applications to ET FOAs, but received only 19% of the funding. Similarly, in FY15 universities submitted 31% of the concept papers and 35% of the full applications (not counting the FY15 BUILD FOA), but received only 20% of the funding. These data suggests that universities are less successful in applying to BTO than other entities. However, BTO recognizes that "our nation's primary source of both new knowledge and

[67] The DOE Challenge Home (eere.energy.gov/buildings/residential/ch_index.html) requires an air-tightness of 1.5 ACH50 in climate zone 8, while the Passive House (passivehouse.us/passiveHouse/PassiveHouseInfo.html) requires 0.6 ACH50 in all climate zones.

[68] More information can be found at ashrae.org/resources--publications/bookstore/standard-189-1

[69] U.S. Army Corps of Engineers ERDC (11 May 2012). "U.S. Army Corps of Engineers Air Leakage Test Protocol for Envelope Buildings Version 3," Accessed July 17 2013: wbdg.org/pdfs/usace_airleakagetestprotocol.pdf

graduates with advanced skills continues to be our research universities."[70] Furthermore, the President's Council of Advisors on Science and Technology (PCAST) recommended that "DOE also should consider augmenting its principal investigator research funding program to include not just PhD students but also master's degree students working in relevant fields."[71] These reports suggest that DOE (and the nation) would benefit by not only including more universities in building energy efficiency R&D, but also by engaging greater numbers of students in these activities.

The same study cited above by the National Research Council also highlights the need for universities to develop stronger partnerships with businesses and industry.[70] The BUILD supplement is therefore structured to enable partnerships between universities and industry to increase the competitiveness of American universities in building energy efficiency R&D and to drive the innovative solutions developed in academic laboratories into the market. At the same time, enhancing the competiveness of American manufacturers requires "a strong educational supply chain," as pointed out by the CEO/President of the Federal Reserve Bank of Cleveland, Sandra Pianalto.[72] The Society of Manufacturing Engineers has emphasized the need for expanding manufacturing education at all levels, including undergraduate and graduate students, in order for the USA to continue to provide leadership in manufacturing.[73]

The BUILD Supplements address all three of these issues through the following objectives:

(i) Improving the competitiveness of American universities to conduct building energy-efficiency R&D

(ii) Enabling American universities to develop stronger partnerships with industry and drive more innovation solutions from academia to the market

(iii) Improving manufacturing education in American universities

BTO Applicants may propose an optional BUILD Supplement in support of the activities described in their primary application to any of the five topics in this FOA. The BUILD Supplements are for a maximum of $100K/year for each year of a project, not to exceed $300K for a 3-year project. Prime recipients that are for-profit companies may apply for a BUILD Supplement to partner with a university. Equivalently, university prime recipients may apply for a BUILD Supplement to partner with a for-profit company. The activities supported by the BUILD Supplement must include meaningful engagement between a university (or multiple universities) and the for-profit company (or multiple for-profit companies) that also accelerates the technology development described in the primary application. Annual "go/no-go" milestones for the BUILD Supplement will include evidence of this meaningful engagement,

[70] "Research Universities and the Future of America," National Research Council, The National Academies Press, 2012

[71] "Report to the President on Accelerating the Pace of Change in Energy Technologies Through an Integrated Federal Energy Policy," 2010, President's Council of Advisors on Science and Technology.

[72] R.A. McCafferty, "Pianalto says education is crucial for manufacturing," Crain's Cleveland Business, April 7, 2014

[73] "Workforce Imperative: A Manufacturing Education Strategy," 2012, Society of Manufacturing Engineers

such as multiple face-to-face meetings between the university team and the industrial partner, cost-share contributions by the industrial partner (cash or in kind), hosting students and/or faculty at industrial facilities, hosting industrial researchers at the university, or other comparable activities. The BUILD Supplement cannot be submitted as a stand-alone application, and must describe technical work related to that described in the primary application.

The BUILD Supplement will be evaluated separately such that the primary application may be selected for an award with or without the BUILD Supplement. The merit of a proposed BUILD Supplement will be evaluated by the following technical review criteria:

- Quality of the proposed BUILD Supplement in addressing one or more of the BUILD objectives stated above
- Relationship between the BUILD Supplement and the proposed work described in the primary application, including the technical value of the work done via the supplement
- Strength of student involvement,[74] including the number of students involved (undergraduate and graduate) and annual go/no-go milestones that describe substantial engagement between the university and the for-profit company

Applicants for BUILD Supplements are encouraged to involve students, regardless of whether the prime recipient is a university or a for-profit company. These student teams may include both undergraduate and graduate students, and must be led by faculty with relevant expertise in energy efficient technologies, manufacturing (for projects developing hardware), or other relevant fields. Student involvement will be emphasized by one of the technical review criteria, which will be based on the strength of student involvement, including the number of students (undergraduate and graduate) involved with the project. The students must be enrolled at an Institution of Higher Education, which includes, but is not limited to, universities, 2-year community colleges, and predominantly undergraduate institutions. The partner for the BUILD Supplement must send a letter of support describing the nature of the partnership at the time of application.

Each university team, represented by a faculty member and at least one student participant, will be required to attend and present at the annual BTO Peer Review in a special session devoted to the BUILD Program. Select students (no more than 2 per team/per year, to be nominated by the faculty PI) will be recognized by BTO for their achievements in the project with a certificate. Social media (LinkedIn, Facebook) will be used to connect student teams with one another, both before and after graduation, and to monitor the long-term impact of the BUILD Program.

[74] At least one student must be involved in the BUILD Supplement.

All work under EERE funding agreements must be performed in the United States. See Section IV.J.3 and Appendix C.

C. Applications Specifically Not of Interest

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

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

D. Authorizing Statutes

The programmatic authorizing statute is EPAct 2005 §911(a)(2)(B).

Awards made under this announcement will fall under the purview of 2 CFR Part 200 as amended by 2 CFR Part 910.

II. Award Information

A. Award Overview

1. Estimated Funding

EERE expects to make approximately $20 million of Federal funding available for new awards under this FOA, of which approximately $600k is for BUILD supplements, subject to the availability of appropriated funds. EERE anticipates making approximately 17–25 awards under this FOA. EERE may issue one, multiple, or no awards.

Individual awards may vary between $200k and $2 million. Optional BUILD Supplements are for a maximum of $100K/year for each year of a project, not to exceed $300K for a 3-year project.

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

Topic 1: Open Topic for Energy Efficiency Solutions for Residential and Commercial Buildings
Topic 2: Human-in-the-loop Sensor & Control Systems
Topic 3: Infiltration Diagnostic Technologies

Topic 4: Plug and Play Sensor Systems
Topic 5: Advanced Air-Sealing Technologies for Existing Buildings
Optional Buildings University Innovators and Leaders Development (BUILD) Supplement

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.

2. PERIOD OF PERFORMANCE

EERE anticipates making awards that will run up to 36 months in length. 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 the project, re-direct the project, or discontinue funding the project.

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.

1. 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.9 of the FOA for more information on what substantial involvement may involve.

2. FUNDING AGREEMENTS WITH FFRDCS

In most cases, Federally Funded Research and Development Centers (FFRDC) 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.

3. 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.

4. TECHNOLOGY INVESTMENT AGREEMENTS

In rare cases and if determined appropriate, EERE will consider awarding a Technology Investment Agreement (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.

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 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 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

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

A. ELIGIBLE APPLICANTS

1. INDIVIDUALS

U.S. citizens and lawful permanent residents are eligible to apply for funding as a Prime Recipient or Subrecipient.

2. 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 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 Federally Funded Research and Development Centers (FFRDCs) are eligible to apply for funding as a Prime Recipient or Subrecipient.

Non-DOE/NNSA FFRDCs are eligible to apply for funding as a 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.

3. 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. If a foreign entity applies for funding as a Prime 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.

4. 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.

5. 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.

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.

For the optional BUILD Supplements eligibility is limited as follows:
If the Prime Recipient is a university, the BUILD Supplement must describe a collaboration with an industrial partner (a for-profit company or companies).

1) If the Prime Recipient is a for-profit company, the BUILD Supplement must describe a collaboration with a university (or multiple universities) partner

Build supplements are not allowed between universities and any other type of partner besides for-profit companies.

B. COST SHARING

Cost Share 20%, Cost Share Waiver Utilized

i. Cost Sharing Generally

The cost share must be at least 20% of the total allowable costs for research and development projects (i.e., the sum of the Government share, including FFRDC costs if applicable, and the recipient share of allowable costs equals the total allowable cost of the project) and must come from non-Federal sources unless otherwise allowed by law. (See 2 CFR 200.306 and 2 CFR 910.130 for the applicable cost sharing requirements.)

ii. Special Cost Share Waiver for Domestic Institutions of Higher Education, Domestic Nonprofit Entities, FFRDCs, or U.S. State, Local, or Tribal Government Entity

The Assistant Secretary for the Office of Energy Efficiency and Renewable Energy has issued a Cost Share Reduction determination pursuant to Section 988(b)(3) of the Energy Policy Act of

2005 that is applicable to certain entities applying under this FOA. Specifically, recipient cost share requirement for applied research and development activities projects is reduced from 20% to 10% where:

1. The Prime Recipient is a domestic institution of higher education; domestic nonprofit entity; FFRDC; or U.S. State, local, or tribal government entity; and
2. The Prime Recipient performs more than 50% of the project work, as measured by the Total Project Cost.

Applicants who believe their project qualifies for the reduced recipient cost share must be able to provide verification that the above requirements are satisfied.

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

1. 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. The Prime Recipient's cost share obligation is expressed in the Assistance Agreement as a static amount in U.S. dollars (cost share amount) and as a percentage of the Total Project Cost (cost share percentage). 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.

2. 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.

3. 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. Cash contributions may be provided by the Prime Recipient or Subrecipients. Allowable in-kind

contributions include, but are not limited to: personnel costs, indirect costs, facilities and administrative costs, rental value of buildings or equipment, and the value of a service, other resource, or third party in-kind contribution.

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

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

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

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

Cost share contributions must be specified in the project budget, verifiable from the Prime Recipient's records, and necessary and reasonable for proper and efficient accomplishment of the project. As all sources of cost share are considered part of total project cost, the cost share dollars will be scrutinized under the same Federal regulations as Federal dollars to the project. Every cost share contribution must be reviewed and approved in advance by the Contracting Officer and incorporated into the project budget before the expenditures are incurred.

Applicants are encouraged to refer to 2 CFR 200.306 as amended by 2 CFR 910.130 & 10 CFR 603.525-555 for additional guidance on cost sharing.

4. 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.

5. 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.

6. 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).

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

1. COMPLIANCE CRITERIA

i. 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.

ii. 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.

iii. 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.C of the FOA, are deemed nonresponsive and are not reviewed or considered.

E. OTHER ELIGIBILITY REQUIREMENTS

1. REQUIREMENTS FOR DOE/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. 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.

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.

2. *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:

i. 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.

ii. Authorization for DOE/NNSA FFRDCs

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

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

iii. 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 system and non-DOE/NNSA FFRDC through an interagency agreement with the sponsoring agency.

iv. 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 and the FFRDC's portions of the project.

v. 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.

vi. Limit on FFRDC Effort

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

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

Applicants may submit more than one Full Application to this FOA, provided that each application describes a unique, scientifically distinct project.

G. Questions Regarding Eligibility

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

IV. Application and Submission Information

A. Application Process

The application process will include two phases: a Concept Paper phase and a Full Application phase. **Only applicants who have submitted an eligible Concept Paper will be eligible to submit a Full Application**. At each phase, EERE performs an initial eligibility review of the applicant submissions to determine whether they meet the eligibility requirements of Section III of the FOA. EERE will not review or consider submissions that do not meet the eligibility requirements of Section III. All submissions must conform to the following form and content requirements, including maximum page lengths (described below) and must be submitted via EERE Exchange at https://eere-exchange.energy.gov/, unless specifically stated otherwise. **EERE will not review or consider submissions submitted through means other than EERE Exchange, submissions submitted after the applicable deadline, and 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 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.
- Each submission must not exceed the specified maximum page limit, including cover page, charts, graphs, maps, and photographs when printed using the formatting requirements set forth above and single spaced. If applicants exceed the maximum page lengths indicated below, EERE will review only the authorized number of pages and disregard any additional pages.

Applicants are responsible for meeting each submission deadline. **Applicants are strongly encouraged to submit their Concept Papers and Full Applications at least 48 hours in advance of the submission deadline**. Under normal conditions (i.e., at least 48 hours in advance of the submission deadline), applicants should allow at least 1 hour to submit a Concept Paper, Full Application, or Reply to Reviewer Comments. Once the Concept Paper, Full Application, or Reply to Reviewer Comments is submitted in EERE Exchange, applicants may revise or update that submission until the expiration of the applicable deadline. If changes are made, 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.2 of the FOA.

1. 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 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 Application should contact the Exchange helpdesk for assistance (EERE-ExchangeSupport@hq.doe.gov). The Exchange helpdesk and/or the EERE Exchange system administrators will assist Applicants in resolving issues.

Applicants that experience issue with submissions that result in late submissions: In the event that an applicant experiences technical difficulties so severe that they are unable to submit their application by the deadline, the applicant should contact the Exchange helpdesk for assistance (EERE-ExchangeSupport@hq.doe.gov). The Exchange helpdesk and/or the EERE

Exchange system administrators will assist the applicant in resolving all issues (including finalizing submission on behalf of and with the applicant's concurrence). PLEASE NOTE, however, those applicants who are unable to submit their application on time due to their waiting until the last minute when network traffic is at its heaviest to submit their materials will not be able to use this process.

B. APPLICATION FORMS

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

Note: The maximum file size that can be uploaded to the EERE Exchange website is 10MB. Files in excess of 10MB cannot be uploaded, and hence cannot be submitted for review. If a file exceeds 10MB but is still within the maximum page limit specified in the FOA, it must be broken into parts and denoted to that effect. For example:
ControlNumber_LeadOrganization_Project_Part_1
ControlNumber_LeadOrganization_Project_Part_2, etc.

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.

1. 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	• Applicants are required to include a Cover Page with their Concept Paper containing: o Topic Area Number o Project Title o Lead Organization o Organization Type o Anticipated Project Budget (Federal and Cost Share) o Principal Investigator, Team Members, and Key Participants o BUILD Supplement? (Yes or No)

		Abstract – no more than 200 words in length, and it should provide a truncated explanation of the proposed project
Technology Description	2 pages maximum	Applicants are required to describe succinctly: • 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 page maximum	Applicants are required to describe succinctly the qualifications, experience, and capabilities of the proposed Project Team, including: • Whether the Principal Investigator (PI) and Project Team have the skill and expertise needed to successfully execute the project plan; • Whether the applicant has prior experience which demonstrates an ability to perform tasks of similar risk and complexity; • Whether the applicant has worked together with its teaming partners on prior projects or programs; and • Whether the applicant has adequate access to equipment and facilities necessary to accomplish the effort and/or clearly explain how it intends to obtain access to the necessary equipment and facilities. Applicants may provide graphs, charts, or other data to supplement their Technology Description.
BUILD Supplement (Optional)	1 page maximum	• Relationship between the BUILD Supplement and the primary application • Describe the relationship between the BUILD Supplement and the proposed work described in the primary application, including the technical value of the work done via the supplement • Student Involvement

		• Describe the types of students to be engaged, and the kinds of activities in which they will be participating • How the proposed BUILD Supplement addresses one or more of the BUILD objectives

EERE makes an independent assessment of each Concept Paper based on the criteria in Section V.A.1 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 sent to applicants 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 to prepare and submit a Full Application. Regardless of the date the applicant receives the Encourage/Discourage notification, the submission deadline for the Full Application remains the date and time stated on the FOA cover page.

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

1. FULL APPLICATION CONTENT REQUIREMENTS

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

Each Full Application shall be limited to a single concept or technology. Unrelated concepts and technologies shall not be consolidated in a single Full Application.

Full Applications must conform to the following requirements:

SUBMISSION	COMPONENTS	FILE NAME
Full Application (PDF, unless stated otherwise)	Technical Volume (See Chart in Section IV.D.2)	ControlNumber_LeadOrganization_Technical Volume
	Statement of Project Objectives (Microsoft Word format) (5 page limit excluding PMP and Milestone table)	ControlNumber_LeadOrganization_SOPO
	SF-424	ControlNumber_LeadOrganization_App424
	Budget Justification (EERE 335) (Microsoft Excel format. Applicants must use the template available in EERE Exchange)	ControlNumber_LeadOrganization_Budget_Justification
	Summary for Public Release (1 page limit)	ControlNumber_LeadOrganization_Summary
	Summary Slide (1 page limit, Microsoft PowerPoint format)	ControlNumber_LeadOrganization_Slide
	Subaward Budget Justification (EERE 335) (Microsoft Excel format. Applicants must use the template available in EERE Exchange)	ControlNumber_LeadOrganization_Subawardee_Budget_Justification
	Budget for FFRDC, if applicable	ControlNumber_LeadOrganization_FWP
	Authorization from cognizant Contracting Officer for FFRDC, if applicable	ControlNumber_LeadOrganization_FFRDCAuth
	SF-LLL Disclosure of Lobbying Activities	ControlNumber_LeadOrganization_SF-LLL
	Foreign Entity and Performance of Work in the United States waiver requests, if applicable	ControlNumber_LeadOrganization_Waiver
	U.S. Manufacturing Plans	ControlNumber_LeadOrganization_USMP
	Data Management Plan	ControlNumber_LeadOrganization_DMP
	Open Source Software Distribution Plan	ControlNumber_LeadOrganization_OSSDP

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, etc.

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.

2. 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.2 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 will be the primary energy savings technical potential. Each application must describe a technology or an approach that leads to a minimum annual primary energy savings technical potential of at least 250 TBtu (i.e., 0.25 Quads) for U.S. residential and/or commercial buildings. All applicants proposing a technology, again except for enabling technologies and design tools, will be required to use the BTO Market Calculator (http://trynthink.github.io/scout/calculator.html) to compute the total market size (in TBtu – Trillion British Thermal Units) 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 automatically calculate 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 BTO Market Calculator.

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 proposals, and not to other proposals 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.

All applicants will be required to provide an estimate of primary energy savings potentially resulting from their solution, even non-technological solutions. Such non-technological solutions 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.2 of the FOA) when preparing the Technical Volume.

SECTION/PAGE LIMIT	DESCRIPTION
Cover Page	The cover page should include the project title, the specific FOA 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.
Project Overview (This section should constitute approximately 10% of the Technical Volume)	The Project Overview should contain the following information: • Background: The applicant should discuss the background of their organization, including the history, successes, and current research and development status (i.e., the technical baseline) relevant to the technical topic being addressed in the Full Application. • Project Goal: The applicant should explicitly identify the targeted improvements to the baseline technology and the critical success factors in achieving that goal. • DOE Impact: The Applicant should discuss the quantitative and qualitative impact that DOE funding would have on the proposed project. Applicants are required to report two performance metrics: primary energy savings and cost effectiveness, as measured by the simple payback. Except for proposal for enabling technologies and design tools, applicants are required to use the BTO Market Calculator web tool to report the primary energy savings for the proposed technology. The web tool will allow applicants to compute total market size (in TBtu). The applicants will also need to provide an estimate of the % energy savings applicable to this market, with supporting analysis. The product of the % energy savings and the energy market size yields the primary energy savings technical potential. 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. See section IV.D.2. Technical Volume and Appendix F for further guidance.
Technical Description, Innovation, and Impact (This section should constitute approximately 30% of the Technical Volume)	The Technical Description should contain the following information: • Relevance and Outcomes: The applicant should provide a detailed description of the technology, including the scientific and other principles and objectives that will be pursued during the project. This section should describe the relevance of the proposed project to the goals and objectives of the FOA, including the potential to meet specific DOE technical targets or other relevant performance targets. The applicant should clearly specify the expected outcomes of the project. • Feasibility: The applicant should demonstrate the technical feasibility of the proposed technology and capability of achieving the anticipated performance targets, including a description of previous work done and prior results. • Innovation and Impacts: The applicant should describe the current state of the art in the applicable field, the specific innovation of the proposed technology, the advantages of proposed technology over current and emerging technologies, and the overall impact on advancing the state of the art/technical baseline if the project is successful.

Workplan and Market Transformation Plan (This section should constitute approximately 40% of the Technical Volume)	The Workplan should include a summary of the Project Objectives, Technical Scope, Work Breakdown Structure, Milestones, Go/No-Go Decision Points, and Project Schedule. A detailed Statement of Project Objectives (SOPO) is separately requested. The Workplan should contain the following information: • Project Objectives: The applicant should provide a clear and concise (high-level) statement of the goals and objectives of the project as well as the expected outcomes. • Technical Scope Summary: The applicant should provide a summary description of the overall work scope and approach to achieve the objective(s). The overall work scope is to be divided by performance periods that are separated by discrete, approximately annual decision points (see below for more information on go/no-go decision points). The applicant should describe the specific expected end result of each performance period. • Work Breakdown Structure (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 work breakdown structure (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, where success is defined as technical achievement rather than simply completing a task. To ensure that milestones are relevant, applicants should follow the SMART rule of thumb, which is that all milestones should be **S**pecific, **M**easurable, **A**chievable, **R**elevant, and **T**imely. 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 (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 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: o The overall approach to and organization for managing the work o The roles of each Project Team member o Any critical handoffs/interdependencies among Project Team members o The technical and management aspects of the management plan, including systems and practices, such as financial and project management practices o The approach to project risk management o A description of how project changes will be handled o If applicable, the approach to Quality Assurance/Control o How communications will be maintained among Project Team members • Commercialization and Market Transformation Plans The Applicant should provide both commercialization and market transformation plans, including the following: Market Transformation Plan: o Identification of the target market, quantification of the market opportunity, and distribution channels for proposed solution along with known or perceived barriers to market penetration, including a mitigation plan o Identification of market barriers and a plan to overcome those barriers. o 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 etc., and product distribution. Commercialization Plan: o Identification of the technology transition and commercialization plan and timeline, including strategic partnerships and potential follow-on funding sources, from its current state to ultimate market deployment. Please note that while some projects funded through this FOA will be ready to transition to a commercial or deployment-focused effort, this is not by any means a

	requirement. Examples of variables to be considered in the plan include: ▪ Product development, financing and/or service plan ▪ Product marketing strategy ▪ Legal and regulatory considerations including intellectual property, open source software distribution plan and data dissemination plans (as applicable) ▪ Infrastructure requirements such as existing utility practices U.S. manufacturing plan etc., and product distribution. Identification of commercialization project lead team member responsible for leading and coordinating all commercialization activities for the project. Open Source Software Distribution Plan: o If your application includes the development of software tools, submission of the Open Source Software Distribution Plan (Appendix E), is required. Interoperability Plan: o In addition to the software distribution plan, all applicants that are proposing to develop sensors or controls are required to submit Plans for Interoperability with their applications, covering each hierarchical level at which systems interact. As a minimal requirement, where possible all device(s) to be controlled should be accessed by open communication standards, and using open or consensus-based information and data standards. The VOLTTRON platform may also be leveraged as a resource, but is not required. The following elements should be addressed in the interoperability plan: ▪ Identify the information exchange interfaces for communicating devices and systems (i.e., their points of connection with other elements of the system), ▪ Identify the openly-available (and proprietary, if applicable) aspects of the interface specifications, and how existing (legacy) communicating devices or systems are integrated into the project, Note, that NIST's emerging smart grid framework (http://www.nist.gov/smartgrid/upload/NIST-SP-1108r3.pdf), may be a good framework to use to describe the project's interoperability but must address it in terms of buildings.

Technical Qualifications and Resources (Approximately 20% of the Technical Volume)	The Technical Qualifications and Resources should contain the following information:

	• Describe the Project Team's unique qualifications and expertise, including those of key Subrecipients. • Describe the Project Team's existing equipment and facilities that will facilitate the successful completion of the proposed project; include a justification of any new equipment or facilities requested as part of the project. • This section should also include relevant, previous work efforts, demonstrated innovations, and how these enable the applicant to achieve the project objectives. • Describe the time commitment of the key team members to support the project. • 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 support from partners/end users as an appendix (1 page maximum per letter). Letters of support do not count towards the page limit. • For multi-organizational or multi-investigator projects, describe succinctly: o The roles and the work to be performed by each PI and Key Participant; o Business agreements between the applicant and each PI and Key Participant; o How the various efforts will be integrated and managed; o Process for making decisions on scientific/technical direction; o Publication arrangements; o Intellectual Property issues; and o Communication plans
FOA-Specific Requirements	Applicants proposing an optional BUILD Supplement are provided an additional 5 pages in the Technical Volume in which to describe the proposed Supplement. This section should describe how the proposed BUILD Supplement addresses one or more of the BUILD objectives, including the substantial engagement between the university and for-profit company partners during each year of the collaboration, and how students will participate.

3. STATEMENT OF PROJECT OBJECTIVES

Applicants are required to complete a Statement of Project Objectives (SOPO). A SOPO template is available on EERE Exchange at https://eere-Exchange.energy.gov/. The SOPO, including the Milestone Table, must not exceed 5 pages, excluding PMP and Milestone table. 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".

4. SF-424: APPLICATION FOR FEDERAL ASSISTANCE

Complete all required fields in accordance with the instructions on the form. The list of certifications and assurances in Field 21 can be found at http://energy.gov/management/office-management/operational-management/financial-assistance/financial-assistance-forms, under Certifications and Assurances. Note: The dates and dollar amounts on the SF-424 are for the complete project period and not just the first project year, first phase or other subset of the project period. Save the SF-424 in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_App424".

5. BUDGET JUSTIFICATION WORKBOOK (EERE 335)

Applicants are required to complete the Budget Justification Workbook. This form is available on EERE Exchange at https://eere-Exchange.energy.gov/. Prime Recipients must complete each tab of the Budget Justification Workbook for the project as a whole, including all work to be performed by the Prime Recipient and its Subrecipients and Contractors, and provide all requested documentation (e.g., a Federally-approved rate agreement, vendor quotes). 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".

6. *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".

7. *SUMMARY SLIDE*

Applicants are required to provide a single PowerPoint slide summarizing the proposed project. The slide must be submitted in Microsoft PowerPoint format. This slide is used during the evaluation process. Save the Summary Slide in a single file using the following convention for the title "ControlNumber_LeadOrganization_Slide".

The Summary Slide template requires the following information:

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

8. *SUBAWARD BUDGET JUSTIFICATION (EERE 335)*

Applicants must provide a separate budget justification, EERE 335 (i.e., budget justification for each budget year and a cumulative budget) for each subawardee 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 subaward budget justification in a Microsoft Excel file using the following convention for the title "ControlNumber_LeadOrganization_Subawardee_Budget_Justification".

9. 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 Field Work Proposal (FWP) in accordance with the requirements in DOE Order 412.1, Work Authorization System. DOE Order 412.1 and DOE O 412.1 (Field Work Proposal form) area available at the following link, under "DOE Budget Forms": https://www.directives.doe.gov/directives/0412.1-BOrder-a/view. Save the FWP in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_FWP".

10. 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".

11. SF-LLL: DISCLOSURE OF LOBBYING ACTIVITIES

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" (http://www.whitehouse.gov/sites/default/files/omb/grants/sflllin.pdf) if any non-Federal funds have been paid or will be paid to any person for influencing or attempting to influence any of the following in connection with your 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".

12. WAIVER REQUESTS: FOREIGN ENTITIES AND PERFORMANCE OF WORK IN THE UNITED STATES

i. Foreign Entity Participation:

As set forth in Section III.A.3, 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.

ii. Performance of Work in the United States

As set forth in Section IV.J.3, 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.

13. U.S. MANUFACTURING COMMITMENTS

As part of the application, applicants are required to submit a U.S. Manufacturing Plan. The U.S. Manufacturing Plan represents the applicant's measurable commitment to support U.S. manufacturing as a result of its award.

The weight given to the U.S. Manufacturing Plans during the review and selection process varies based on the particular FOA. Applicants should review Section V.A.2 of this FOA to determine the weight given to the U.S. Manufacturing Plans under this FOA.

A U.S. Manufacturing Plan should contain the following or similar preamble: "If selected for funding, the applicant agrees to the following commitments as a condition of that funding:" and, after the preamble, the plan should include one or more specific and measureable commitments. For example, an applicant may commit particular types of products to be manufactured in the U.S. In addition to or instead of making a commitment tied to a particular product, the applicant may make other types of commitments still beneficial to U.S. manufacturing. An applicant may commit to a particular investment in a new or existing U.S. manufacturing facility, keep certain activities based in the U.S. (i.e., final assembly) or support a certain number of jobs in the U.S. related to the technology and manufacturing. For 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 licensing strategy that would likely support U.S. manufacturing.

When an applicant that is a domestic small business, domestic educational institution, or nonprofit organization is selected for an award, the U.S. Manufacturing Plan submitted by the applicant becomes part of the terms and conditions of the award. The applicant/awardee may request a waiver or modification of the U.S. Manufacturing Plan from DOE upon a showing that the original U.S. Manufacturing Plan is no longer economically feasible.

When an applicant that is a domestic large business is selected for an award, a class patent waiver applies as set forth in Section VIII. L. Under this class patent 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 patent waiver, a domestic large business must agree that any products embodying or produced through the use of an invention conceived or first actually reduced to practice under the award will be substantially manufactured in the United States, unless DOE agrees that the commitments proposed in the U.S. Manufacturing Plan are sufficient.

For other entity types that are selected for award, please see Section VIII.L regarding U.S. manufacturing commitments.

14. DATA MANAGEMENT PLAN

Applicants whose Full Applications are selected for award negotiations will be required to submit a Data Management Plan during the award negotiations phase. The Data Management Plan is a document that outlines the proposed plan for data sharing or preservation. Submission of this plan is required, and failure to submit the plan may result in the termination of award negotiations. As a courtesy, guidance for preparing a Data Management Plan is provided in Appendix D of the FOA.

15. OPEN SOURCE SOFTWARE DISTRIBUTION PLAN

Applicants who propose to develop software under their awards are required to submit an Open Source Software Distribution Plan as part of their Full Application. This plan describes how software produced under this FOA will be distributed. Submission of an Open Source Software Distribution Plan is required; failure to submit a complete Plan may result in a determination of non-compliance for your Full Application. Guidance for preparing an Open Source Software Distribution Plan is included in Appendix E of the FOA.

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 notify applicants via email when the Reviewer Comments are available for reply. The expected submission deadline is on the cover page of the FOA; however, it is the applicant's responsibility to monitor email 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 email or relying on the expected date alone. Applicants should anticipate having approximately three (3) business days to submit Replies to Reviewer Comments.

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

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

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

F. POST-AWARD INFORMATION REQUESTS

If selected for award, EERE reserves the right to request additional or clarifying information for any reason deemed necessary, including but not limited to:

- 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

G. DUN AND BRADSTREET UNIVERSAL NUMBERING SYSTEM NUMBER AND SYSTEM FOR AWARD MANAGEMENT

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: (i) Be registered in the System for Award Management (SAM) at https://www.sam.gov before submitting its application; (ii) provide a valid Dun and Bradstreet Universal Numbering System (DUNS) number in its application; and (iii) 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 may 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 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

1. 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:

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

2. 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.

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

EERE's decision whether and how to distribute Federal funds under this FOA is subject to NEPA. Applicants should carefully consider and should seek legal counsel or other expert advice before taking any action related to the proposed project that would have an adverse effect on the environment or limit the choice of reasonable alternatives prior to EERE completing the NEPA review process.

EERE does not guarantee or assume any obligation to reimburse costs where the Prime Recipient incurred the costs prior to receiving written authorization from the Contracting Officer. If the applicant elects to undertake activities that may have an adverse effect on the environment or limit the choice of reasonable alternatives prior to receiving such written authorization from the Contracting Officer, the applicant is doing so at risk of not receiving Federal funding and such costs may not be recognized as allowable cost share. Likewise, if a project 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.

3. PERFORMANCE OF WORK IN THE UNITED STATES

a. 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.

b. 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.

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

4. CONSTRUCTION

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

5. FOREIGN TRAVEL

Foreign travel costs are not allowable under this FOA.

6. EQUIPMENT AND SUPPLIES

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

Property disposition will be required at the end of a project if the current fair market value of property exceeds $5,000. The rules for property disposition are set forth in 2 CFR 200.310 – 200.316 as amended by 2 CFR 910.360.

7. 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" (http://www.whitehouse.gov/sites/default/files/omb/grants/sflllin.pdf) if

any non-Federal funds have been paid or will be paid to any person for influencing or attempting to influence any of the following in connection with your 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.

8. 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 OMB-designated repositories of government-wide eligibility qualification or financial integrity information, such as SAM Exclusions and "Do Not Pay."

In addition, DOE evaluates the risk(s) posed by applicants before they receive Federal awards. This evaluation may consider: results of the evaluation of the applicant's eligibility; the quality of the application; financial stability; quality of management systems and ability to meet the management standards prescribed in this part; history of performance; reports and findings from audits; and the 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.

V. APPLICATION REVIEW INFORMATION

A. TECHNICAL REVIEW CRITERIA

1. 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%)

- 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.

2. 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%)

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%)

Research Approach, Workplan and SOPO

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

Identification of Technical Risks

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

Baseline, Metrics, and Deliverables

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

Market Transformation Plan

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

Criterion 3: Team and Resources (20%)

- 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.

BUILD Supplement

Criterion 1: BUILD Supplements (only applies to the optional BUILD Supplements) **Weight: 100%**

- Quality of the proposed BUILD Supplement in addressing one or more of the BUILD objectives:
  (i) Improving the competitiveness of American universities to conduct building energy-efficiency R&D
  (ii) Enabling American universities to develop stronger partnerships with industry
  (iii) Improving manufacturing education in American universities
- Relationship between the BUILD Supplement and the proposed work described in the primary application, including the technical value of the work done via the supplement

- Strength of student involvement, including the number of students involved (undergraduate and graduate) and annual go/no-go milestones that describe substantial engagement between the university and for-profit company partner(s).

3. 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 "Department of Energy Merit Review Guide for Financial Assistance," which is available at: http://energy.gov/sites/prod/files/meritrev.pdf.

C. OTHER SELECTION FACTORS

1. 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, including proposed cost share, optimizes the use of available EERE funding to achieve programmatic objectives;
- The level of industry involvement and demonstrated ability to commercialize energy or related technologies;
- Technical, market, organizational, and environmental risks associated with the project;
- Whether the proposed project is likely to lead to increased employment and manufacturing in the United States;
- Whether 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

Whether the proposed project will advance the goals of the Climate Action Champion initiative, as committed to by the designated Champion pursuant to its designation agreement. The Climate Action Champion initiative goals include improving climate resilience and reducing greenhouse gas emissions.

Note: The Climate Action Champion initiative program policy factor is only applicable to (1) projects proposed by Climate Action Champions[75] as designated under DOE's Request for Applications DE-FOA-0001189; (2) projects proposed by a member of a regional collaboration or consortium designated as a Champion; and (3) projects proposed in a Climate Action Champion community where the applicant submits a letter from the Champion confirming the proposed project would further the Champion's goals under the Climate Action Champion initiative. If an applicant is seeking to receive consideration under (3), the applicant must contact the applicable Champion to obtain a letter of support.

D. EVALUATION AND SELECTION PROCESS

1. 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.

2. 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.3 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.

[75] In recognition of the importance of the dual policy goals of reducing greenhouse gas emissions and enhancing climate resilience, the U.S. Department of Energy (DOE) – in close collaboration with other Federal agencies – launched the Climate Action Champion initiative to identify and showcase U.S. local and tribal governments that have proven to be climate leaders through pursuing opportunities to advance both of these goals in their communities. Recently, DOE selected sixteen (16) U.S. local governments and tribal governments – or regional collaborations or consortia thereof – that demonstrated a strong and ongoing commitment to implementing strategies that both reduce greenhouse gas emissions and enhance climate resilience, with a particular emphasis on strategies that further both goals. http://www.whitehouse.gov/blog/2014/12/03/announcing-first-class-climate-action-champions

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.

3. PRE-SELECTION CLARIFICATION

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

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

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

4. 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 DATES

EERE anticipates notifying applicants selected for negotiation of award by May 2016 and making awards by September 2016.

VI. AWARD ADMINISTRATION INFORMATION

A. AWARD NOTICES

1. 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.

2. CONCEPT PAPER NOTIFICATIONS

EERE will notify applicants of its determination to encourage or discourage the submission of a Full Application. EERE will send a notification letter by email to the technical and administrative points of contact designated by the applicant in 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 letter encouraging the submission of a Full Application does not authorize the applicant to commence performance of the project. Please refer to Section IV.J.2 of the FOA for guidance on pre-award costs.

3. 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.

4. 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.2 of the FOA for guidance on pre-award costs.

5. 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.

6. 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

1. 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:

i. 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**.

ii. DUNS Number

Obtain a Dun and Bradstreet Data Universal Numbering System (DUNS) number (including the plus 4 extension, if applicable) at http://fedgov.dnb.com/webform.

iii. System for Award Management

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

iv. 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 http://www.fedconnect.net/FedConnect/Marketing/Documents/FedConnect_Ready_Set_Go.pdf.

v. 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.

vi. Electronic Authorization of Applications and Award Documents

Submission of an application and supplemental information under this FOA through electronic systems used by the Department of Energy, including EERE Exchange and FedConnect.net, constitutes the authorized representative's approval and electronic signature.

2. 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.

3. *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.

4. *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.

5. *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.

6. *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 the National Environmental Policy Act (42 USC 4321, *et seq.*). NEPA requires Federal agencies to integrate environmental values into their decision-making processes by considering the potential environmental impacts of their proposed actions. For additional background on NEPA, please see DOE's NEPA website, at http://nepa.energy.gov/.

While NEPA compliance is a Federal agency responsibility and the ultimate decisions remain with the Federal agency, all 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.

7. APPLICANT REPRESENTATIONS AND CERTIFICATIONS

i. 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.

ii. Corporate Felony Conviction and Federal Tax Liability Representations

In submitting an application in response to this FOA, the applicant represents that:

(1) It is **not** a corporation that has been convicted of a felony criminal violation under any Federal law within the preceding 24 months, and

(2) 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.

iii. Nondisclosure and Confidentiality Agreements Representations

In submitting an application in response to this FOA the applicant represents that:

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

(2) 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:

a. *"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.''

b. The limitation above shall not contravene requirements applicable to Standard Form 312, Form 4414, or any other form issued by a Federal department or agency governing the nondisclosure of classified information.

c. 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.

8. 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 usual 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.

9. 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 reviews and approves in a timely manner project plans, including project management, testing and technology transfer plans, and recommending alternate approaches, if the plans do not address the critical programmatic issues.

3. 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.

4. 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.

5. EERE promotes and facilitates technology transfer activities, including disseminating Technology Office results through presentations and publications.

6. EERE may redirect or discontinue funding the Project based on the outcome of EERE's evaluation of the Project at that the Go/No Go decision point(s).

7. EERE participates in major project decision-making processes.

10. INTELLECTUAL PROPERTY MANAGEMENT PLAN

Within 30 days of selection, applicants must submit an executed IP Management Plan between the members of the consortia or team if required to do so by the Contracting Officer.

The award will set forth the treatment of and obligations related to intellectual property rights between EERE and the individual members. The IP Management Plan should describe how the members will handle intellectual property rights and issues between themselves while ensuring compliance with Federal IP laws, regulations, and policies (see Sections VIII.L-VIII.O of this FOA for more details on applicable Federal IP laws and regulations). Guidance regarding the contents of IP Management Plans is available from EERE upon request.

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

- The treatment of confidential information between members (i.e., the use of non-disclosure agreements);
- The treatment of background IP (e.g., any requirements for identifying it or making it available);

- The treatment of inventions made under the project (e.g., any requirements for disclosing to the other members, 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 project (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.

11. 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.

12. 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.

13. Reporting

Reporting requirements are identified on the Federal Assistance Reporting Checklist, DOE F 4600.2, attached to the award agreement. The checklist can be accessed at http://energy.gov/sites/prod/files/2013/05/f0/Attch_FA_RepReqChecklist_COMBINED_FINAL_4-23-13%20%283%29_0.pdf.

14. 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. Federal funding beyond the Go/No Go decision point (continuation funding), is contingent on (1) the availability of funds appropriated by Congress for the purpose of this program and the availability of future-year budget authority; (2) meeting the objectives, milestones, deliverables, and decision point criteria of recipient's approved project and

obtaining approval from EERE to continue work on the project; and (3) the submittal of required reports in accordance with the Statement of Project Objectives.

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

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

15. 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.

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: BENEFIT2016@ee.doe.gov. Questions must be submitted no later than 3 business days prior to the application due date and time.

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. INFORMATIONAL WEBINAR

EERE will conduct one informational webinar during the FOA process. It will be held after the initial FOA release but before the due date for Concept Papers.

Attendance is not mandatory and will not positively or negatively impact the overall review of any applicant submissions. As the webinar will be open to all applicants who wish to participate, applicants should refrain from asking questions or communicating information that would reveal confidential and/or proprietary information specific to their project. Specific dates for the webinar can be found on the cover page of the FOA.

C. 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.

D. 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.

E. 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. Applications containing trade secrets or commercial or financial information that is privileged or

confidential, which the applicant does not want disclosed to the public or used by the Government for any purpose other than application evaluation, must be marked as described in this section.

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.

The above markings enable EERE to follow the provisions of 10 CFR 1004.11(d) in the event a Freedom of Information Act (FOIA) request is received for information submitted with an application. Failure to comply with these marking requirements may result in the disclosure of the unmarked information under a FOIA request or otherwise. The U.S. Government is not liable for the disclosure or use of unmarked information, and may use or disclose such information for any purpose.

Subject to the specific FOIA exemptions identified in 5 U.S.C. 552(b), all information submitted to EERE by a FOA applicant is subject to public release under the Freedom of Information Act, 5 U.S.C. §552, as amended by the OPEN Government Act of 2007, Pub. L. No. 110-175. It is the applicant's responsibility to review FOIA and its exemptions to understand (1) what information may be subject to public disclosure and (2) what information applicants submit to the Government that are protected by law. In some cases, DOE may be unable to make an independent determination regarding which information submitted by an applicant is releasable and which is protected by an exemption. In such cases, DOE will consult with the applicant, in accordance with 10 C.F.R. §1004.11, to solicit the applicant's views on how the information should be treated.

F. 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. The applicant, by submitting its application, consents to the use of non-Federal reviewers/administrators. Non-Federal reviewers must sign conflict of interest and non-disclosure agreements prior to reviewing an application. Non-Federal personnel conducting administrative activities must sign a non-disclosure agreement.

G. 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.

H. 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).

I. Notice of Potential Disclosure Under Freedom of Information Act

Applicants should be advised that identifying information regarding all applicants, including applicant names and/or points of contact, may be subject to public disclosure under the Freedom of Information Act, whether or not such applicants are selected for negotiation of award.

J. Requirement for Full and Complete Disclosure

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

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

K. 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.

L. 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.

- Determination of Exceptional Circumstances (DEC): Each applicant is required to submit a U.S. Manufacturing Plan as part of its application. If selected, the U.S. Manufacturing Plan shall be incorporated into the award terms and conditions for domestic small businesses and nonprofit organizations. DOE has determined that exceptional circumstances exist that warrants the modification of the standard patent rights clause for small businesses and non-profit awardees under Bayh-Dole to the extent necessary

to implement and enforce the U.S. Manufacturing Plan. For example, the commitments and enforcement of a U.S. Manufacturing Plan may be tied to subject inventions. Any Bayh-Dole entity (domestic small business or nonprofit organization) affected by this DEC has the right to appeal it.

M. GOVERNMENT RIGHTS IN SUBJECT INVENTIONS

Where Prime Recipients and Subrecipients retain title to subject inventions, the U.S. Government retains certain rights.

1. GOVERNMENT USE LICENSE

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

2. MARCH-IN RIGHTS

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

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

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

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

N. 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.

O. 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 E must be addressed in the application.

P. PROTECTED PERSONALLY IDENTIFIABLE INFORMATION

In responding to this FOA, applicants must ensure that Protected Personally Identifiable Information (PII) is not included in the application documents. These documents will be used by the Merit Review Committee in the review process to evaluate each application. PII is defined by the Office of Management and Budget (OMB) and EERE as:

Any information about an individual maintained by an agency, including but not limited to, education, financial transactions, medical history, and criminal or employment history and information that can be used to distinguish or trace an individual's identity, such as their name,

social security number, date and place of birth, mother's maiden name, biometric records, etc., including any other personal information that is linked or linkable to an individual.

This definition of PII can be further defined as: (1) Public PII and (2) Protected PII.

Public PII: PII found in public sources such as telephone books, public websites, business cards, university listing, etc. Public PII includes first and last name, address, work telephone number, email address, home telephone number, and general education credentials.

Protected PII: PII that requires enhanced protection. This information includes data that if compromised could cause harm to an individual such as identity theft.

Listed below are examples of Protected PII that applicants must not include in the files listed above to be evaluated by the Merit Review Committee. This list is not all inclusive.

- Social Security Numbers in any form
- Place of Birth associated with an individual
- Date of Birth associated with an individual
- Mother's maiden name associated with an individual
- Biometric record associated with an individual
- Fingerprint
- Iris scan
- DNA
- Medical history information associated with an individual
- Medical conditions, including history of disease
- Metric information, e.g. weight, height, blood pressure
- Criminal history associated with an individual
- Employment history and other employment information associated with an individual
- Ratings
- Disciplinary actions
- Performance elements and standards (or work expectations) are PII when they are so intertwined with performance appraisals that their disclosure would reveal an individual's performance appraisal
- Financial information associated with an individual
- Credit card numbers
- Bank account numbers
- Security clearance history or related information (not including actual clearances held)

Q. ANNUAL COMPLIANCE AUDITS

If a for-profit entity is a Prime Recipient or Subrecipient and has expended $750,000 or more of DOE funds during the entity's fiscal year, an annual compliance audit performed by an

independent auditor is be 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 funds 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 sub-recipients (if applicable) should propose sufficient costs in the project budget to cover the costs associated with the audit. EERE will share in the cost of the audit at its applicable cost share ratio.

APPENDIX A – COST SHARE INFORMATION

Cost Sharing or Cost Matching

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

How Cost Sharing Is Calculated

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

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

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

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

What Qualifies For Cost Sharing

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

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

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

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

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

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 Federal Acquisition Regulation, 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

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

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

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

(B) Valuing and documenting contributions

(1) Valuing recipient's property or services of recipient's employees. Values are established in accordance with the applicable cost principles, which mean that amounts chargeable to the project are determined on the basis of costs incurred. For real property or equipment used on the project, the cost principles authorize depreciation or use charges. The full value of the item may be applied when the item will be consumed in the performance of the award or fully depreciated by the end of the award. In cases where the full value of a donated capital asset is to be applied as cost sharing or matching, that full value must be the lesser or the following:

a. The certified value of the remaining life of the property recorded in the recipient's accounting records at the time of donation; or
b. The current fair market value. If there is sufficient justification, the 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)

The calculation may then be completed as follows:

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

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

APPENDIX C – WAIVER REQUESTS: FOREIGN ENTITY PARTICIPATION AS THE PRIME RECIPIENT AND PERFORMANCE OF WORK IN THE UNITED STATES

1. WAIVER FOR FOREIGN ENTITY PARTICIPATION AS THE PRIME RECIPIENT

As set forth in Section III.A.3, 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, 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;
- 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

As set forth in Section IV.J.3, 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 - DATA MANAGEMENT PLAN

A data management plan ("DMP") explains how data generated in the course of the work performed under an EERE award will be shared and preserved or, when justified, explains why data sharing or preservation is not possible or scientifically appropriate.

DMP Requirements

In order for a DMP to be considered acceptable, the DMP must address the following:

At a minimum, the DMP must describe how data sharing and preservation will enable validation of the results from the proposed work, or how results could be validated if data are not shared or preserved.

The DMP must provide a plan for making all research data displayed in publications resulting from the proposed work digitally accessible at the time of publication. This includes data that are displayed in charts, figures, images, etc. In addition, the underlying digital research data used to generate the displayed data should be made as accessible as possible in accordance with the principles stated above. This requirement could be met by including the data as supplementary information to the published article, or through other means. The published article should indicate how these data can be accessed.

The DMP should consult and reference available information about data management resources to be used in the course of the proposed work. In particular, a DMP that explicitly or implicitly commits data management resources at a facility beyond what is conventionally made available to approved users should be accompanied by written approval from that facility. In determining the resources available for data management at DOE User Facilities, researchers should consult the published description of data management resources and practices at that facility and reference it in the DMP. Information about other DOE facilities can be found in the additional guidance from the sponsoring program.

The DMP must protect confidentiality, personal privacy, Personally Identifiable Information, and U.S. national, homeland, and economic security; recognize proprietary interests, business confidential information, and intellectual property rights; avoid significant negative impact on innovation, and U.S. competitiveness; and otherwise be consistent with all laws (i.e., export control laws), and DOE regulations, orders, and policies.

Data Determination for a DMP

The Principal Investigator should determine which data should be the subject of the DMP and, in the DMP, propose which data should be shared and/or preserved in accordance with the DMP Requirements noted above.

For data that will be generated through the course of the proposed work, the Principal Investigator should indicate what types of data should be protected from immediate public disclosure by DOE (referred to as "protected data") and what types of data that DOE should be able to release immediately. Similarly, for data developed outside of the proposed work at private expense that will be used in the course of the proposed work, the Principal Investigator should indicate whether that type of data will be subject to public release or kept confidential (referred to as "limited rights data"). Any use of limited rights data or labeling of data as "protected data" must be consistent with the DMP Requirements noted above.

Suggested Elements for a DMP

The following list of elements for a DMP provides suggestions regarding the data management planning process and the structure of the DMP:

Data Types and Sources: A brief, high-level description of the data to be generated or used through the course of the proposed work and which of these are considered digital research data necessary to validate the research findings or results.

Content and Format: A statement of plans for data and metadata content and format including, where applicable, a description of documentation plans, annotation of relevant software, and the rationale for the selection of appropriate standards. Existing, accepted community standards should be used where possible. Where community standards are missing or inadequate, the DMP could propose alternate strategies for facilitating sharing, and should advise the sponsoring program of any need to develop or generalize standards.

Sharing and Preservation: A description of the plans for data sharing and preservation. This should include, when appropriate: the anticipated means for sharing and the rationale for any restrictions on who may access the data and under what conditions; a timeline for sharing and preservation that addresses both the minimum length of time the data will be available and any anticipated delay to data access after research findings are published; any special requirements for data sharing, for example, proprietary software needed to access or interpret data, applicable policies, provisions, and licenses for re-use and re-distribution, and for the production of derivatives, including guidance for how data and data products should be cited; any resources and capabilities (equipment, connections, systems, software, expertise, etc.) requested in the research proposal that are needed to meet the stated goals for sharing and preservation (this could reference the relevant section of the associated research proposal and budget request); and

whether/where the data will be preserved after direct project funding ends and any plans for the transfer of responsibilities for sharing and preservation.

Protection: A statement of plans, where appropriate and necessary, to protect confidentiality, personal privacy, Personally Identifiable Information, and U.S. national, homeland, and economic security; recognize proprietary interests, business confidential information, and intellectual property rights; and avoid significant negative impact on innovation, and U.S. competitiveness.

Rationale: A discussion of the rationale or justification for the proposed data management plan including, for example, the potential impact of the data within the immediate field and in other fields, and any broader societal impact.

Additional Guidance

In determining which data should be shared and preserved, researchers must consider the data needed to validate research findings as described in the Requirements, and are encouraged to consider the potential benefits of their data to their own fields of research, fields other than their own, and society at large.

DMPs should reflect relevant standards and community best practices and make use of community accepted repositories whenever practicable.

Costs associated with the scope of work and resources articulated in a DMP may be included in the proposed research budget as permitted by the applicable cost principles.

To improve the discoverability of and attribution for datasets created and used in the course of research, EERE encourages the citation of publicly available datasets within the reference section of publications, and the identification of datasets with persistent identifiers such as Digital Object Identifiers (DOIs). In most cases, EERE can provide DOIs free of charge for data resulting from DOE-funded research through its Office of Scientific and Technical Information (OSTI) DataID Service.

Definitions

Data Preservation: Data preservation means providing for the usability of data beyond the lifetime of the research activity that generated them.

Data Sharing: Data sharing means making data available to people other than those who have generated them. Examples of data sharing range from bilateral communications with colleagues, to providing free, unrestricted access to anyone through, for example, a web-based platform.

Digital Research Data: The term digital data encompasses a wide variety of information stored in digital form including: experimental, observational, and simulation data; codes, software and algorithms; text; numeric information; images; video; audio; and associated metadata. It also encompasses information in a variety of different forms including raw, processed, and analyzed data, published and archived data.

Research Data: The recorded factual material commonly accepted in the scientific community as necessary to validate research findings, but not any of the following: preliminary analyses, drafts of scientific papers, plans for future research, peer reviews, or communications with colleagues. This 'recorded' material excludes physical objects (e.g., laboratory samples). Research data also do not include:

> (A) Trade secrets, commercial information, materials necessary to be held confidential by a researcher until they are published, or similar information which is protected under law; and
>
> (B) Personnel and medical information and similar information the disclosure of which would constitute a clearly unwarranted invasion of personal privacy, such as information that could be used to identify a particular person in a research study."

Validate: In the context of DMPs, validate means to support, corroborate, verify, or otherwise determine the legitimacy of the research findings. Validation of research findings could be accomplished by reproducing the original experiment or analyses; comparing and contrasting the results against those of a new experiment or analyses; or by some other means.

APPENDIX E – 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 Management and Operating (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:

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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.

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.

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Examples of Acceptable Licenses
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Mozilla Public License 2.0 (MPL-2.0)
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APPENDIX F – TECHNICAL POTENTIAL AND PAYBACK CALCULATION

One performance metric used to evaluate applications will be the 2030 primary energy savings technical potential. Each application must describe a technology or approach that leads to a minimum annual primary energy savings technical potential in 2030 of at least 250 TBtu (i.e., 0.25 Quads). All applicants proposing a technology innovation should provide the *Primary Energy Savings Technical Potential* (TBtu), and the *Simple Payback* (years). 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 Market Calculator (http://trynthink.github.io/scout/calculator.html) 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 BTO Market Calculator will need to be used twice to obtain the market size for each affected end use. Detailed instructions on how to use the BTO Market 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,[76] 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" 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 efficiency[77]

Equipment Class	Stock (million units)	Stock Average Efficiency
Main Space Heaters		
Electric Heat Pumps (HSPF)	15.30	8.81
Natural Gas Heat Pumps (GCOP)	0.38	1.30
Geothermal Heat Pumps (COP)	1.69	3.45
Natural Gas Furnace (AFUE)	67.19	0.85
Distillate Furnace (AFUE)	5.59	0.87
Space Cooling		
Electric Heat Pumps (SEER)	15.30	14.08
Natural Gas Heat Pumps (GCOP)	0.38	0.67
Geothermal Heat Pumps (EER)	1.69	15.77
Central Air Conditioners (SEER)	76.96	13.61
Room Air Conditioners (EER)	47.05	10.52
Water Heaters		
Electric (EF)	60.56	0.97
Natural Gas (EF)	65.28	0.63
Distillate Fuel Oil (EF)	1.64	0.62
Propane (EF)	2.32	0.62
Refrigeration		
Refrigerators (kW.hr/yr)	166.17	479.30
Freezers (kW.hr/yr)	43.36	412.56

[76] http://www1.eere.energy.gov/buildings/appliance_standards/standards_test_procedures.html

[77] Residential Sector Equipment Stock and Efficiency, Reference case: http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2015&subject=12-AEO2015&table=30-AEO2015&region=0-0&cases=ref2015-d021915a

Table F2 2030 Commercial equipment average efficiency[78]

Equipment Class	Stock Average Efficiency[79]
Space Heating	
Electricity	1.63
Natural Gas	0.78
Distillate Fuel Oil	0.80
Space Cooling	
Electricity	3.75
Natural Gas	0.98
Water Heating	
Electricity	1.10
Natural Gas	0.91
Distillate Fuel Oil	0.79
Ventilation (cfm/Btu)	0.50
Refrigeration	3.16

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

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):

[78] Commercial Sector Energy Consumption, Floorspace, and Equipment Efficiency, Reference case: http://www.eia.gov/oiaf/aeo/tablebrowser/#release=AEO2015&subject=13-AEO2015&table=32-AEO2015&region=0-0&cases=ref2015-d021915a. Note that the stock (millions of units) are not available from this source.

[79] Unless noted otherwise, efficiencies are in units of Btu's of energy output divided by Btu's of energy input.

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

$$= \frac{\left[\begin{array}{c}\text{Incremental Initial}\\ \text{Cost of Proposed}\\ \text{Technology at Scale }(\$)\end{array}\right]}{\left[\begin{array}{c}\text{Unit Energy Consumed by}\\ \text{Typical New Technology}\\ \text{Per Year }(\text{kWh/Yr})\end{array}\right]\left[\begin{array}{c}\text{Energy}\\ \text{Cost}\end{array}\left(\frac{\$}{\text{kWh}}\right)\right]\left[\begin{array}{c}\text{\% Energy Savings}\\ \text{Over Typical New}\\ \text{Technology}\end{array}\right]} \quad \text{(F2)}$$

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

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

Note that the *% Energy Savings OverTypical 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 F2 *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 F2 Retail energy 2015 pricing (year-to-date)

Sector	Electricity, ¢/kWh[80]	Natural Gas	
		$/Thousand Cubic Feet[81]	$/MMBTU[82]
Residential	12.64	12.36	12.02
Commercial	10.65	8.15	7.93

Proposers of non-technological solutions, e.g., modeling approaches, are also required to provide an estimate of primary energy savings potentially resulting from their innovation, as well as an analysis of their cost effectiveness. The approaches used in these analyses need to be appropriately justified.

[80] http://www.eia.gov/electricity/monthly/epm_table_grapher.cfm?t=epmt_5_3
[81] http://www.eia.gov/dnav/ng/ng_pri_sum_a_EPG0_PCS_DMcf_a.htm
[82] http://www.eia.gov/tools/faqs/faq.cfm?id=45&t=8