FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT

ADVANCED RESEARCH PROJECTS AGENCY – ENERGY (ARPA-E)
U.S. DEPARTMENT OF ENERGY

MODELING-ENHANCED INNOVATIONS TRAILBLAZING NUCLEAR ENERGY REINVIGORATION (MEITNER)

Announcement Type: Initial Announcement
Funding Opportunity No. DE-FOA-0001798
CFDA Number 81.135

Funding Opportunity Announcement (FOA) Issue Date:	October 20, 2017
First Deadline for Questions to ARPA-E-CO@hq.doe.gov:	5 PM ET, Friday, November 24, 2017
Submission Deadline for Concept Papers:	5 PM ET, Monday, December 4, 2017
Second Deadline for Questions to ARPA-E-CO@hq.doe.gov:	5 PM ET, TBD
Submission Deadline for Full Applications:	5 PM ET, TBD
Submission Deadline for Replies to Reviewer Comments:	5 PM ET, TBD
Expected Date for Selection Notifications:	TBD
Total Amount to Be Awarded	Approximately $20 million, subject to the availability of appropriated funds.
Anticipated Awards	ARPA-E may issue one, multiple, or no awards under this FOA. Awards may vary between $500,000 and $5 million.

- For eligibility criteria, see Section III.A of the FOA.
- For cost share requirements under this FOA, see Section III.B of the FOA.
- To apply to this FOA, Applicants must register with and submit application materials through ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov/Registration.aspx). For detailed guidance on using ARPA-E eXCHANGE, see Section IV.H.1 of the FOA.
- Applicants are responsible for meeting each submission deadline. Applicants are strongly encouraged to submit their applications at least 48 hours in advance of the submission deadline.
- For detailed guidance on compliance and responsiveness criteria, see Sections III.C.1 through III.C.4 of the FOA.

Questions about this FOA? Check the Frequently Asked Questions available at http://arpa-e.energy.gov/faq. For questions that have not already been answered, email ARPA-E-CO@hq.doe.gov (with FOA name and number in subject line); see FOA Sec. VII.A. Problems with ARPA-E eXCHANGE? Email ExchangeHelp@hq.doe.gov (with FOA name and number in subject line).

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REQUIRED DOCUMENTS CHECKLIST

For an overview of the application process, see Section IV.A of the FOA.

For guidance regarding requisite application forms, see Section IV.B of the FOA.

For guidance regarding the content and form of Concept Papers, Full Applications, and Replies to Reviewer Comments, see Sections IV.C, IV.D, and IV.E of the FOA.

SUBMISSION	COMPONENTS	OPTIONAL/ MANDATORY	FOA SECTION	DEADLINE
Concept Paper	• Each Applicant must submit a Concept Paper in Adobe PDF format by the stated deadline. The Concept Paper must not exceed 6 pages in length (5 pages with a schematic up to 1 page) and must include the following: o Concept and Innovation o Proposed Work o Team Organization(s), Capabilities, and Budget Breakdown	Mandatory	IV.C	5 PM ET, Monday, December 4, 2017
Full Application	[TO BE INSERTED BY FOA MODIFICATION IN JANUARY 2018]	Mandatory	IV.D	5 PM ET, TBD
Reply to Reviewer Comments	[TO BE INSERTED BY FOA MODIFICATION IN JANUARY 2018]	Optional	IV.E	5 PM ET, TBD

I. FUNDING OPPORTUNITY DESCRIPTION

A. AGENCY OVERVIEW

The Advanced Research Projects Agency – Energy (ARPA-E), an organization within the Department of Energy (DOE), is chartered by Congress in the America COMPETES Act of 2007 (P.L. 110-69), as amended by the America COMPETES Reauthorization Act of 2010 (P.L. 111-358) to:

"(A) to enhance the economic and energy security of the United States through the development of energy technologies that result in—
(i) reductions of imports of energy from foreign sources;
(ii) reductions of energy-related emissions, including greenhouse gases; and
(iii) improvement in the energy efficiency of all economic sectors; and
(B) to ensure that the United States maintains a technological lead in developing and deploying advanced energy technologies."

ARPA-E issues this Funding Opportunity Announcement (FOA) under the programmatic authorizing statute codified at 42 U.S.C. § 16538. The FOA and any awards made under this FOA are subject to 2 C.F.R. Part 200 as amended by 2 C.F.R. Part 910.

ARPA-E funds research on and the development of high-potential, high-impact energy technologies that are too early for private-sector investment. The agency focuses on technologies that can be meaningfully advanced with a modest investment over a defined period of time in order to catalyze the translation from scientific discovery to early-stage technology. For the latest news and information about ARPA-E, its programs and the research projects currently supported, see: http://arpa-e.energy.gov/.

ARPA-E funds transformational research. Existing energy technologies generally progress on established "learning curves" where refinements to a technology and the economies of scale that accrue as manufacturing and distribution to develop drive down the cost/performance metric in a gradual fashion. This continual improvement of a technology is important to its increased commercial deployment and is appropriately the focus of the private sector or the applied technology offices within DOE. By contrast, ARPA-E supports transformative research that has the potential to create fundamentally new learning curves. ARPA-E technology projects typically start with cost/performance estimates well above the level of an incumbent technology. Given the high risk inherent in these projects, many will fail to progress, but some may succeed in generating a new learning curve with a projected cost/performance metric that is significantly lower than that of the incumbent technology.

ARPA-E funds technology with the potential to be disruptive in the marketplace. The mere creation of a new learning curve does not ensure market penetration. Rather, the ultimate value of a technology is determined by the marketplace, and impactful technologies ultimately become disruptive – that is, they are widely adopted and displace existing technologies from

the marketplace or create entirely new markets. ARPA-E understands that definitive proof of market disruption takes time, particularly for energy technologies. Therefore, ARPA-E funds the development of technologies that, if technically successful, have the clear disruptive potential, e.g., by demonstrating capability for manufacturing at competitive cost and deployment at scale.

ARPA-E funds applied research and development. The Office of Management and Budget defines "applied research" as an "original investigation undertaken in order to acquire new knowledge…directed primarily towards a specific practical aim or objective" and defines "development" as "creative and systematic work, drawing on knowledge gained from research and practical experience, which is directed at producing new products of processes or improving existing products or processes."[1] Applicants interested in receiving financial assistance for basic research should contact the DOE's Office of Science (http://science.energy.gov/). Office of Science national scientific user facilities (http://science.energy.gov/user-facilities/) are open to all researchers, including ARPA-E Applicants and Awardees. These facilities provide advanced tools of modern science including accelerators, colliders, supercomputers, light sources and neutron sources, as well as facilities for studying the nanoworld, the environment, and the atmosphere. Projects focused on the improvement of existing technology platforms along defined roadmaps may be appropriate for support through the DOE offices such as: the Office of Energy Efficiency and Renewable Energy (http://www.eere.energy.gov/), the Office of Fossil Energy (http://fossil.energy.gov/), the Office of Nuclear Energy (http://www.energy.gov/ne/office-nuclear-energy), and the Office of Electricity Delivery and Energy Reliability (http://energy.gov/oe/office-electricity-delivery-and-energy-reliability).

B. PROGRAM OVERVIEW

1. SUMMARY

Nuclear reactor plants are complex systems where many types and scales of technologies must work together seamlessly. Design choices at each of those scales and for each of those technologies impact the rest of the system in terms of functionality, cost, and constructability.

For nuclear energy to contribute in the coming decades, the next generation of nuclear reactor plants need to simultaneously achieve "walkaway" safe and secure operation, extremely low construction capital costs, and dramatically shorter construction and commissioning times than currently-available plants. To attain these goals, new, innovative, enabling technologies for existing advanced reactor designs are needed. The development of these enabling technologies requires understanding the inter-relatedness of design choices. Thus, ARPA-E encourages a

1 OMB Circular A-11 (https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/assets/a11_current_year/a11_2017.pdf), Section 84, pgs. 3-4.

rethinking of how pieces of the nuclear reactor system fit together when developing these enabling technologies.

Through the MEITNER[2] (**M**odeling-**E**nhanced **I**nnovations **T**railblazing **N**uclear **E**nergy **R**einvigoration) program, ARPA-E seeks to identify and develop innovative technologies to enable the advanced nuclear reactor design community to mature their designs for future commercial deployment. These enabling technologies can establish the basis for a modern, domestic supply chain supporting nuclear technology.

As provided in this FOA, ARPA-E will select multiple Awardees (Prime Recipients) to develop innovative technologies using advanced modeling and simulation (M&S) tools and by leveraging expert input to enable advanced reactor systems.[3] The MEITNER Program will establish a set of well-characterized enabling technologies where:

- performance and safety have been studied with multi-physics M&S tools;
- key cost and performance drivers have been identified for critical development and testing;
- key gaps in models or data have been identified, which can be addressed through targeted experimental work;
- costs and construction timelines are well projected; and
- robust techno-economic analysis (TEA) has been performed and a clear technology-to-market (T2M) plan has been created.

MEITNER Awardees will perform key enabling technology development for nuclear reactor systems, components, and structures, moving those technologies toward commercialization. The program will not support development of fundamentally new reactor core concepts nor the design of entire reactor plants. This approach is intended to focus on identifying and developing key enabling technologies for the existing U.S. advanced reactor design community that take advantage of fields adjacent to those that are typically considered nuclear energy research and development (R&D). The MEITNER Program will use modeling and simulation and, optionally, applied science and engineering-based experimental work.

The MEITNER Program will require a system-level approach in describing and quantifying how new and innovative enabling technologies fit into a plant design to make the plant "walkaway" safe, quickly-deployable, safeguardable, cost-competitive, and commercially-viable. To facilitate such a holistic view, ARPA-E will establish a separately-funded Resource Team to work with Awardees, as described in Section 2.3 below. The Resource Team will consist of three coordinated sub-teams: a computational modeling and simulation (M&S) sub-team, a techno-economic analysis (TEA) sub-team, and a subject matter expert (SME) sub-team (see Section I.E of the FOA). Through the Resource Team, Awardees will have access to SMEs from both the nuclear and non-nuclear disciplines. These resources will allow Awardees to more accurately place their enabling technologies into the larger reactor plant context.

2 Named in honor of Lise Meitner who, together with Otto Hahn, first discovered nuclear fission of uranium in the 1930s.

3 Refer to FOA Section I.B.2.3, titled *ARPA-E MEITNER Program Resource Team*, for additional information.

Awardees are encouraged to leverage DOE Office of Nuclear Energy (DOE-NE) programs, such as the GAIN (Gateway for Accelerated Innovation in Nuclear) initiative (https://www.inl.gov/research-program/gain) and the Nuclear Science User Facilities (NSUF) Network (https://nsuf.inl.gov/), to perform strategic experiments–either during or after completion of the Program.

2. BACKGROUND AND MOTIVATION

2.1 Opportunities and Challenges of Nuclear Energy

Nuclear electricity generation accounts for about 63% of the total low-emissions electricity generation worldwide.[4] In the U.S., nearly 20% of the total electricity generation, or about 800 billion kW-hr per annum, comes from 99 operating nuclear reactors that have a total installed capacity of 98.7 gigawatts of electricity (GW_e) operating with a fleet-average capacity factor of 95%.[5] These nuclear plants are all conventional light water reactors (LWRs), which have been the workhorse of the nuclear industry since its inception. Most reactors currently in operation around the world are classified as second- or third-generation systems, with the first-generation systems having been retired some time ago. New LWRs (Generation III+) with simplified physical plants, optimized control systems, significantly enhanced passive safety systems,[6] and standardized designs that may reduce maintenance and capital costs[7] are commercially available today (e.g., Westinghouse AP1000™).

However, the future of nuclear energy in the U.S. is unclear. Existing nuclear power plants are facing the significant challenge of having comparatively high operational and maintenance (O&M) costs.[8] Many of the Generation III+ reactors under construction have been plagued by escalating capital costs and unpredictable construction schedules. Today, only two such Gen III+ LWRs are scheduled to come online in the U.S. by 2021.[9] The low volume of new plant construction combined with expected retirements of the existing U.S. nuclear fleet is projected

4 Nuclear Energy Institute (NEI), http://www.nei.org/Knowledge-Center/Nuclear-Statistics/Environment-Emissions-Prevented. Calculated from U.S. EPA and EIA data for 2014. Nuclear power amounted to some 595 million metric tons of avoided carbon dioxide emissions.

5 U.S. Energy Information Administration (EIA), Nuclear Energy Overview (1957-2015), http://www.eia.gov/totalenergy/data/monthly/pdf/sec8.pdf

6 Passive safety systems rely almost exclusively on natural forces, such as density differences, gravity, and stored energy, to supply safety injection water and provide core and containment cooling. These passive systems do not include pumps. However, they do include some active valves, but all the safety-related active valves require either dc safety-related electric power (supplied by batteries), are air operated (and fail safe on loss of air), or are of the check valve type. U.S. Nuclear Regulatory Commission (NRC), http://www.nrc.gov/reading-rm/doc-collections/nuregs/staff/sr1793/initial/chapter22.pdf.

7 https://www.iaea.org/NuclearPower/Downloads/Technology/meetings/2011-Jul-4-8-ANRT-WS/2_USA_UK_AP1000_Westinghouse_Pfister.pdf

8 Nuclear Energy Institute. *Nuclear Costs in Context*. April 2016.

9 http://www.world-nuclear.org/information-library/country-profiles/countries-t-z/usa-nuclear-power.aspx, https://www.scana.com/investors/nuclear/questions-answers

to reduce nuclear electricity capacity by 20.8 GW by 2050, even with planned license extensions and power uprates to enable some plants to reach 60- or 80-year operations or increase their electrical output.[10]

For nuclear energy to be more attractive and competitive, both the overnight construction cost and the O&M cost need to be significantly reduced—these are the two major contributors to the levelized cost of electricity (LCOE).[11] Construction of large-scale LWRs, similar to the construction of other megastructures,[12,13] is prone to delays and cost-overruns,[14,15] which can lead to a significant increase in LCOE due to the increased capital involved and additional interest payments on the construction loans. The uncertainties associated with the construction time and cost make it more difficult for utilities to commit to new, large LWRs.

The relatively high O&M cost of the current nuclear fleet stems largely from the high staffing level required for the nuclear power plant operation, maintenance, safety, and security. A staffing level of more than 450 full time staff equivalents (FTE) per GW_e is typically required.[16] In contrast, as few as eight staff members are required to run a 300 MW_e natural gas power plant. The high O&M cost is a major reason some utilities are, or are considering, closing some existing operational nuclear plants before the conclusion of their licensed operational lifetimes in some highly competitive markets/states.[17,18]

2.2 Call for Innovative Technologies for Advanced Nuclear Power Plants

It is clear that a substantial reduction of construction cost, O&M cost, and construction time, in combination with targeting reactor plant operation for commercial viability, is required to fundamentally enhance the competitiveness and attractiveness of nuclear energy so that it can be available for affordable, low-emissions future energy scenarios.[19] Thus, ARPA-E seeks applications for research funding for transformative technologies to enable advanced nuclear reactor plant designs that simultaneously achieve:

10 https://www.eia.gov/todayinenergy/detail.php?id=31192
11 B. Vegel and J.C. Quinn, Economic evaluation of small modular nuclear reactors and the complications of regulatory fee structures, Energy Policy, 104 (2017) 395-403; and communications with the authors.
12 B. Flyvbjerg, M. Garbuio, and D. Lovallo, Delusion and deception in large infrastructure projects: two models for explaining and preventing executive disaster, California Management Review, 51 (2) (2009) 170-193.
13 B. Flyvbjerg, What you should know about megaprojects and why: an overview, Project Management Journal, 45 (2) (2014) 6–19.
14 J.R. Lovering, A.Yip, and T. Nordhaus, Historical construction costs of global nuclear power reactors, Energy Policy, 91 (2016) 371–382.
15 A. Gilbert, B.K. Sovacool, P. Johnstone, and A. Stirling, Cost overruns and financial risk in the construction of nuclear power reactors: a critical appraisal, Energy Policy, 102 (2017) 644–649.
16 https://www.eucg.org/pub/3ff048c1-f842-57dd-f625-bc35440aa9c4
17 https://www.everycrsreport.com/files/20161214_R44715_e13f9da7116c0368451dd56ac6f1c729b593d21c.pdf
18 http://faculty.haas.berkeley.edu/ldavis/Davis%20and%20Hausman%20AEJ%202016.pdf
19 J. Jenkins and S. Thernstrom, Deep decarbonization of the electric power sector: Insights from recent literature. *Energy Innovation Reform Project*. March 2017.

1) Low overnight construction cost.
2) Substantially autonomous operations to reduce the total (onsite and offsite) staffing level.
3) "Walkaway" safety when considering
    a. the amount of time before human intervention or backup power are required in an accident scenario; and
    b. potential for public exposure to radiation.
4) Very short on-site construction time.
5) Proliferation resistance through safeguards by design.[20]
6) The ability to achieve either or both:
    a. operate in a manner that facilitates easy electrical grid integration with intermittent sources such as wind and solar; or
    b. be available to provide economical industrial process heat.[21]

To achieve these goals, ARPA-E seeks applications for research funding for identification and development of transformative technologies that can assist the U.S. advanced reactor design community in maturing their conceptual designs into commercially-deployable products, establishing the basis for a modern, domestic supply chain supporting nuclear technology. These technologies should be considered within the context of an integrated reactor plant system. There are a variety of strategies that could be adopted and combined to work towards the stated goals, some of which are described in the following subsections. It should be noted that current regulatory constraints should not restrict proposed innovations.

2.2.1 System Simplification

Past and current reactor plant construction, and large construction projects in general, have demonstrated that large, complex construction projects are frequently fraught with construction management challenges, cost overruns, and schedule delays.[22] Significant simplification of plant design,[23] reduction in plant size, and manufacturing standardization could all bring large cost reductions.

Nuclear reactor plants are some of the heaviest structures on earth, requiring expensive site preparation. The concrete basemats and containment structures are very complicated to pour. Direct materials, labor, and equipment costs are high. Therefore, reducing the weight and complexity of the entire power plant through advanced construction techniques, or choosing

20 https://nnsa.energy.gov/aboutus/ourprograms/dnn/nis/safeguards/sbd.

21 C. McMillan, R. Boardman, M. McKellar, P. Sabharwall, M. Ruth, and S. Bragg-Sitton, (2016). *Generation and Use of Thermal Energy in the U.S. Industrial Sector and Opportunities to Reduce its Carbon Emissions.* (Report No. NREL/TP-6A50-66763). The Joint Institute for Strategic Energy Analysis.

22 http://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/the-construction-productivity-imperative.

23 I.N. Kessides, The future of the nuclear industry reconsidered: Risks, uncertainties, and continued promise. Energy Policy, 48 (2012) 185–208.

plant designs that are safer or have lower operating pressures that require significantly smaller containments, are all strategies that could lower the capital and construction cost.

Further, many LWR construction projects are plagued by inefficiencies and challenges to construction management caused by the complexity of installing very large systems with many requirements. The project complexity is often compounded by the fact that many components of nuclear power plants are customized to a specific site. The combination of these effects can lead to design changes, re-engineering, and unanticipated costs or delays. These costs and delays can be avoided by designing reactors with simple systems that are easy to construct and that do not require customization for any particular site with respect to requirements such as water availability and seismic preparation.

Both the quality assurance (QA) requirements and the procurement of nuclear-grade components can also lead to high costs. The QA process for components such as pipes or processes such as welding can increase the cost compared to a non-nuclear counterpart by a factor of 10 or more. A potential cost-reduction strategy is to simplify plant design such that fewer overall components and processes need NQA-1[24] certification per plant. Further, since reactor construction stalled in the U.S. for approximately 30 years, the supply chain for nuclear reactor components and availability of craft workers such as nuclear-trained welders and construction experts is currently underdeveloped. All of this can lead to higher costs, uncertainty in supply chain, and delays. Any reduction in the number and volume of nuclear-grade components per MW_e could translate into cost savings.

Well-conceived systems integration of simple technologies may greatly reduce plant construction complexity, avoiding expensive site preparation and customization, and reducing or avoiding large-size components that are difficult to procure.

2.2.2 Substantially-Autonomous and "Walkaway"-Safe Systems

Unlike fossil electricity sources, wherein the fuel cost is the primary component of the electricity cost, the cost of electricity production from current-fleet LWRs is dominated by non-fuel O&M costs, which are driven by the high staffing levels (≥ 450 FTE/GW_e) needed to operate, maintain, and secure the LWR plants.[25,6] Thus, reduced staffing levels are essential for the economically-sustainable operation of nuclear power plants.

Advanced technologies such as robotics, thorough and sophisticated sensing, model-based fault detection, and secure networks may be leveraged to design substantially-autonomous operations for nuclear reactors to significantly reduce the staffing level. Here, substantially-autonomous operations are defined as those that are free from operator interventions during normal operations, and only requiring supervised autonomy or autonomous shut-down in abnormal or accident scenarios.

24 https://www.nrc.gov/reading-rm/doc-collections/cfr/part050/part050-appb.html
25 http://instituteforenergyresearch.org/wp-content/uploads/2015/06/ier_lcoe_2015.pdf

Approaches in sensors, data analytics, and advanced controls (including autonomy and integration of machine learning) that limit or eliminate the need for humans to conduct regular monitoring and maintenance and enable early corrective action for abnormal conditions are encouraged. A simulated system allows exploration of a full range of potential data streams, and can help identify the most relevant sensor needs. This could help set the stage for radically new control approaches and substantial autonomy in nuclear power plants. With the advent of modern machine learning approaches, nuclear plant operators can better understand plant operations, anticipate equipment maintenance, and predict equipment replacement. Machine learning and predictive modeling could also allow nuclear units to communicate with and learn from one another and to operate in an optimal manner to respond to grid variations in energy load demand. Applicants are encouraged to explore novel control schemes and predict responses to a wide range of operating conditions and demands that would be impractical and expensive to explore in a physical prototype. Well-designed experiments may derisk the most uncertain aspects of some of these control schemes.

Inherent safety is characterized by the lowest potential consequences of an accident. In the worst scenarios, there should be no radioactive nuclide releases that could have measurable public health impacts (defined as 0.25 millisieverts/month above background radiation levels). This can be achieved by strategies such as having a reactor with fail-proof systems (with no reliance on electrical power) that provide accident protection, and/or a small nuclear source term. [26]

"Walkaway" safe reactor plant designs may not have accidents that require human intervention or any backup electricity for an extended period of time. This reduces the need for emergency response teams to be on-site and in nearby communities, reduces the complexity of emergency planning, and alleviates the uneasiness of having a reactor near a community.

Designs that are "walkaway" safe also need to protect against sabotage and include safeguards by design. Inherent safety is often linked with increased physical security of nuclear materials. Reactor plants are very physically secure when it is difficult to sabotage the plant, purposefully cause an accident, or divert nuclear materials for nefarious purposes. Very physically secure reactor plants with substantially-autonomous operations may enable the reduction of on-site security staff since the consequence of a reactor breach is minimal and the time to respond is much extended.

Applicants are encouraged to develop other innovative means for reduction of the staffing and overall O&M cost.

2.2.3 Materials and Chemistry

26 https://www.nrc.gov/reading-rm/basic-ref/glossary/source-term.html

Nuclear materials integration, chemical interactions, and corrosion (including coolant chemistry control) are areas that contain some of the largest uncertainties and may have some of the biggest impacts on new reactor plant potential. With the integration of multi-physics models to support the modeling and simulation of integrated power plant systems, plant designers can identify materials challenges in advance of any hardware development, and develop solutions to mitigate or avoid interactions that will limit the safety, performance, or lifetime of components or sub-systems. Identifying the highest-risk or most uncertain areas can inform targeted experimental work to move this area forward.

Applications are encouraged that propose innovative approaches to resolving materials and chemistry issues for advanced reactor plants.

2.2.4 Modular and Advanced Manufacturing

Advanced manufacturing (including additive manufacturing) of nuclear-relevant metals and materials may enable less expensive manufacturing of plant equipment and components, up to and including large components. The ability of additively-manufactured components to withstand the harsh temperature and radiation environments of nuclear reactors needs to be demonstrated to support the commercial use of the technology for nuclear power plant applications. Applicants should consider how work piloted here can rapidly explore component and subsystem designs to bound materials and component requirements, and help guide hardware development with advanced manufacturing.

Beyond advanced manufacturing at the component level, modular manufacturing of systems and sub-systems may be a key enabler to achieving fast on-site construction time. Applicants should consider the factory manufacturing experience of large gas turbines and other similar systems that are made modularly in factories and then assembled on site. In this way, the long-lead-time components can be planned and made according to manufacturing schedules. The reactor plant systems can be made-to-order in factories, which allows the construction of an entire nuclear power plant on site very quickly.

A modular approach may also enable rigorous testing of the reactor core modules in various extremes, such as seismic shaking or system flooding. Nuclear reactor plant designers may be able to leverage the safety design and testing practices used in other industries that use modular manufacturing, such as jet engines and gas turbines, to improve designs and enhance safety. Applicants may also consider the inclusion of other innovative manufacturing and construction processes, such as use of high performance concrete or advanced robotics, as long as fast on-site and overall (on-site + factory time) construction can be achieved.

2.3 ARPA-E MEITNER Program Resource Team

As part of the MEITNER Program, ARPA-E will task and fund the Oak Ridge National Laboratory (ORNL) to establish a Resource Team to provide relevant assistance to Awardees for their

efforts. The Resource Team will consist of three coordinated sub-teams: a computational M&S sub-team, a TEA sub-team, and a SME sub-team. (For details, see Section I.E below, "TECHNICAL SUPPLEMENT: ADDITIONAL INFORMATION ON THE CAPABILITIES OF THE RESOURCE TEAM"). Through the Resource Team, Awardees will have access to SMEs from both the nuclear and non-nuclear disciplines needed for developing the enabling technologies needed by the U.S. advanced reactor design community. As outlined in Section I.E below, Awardees are expected to draw upon Resource Team expertise, and will be required to cooperate with the TEA sub-team, which will ensure that uniform assumptions are applied across all Awardee technologies.

Specifically:

- The M&S sub-team will leverage existing federal DOE investments, primarily embodied in the DOE-NE Nuclear Energy Advanced Modeling and Simulation (NEAMS) program[27] and Consortium for Advanced Simulation of Light water reactors (CASL) Energy Innovation Hub,[28] to perform M&S for and with the Awardees upon request using the best available software. Computing resources will also be provided to the Awardees for this purpose.

- The SME sub-team will provide advice and information to the Awardees to ensure their technologies contribute substantially to safety, security, manufacturability, feasibility, and other design technologies and considerations for advanced reactor designs. Examples include seismic considerations, autonomous operations, advanced manufacturing, sensing and data analytics, component procurement, etc. The SME sub-team will also assist Awardees in placing their technologies into the larger system context.

- The TEA sub-team will be comprised of experts in energy system cost modeling and will work with each Awardee to ensure consistency and quality of TEA of the selected enabling technologies funded through this FOA.

ARPA-E will approve ORNL's proposed members of the Resource Team, including review for potential personal or organization conflicts of interest. MEITNER Awardee and Sub-Awardee personnel and consultants will be excluded from the Resource Team. No Resource Team members or their employers will obtain data rights or other intellectual property rights in any MEITNER Awardee's work products submitted to the Resource Team for evaluation. The Resource Team members will be required, via agreements with MEITNER Awardees (CRADAs or otherwise), to maintain strict confidentiality regarding:

27 http://www.ne.anl.gov/NEAMS/, Advanced Modeling & Simulation Office (NE-41), Nuclear Energy Advanced Modeling & Simulation (NEAMS) Program Overview.

28 http://www.casl.gov/, J. Turner, K. Clarno, M. Sieger, R. Bartlett, B. Collins, R. Pawlowski, R. Schmidt, and R. Summers, The virtual environment for reactor Applications (VERA) design and architecture, Journal of Computational Physics, 326 (2016) 544–568.

a) The proprietary technical details of the MEITNER Awardee's work products provided to the Resource Team members for evaluation, and
b) Results that are generated by the Resource Team, to the fullest extent allowable by statute and regulation. In addition, data generated by the Resource Team members about individual MEITNER work products under the agreements (CRADAs or otherwise) will only be provided to the specific MEITNER Awardee whose work products are being evaluated, and to ARPA-E.

Awardees will be required to establish an Intellectual Property (IP) Management Plan with the Resource Team upon award. Details on the IP Management Plan can be found in Section VIII.H of the FOA, "RIGHTS IN TECHNICAL DATA." Note: MEITNER Awardee and sub-awardee personnel and consultants will be excluded from the Resource Team. Resource Team members will not obtain data rights or other IP rights in any MEITNER Awardee's designs submitted to the Resource Team for evaluation.

No data rights or IP Management needs to be addressed during the Concept Paper or Full Application stages.

C. PROGRAM OBJECTIVES

The objective of the MEITNER Program is to identify, characterize, and develop enabling technologies that support moving existing advanced reactor designs from concept to products that are "walkaway" safe, quickly-deployable, safeguardable, cost-competitive, and commercially-viable. ARPA-E anticipates that most work will be based in M&S, but welcomes targeted experiments that substantially contribute to technology development. It is expected that the improvements and modeling validation in Awardee technologies will reduce the perceived risks, providing more complete and certain information for future development and commercialization.

It is expected that at the end of the MEITNER Program, each Awardee will have established a well-characterized enabling technology or set of technologies where:

- performance and safety have been studied with multi-physics M&S tools;
- key cost and performance drivers have been identified for critical development and testing;
- key gaps in models or data have been identified, which can be addressed through targeted experimental work;
- costs and construction timelines are well projected; and
- robust techno-economic analysis (TEA) has been performed and a clear technology-to-market (T2M) plan has been created.

Further, a successful outcome of the MEITNER Program will be for the Awardees to perform or be ready to perform essential experiments, or to build prototypes or demonstration systems, and to garner follow-on funding at the completion of this Program.

D. TECHNICAL DESIGN TARGETS

Applicants are required to describe and quantify in detail how their technologies will enable nuclear power plant designs to perform significantly better than the state of the art. Table 1 summarizes the metrics of interest, and Applicants must specify how they will perform in each area. Each Applicant must include quantitative analysis, with supporting calculations and references, that demonstrate how the envisioned technology will improve nuclear plant performance in these target areas. This must include estimations of uncertainty associated with each target area. Applications must include the approach used for cost projections.

Applicants are also required to quantify and justify how and how much they anticipate their technologies would improve during this Program. This discussion should include an explicit assessment of technical gaps and critical areas that are to be de-risked and a plan to reduce uncertainties in safety and cost. Specifically, Applicants must discuss what would be accomplished with both the requested financial assistance through this FOA and through access to the Resource Team (funded separately by ARPA-E). Applicants must include what M&S is needed and an estimate of the amount of computing resources they might need to use the software tools as well as what areas of subject matter expertise will be most impactful. Applicants must explain how cost modeling will be implemented in their work strategy. Further, Applicants must outline any experiments they would like to conduct and how the results of those experiments will improve or validate their technology.

Each Applicant must provide a technical description of the work to be performed and discuss how participating in the ARPA-E MEITNER Program will substantially enhance their ability to more rapidly, safely, and cost-effectively develop state-of-the-art technologies that support the licensing and deployment of existing advanced reactor concepts. Each Applicant must propose specific and well-defined deliverables that quantify, to the fullest extent possible, the anticipated improvements in reactor and power plant performance that would be achieved by the end of the Program and explain how those deliverables will enable the Applicant to move to the next stages of development.

Primary Design Target Areas

Table 1 lists the design target areas for the MEITNER Program and provides an assessment of the current state-of-the-art . ARPA-E intends to provide a set of goals for each of these technical target areas for the Full Applications, but for the Concept Papers, Applicants are to provide their own targets. Note that only one of 7a, ability to grid-integrate with intermittent resources, and 7b, ability to produce heat for industrial processes, needs to be targeted.

Table 1. Enabling technologies sought by ARPA-E must improve reactor performance in these target areas.

ID	Metric	Units	State-of-the-Art	Performance to be achieved by using the new technology*
1	Overnight construction cost	$/$W_e$	2-7 [29]	
2	On-site construction time	Months	> 60 [30]	
3	Total staffing level (on-site & off-site)	FTE/GW_e	450-750 [31]	
4	Emergency planning zone (EPZ)[+]	Miles	10 and 50 [32]	
5	Time before human response required for an accident	Days	3 [33]	
6	Onsite backup power	kW_e	> 0 kW [34]	
7a	Ramp rate without steam bypass	power capacity/min	5% [35]	
7b	Process heat temperature	ºC	N/A	

* Applicants are required to provide the projected performance based on the inclusion of their new technology into advanced reactors.

[+] As measured from the center of the nuclear reactor core to the boundary of radiation levels of 0.25 millisieverts/month above the background level.

NOTE FOR FULL APPLICATIONS:

ARPA-E recognizes that suitable high-fidelity analysis tools or data may not exist by the deadline for submission of the application to this FOA to conclusively prove that a new technology will cause a plant design to perform in the manner asserted in each application. To mitigate this issue, each Applicant will be required to provide the following information, termed "Associated Indicators", about the system their technology will fit in to. This information is not required to be submitted in the Concept Paper, but is provided for reference.

29 http://www.world-nuclear.org/information-library/country-profiles/countries-o-s/south-korea.aspx, http://www.world-nuclear-news.org/NN-Flamanville-EPR-timetable-and-costs-revised-0309154.html

30 http://www.world-nuclear-news.org/NN-Key-commissioning-test-completed-at-Korean-unit-1711165.html, http://www.world-nuclear-news.org/NN-Flamanville-EPR-timetable-and-costs-revised-0309154.html

31 https://www.eucg.org/pub/3ff048c1-f842-57dd-f625-bc35440aa9c4

32 https://www.nrc.gov/about-nrc/emerg-preparedness/about-emerg-preparedness/planning-zones.html

33 http://www.nuscalepower.com/images/our_technology/nuscale-safety-nucl-tech-may12-pre.pdf, https://www.iaea.org/NuclearPower/Downloads/Technology/meetings/2011-Jul-4-8-ANRT-WS/2_USA_UK_AP1000_Westinghouse_Pfister.pdf

34 https://www.nrc.gov/docs/ML1122/ML11229A062.pdf

35 http://nuclear-economics.com/12-nuclear-flexibility/

Associated Indicators

Cost

- Power conversion efficiency and/or co-product generation details
- % of construction/fabrication materials by number of components requiring an NQA-1 program
- % of construction by weight that needs to be site-customized
- % of plant by weight that can be manufactured and delivered as modules (by truck, rail, or boat)
- Technical readiness level of fuel
- Cost of fuel in $\$/MW_e$
- Core power density

Safety

- Core damage frequency (or equivalent measure)
- Core melt frequency (or equivalent measure)
- Size of nuclear source term in Curies (Ci) or megawatt thermal (MW_t)
- Ability to test / demonstrate new safety characteristics

Market Appeal

- Refueling frequency and duration
- Core and plant design life
- Reliability and availability
- Electrical output
- Water requirements
- Waste generation and / or ability to consume used fuel

Market Viability

- Target market or markets of the plant
- Justification of how plant characteristics fit that market

Safeguards by Design[20]

- Refueling strategy in terms of potential for material diversion
- Breeding ratio (if applicable)
- Enrichment level (if applicable)
- Fuel form
- Strategy for materials control and accountability and associated uncertainty quantification

If new technologies important to safety are being introduced and these technologies have not yet been tested or demonstrated, Applicants will need to detail in the Full Application the feasibility and timeline of testing and demonstrating such safety features, e.g., the use of a new material or the use of robotics to conduct maintenance activities will require a certain number of hours of testing in specific environments.

E. TECHNICAL SUPPLEMENT: ADDITIONAL INFORMATION ON THE CAPABILITIES OF THE RESOURCE TEAM

The M&S sub-team will support the M&S needs of the MEITNER Awardees. The areas required for M&S support will depend on the technology being developed. Table 2 lists the codes in both the CASL and NEAMS programs, as well as other DOE National Laboratory-developed tools, that can be made available to Awardees through license agreements with the developing organizations. Awardees may need other software, such as MCNP, Serpent, and SCALE, that are commonly used for nuclear reactor plant design. Note this list and Table 2 are not exclusive, and that the software does not need to be developed at DOE National Laboratories.

Table 2. List of potential M&S codes.

Category	Activities	Preliminary list of codes to be leveraged
Software Integration	Physics coupling	SIGMA, DTK, MOOSE
	Usability	VERAin/VERAout/VERAview, NEAMS Workbench
Physics Tool	Neutronics	MC2-3, DIF3D/VARIANT, REBUS, ORIGEN, PROTEUS, PERSENT, MPACT, Shift
	Thermal fluids	SE2-ANL, Nek5000, COBRA-TF,
	Fuel performance	LIFE-METAL, BISON
	Structural mechanics	NUBOW-3D, DIABLO
	Chemistry/corrosion	MAMBA
Systems and Controls	Integrated system modeling	RELAP53D, SAM
	Safety analysis	SAS4A/SASSYS-1, CONTAIN-LMR, RELAP53D
	Dynamic PRA	ADAPT

The TEA sub-team of the Resource Team will be available to assist awardees to evaluate the overnight construction cost, the O&M cost, the LCOE, and the effects of various design trade-offs on the costs. The TEA sub-team members will have established experience in performing

TEA for the nuclear industry. The TEA sub-team will leverage software packages and analysis procedures such as EON's model [36] to perform TEA for various innovative Awardee designs.

The SME sub-team will consist of experts from both nuclear and non-nuclear sectors to provide advice and information to Awardees to improve their technologies as they impact safety, security, manufacturability, feasibility, and other design technologies and considerations. Examples of areas of expertise that could be leveraged include:

- Factory manufacturing of safety-grade and/or large components
- Electricity markets
- Load following and grid integration
- Generation of co-products such as industrial process heat
- Advanced construction techniques
- Reactor physics, neutronics, nuclear data, and shielding
- Structural and functional materials
- Chemistry, chemical interactions, corrosion, and coolant chemistry control
- Nuclear fuel design, fabrication, and performance
- Power conversion and heat transport
- Sensors, instrumentation, controls, autonomous operation, and robotics
- Diagnostics and prognostics
- Safety, severe accidents, and environmental impacts
- Nuclear security and safeguards
- Used fuel and waste management
- Advanced/emerging technologies (such as advanced manufacturing)

The SME sub-team experts will be selected and invited based on the collective needs of expertise expressed post-award to the MEITNER Program Director by Awardees.

II. AWARD INFORMATION

A. AWARD OVERVIEW

ARPA-E expects to make approximately $20 million available for new awards under this FOA, subject to the availability of appropriated funds. ARPA-E anticipates making approximately 8-15 awards under this FOA. ARPA-E may, at its discretion, issue one, multiple, or no awards.

Individual awards may vary between $500,000 and $5 million.

36 http://innovationreform.org/wp-content/uploads/2017/07/Advanced-Nuclear-Reactors-Cost-Study.pdf

The period of performance for funding agreements may range from 24-30 months. ARPA-E expects the start date for funding agreements to be September 2018, or as negotiated.

ARPA-E encourages submissions stemming from ideas that still require proof-of-concept R&D efforts as well as those for which some proof-of-concept demonstration already exists.

Applicants requiring proof-of-concept R&D can propose a project with the goal of delivering on the program metric at the conclusion of the period of performance. These submissions must contain an appropriate cost and project duration plan that is described in sufficient technical detail to allow reviewers to meaningfully evaluate the proposed project. If awarded, such projects should expect a rigorous go/no-go milestone early in the project associated with the proof-of-concept demonstration. Alternatively, Applicants requiring proof-of-concept R&D can propose a project with the project end deliverable being an extremely creative, but partial solution. However, Applicants are required to provide a convincing vision how these partial solutions can enable the realization of the program metrics with further development.

Applicants proposing projects for which some initial proof-of-concept demonstration already exists must submit concrete data that supports the probability of success of the proposed project.

ARPA-E will provide support at the highest funding level only for submissions with significant technology risk, aggressive timetables, and careful management and mitigation of the associated risks.

ARPA-E will accept only new submissions under this FOA. Applicants may not seek renewal or supplementation of their existing awards through this FOA.

ARPA-E plans to fully fund Awardees' negotiated budget at the time of award.

B. ARPA-E FUNDING AGREEMENTS

Through Cooperative Agreements, Technology Investment Agreements, and similar agreements, ARPA-E provides financial and other support to projects that have the potential to realize ARPA-E's statutory mission. ARPA-E does not use such agreements to acquire property or services for the direct benefit or use of the U.S. Government.

Congress directed ARPA-E to "establish and monitor project milestones, initiate research projects quickly, and just as quickly terminate or restructure projects if such milestones are not achieved."[37] Accordingly, ARPA-E has substantial involvement in the direction of every Cooperative Agreement, as described in Section II.C below.

37 U.S. Congress, Conference Report to accompany the 21st Century Competitiveness Act of 2007, H. Rpt. 110-289 at 171-172 (Aug. 1, 2007).

1. COOPERATIVE AGREEMENTS

ARPA-E generally uses Cooperative Agreements to provide financial and other support to Prime Recipients.[38]

Cooperative Agreements involve the provision of 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.

ARPA-E encourages Prime Recipients to review the Model Cooperative Agreement, which is available at http://arpa-e.energy.gov/arpa-e-site-page/award-guidance.

2. FUNDING AGREEMENTS WITH FFRDCS/DOE LABS, GOGOS, AND FEDERAL INSTRUMENTALITIES

Any Federally Funded Research and Development Centers (FFRDC) involved as a member of a Project Team must provide the information requested in the "FFRDC Lab Authorization" and "Field Work Proposal" section of the Business Assurances & Disclosures Form, which is submitted with the Applicant's Full Application.

When a FFRDC/DOE Lab (including the National Energy Technology Laboratory or NETL) is the *lead organization* for a Project Team, ARPA-E executes a funding agreement directly with the FFRDC/DOE Lab and a single, separate Cooperative Agreement with the rest of the Project Team. Notwithstanding the use of multiple agreements, the FFRDC/DOE Lab is the lead organization for the entire project, including all work performed by the FFRDC/DOE Lab and the rest of the Project Team.

When a FFRDC/DOE Lab is a *member* of a Project Team, ARPA-E executes a funding agreement directly with the FFRDC/DOE Lab and a single, separate Cooperative Agreement with the rest of the Project Team. Notwithstanding the use of multiple agreements, the Prime Recipient under the Cooperative Agreement is the lead organization for the entire project, including all work performed by the FFRDC/DOE Lab and the rest of the Project Team.

Funding agreements with DOE/NNSA FFRDCs take the form of Work Authorizations issued to DOE/NNSA FFRDCs through the DOE/NNSA Field Work Proposal system for work performed under Department of Energy Management & Operation Contracts. Funding agreements with non-DOE/NNSA FFRDCs, GOGOs (including NETL), and Federal instrumentalities (e.g., Tennessee Valley Authority) will be consistent with the sponsoring agreement between the U.S. Government and the Laboratory. Any funding agreement with a FFRDC or GOGO will have

38 The Prime Recipient is the signatory to the funding agreement with ARPA-E.

similar terms and conditions as ARPA-E's Model Cooperative Agreement (http://arpa-e.energy.gov/arpa-e-site-page/award-guidance).

Non-DOE GOGOs and Federal agencies may be proposed to provide support to the project team members on an Applicant's project, through a Cooperative Research and Development Agreement (CRADA) or similar agreement.

3. TECHNOLOGY INVESTMENT AGREEMENTS

ARPA-E may use its "other transactions" authority under the America COMPETES Reauthorization Act of 2010 or DOE's "other transactions" authority under the Energy Policy Act of 2005 to enter into Technology Investment Agreements (TIAs) with Prime Recipients. ARPA-E may negotiate a TIA when it determines that the use of a standard cooperative agreement, grant, or contract is not feasible or appropriate for a project.

A TIA is more flexible than a traditional financial assistance agreement. In using a TIA, ARPA-E may modify standard Government terms and conditions. See 10 C.F.R. § 603.105 for a description of a TIA.

In general, TIAs require a cost share of 50%. See Section III.B.2 of the FOA.

C. STATEMENT OF SUBSTANTIAL INVOLVEMENT

ARPA-E is substantially involved in the direction of projects from inception to completion. For the purposes of an ARPA-E project, substantial involvement means:

- Awardees must adhere to ARPA-E's agency-specific and programmatic requirements.
- ARPA-E may intervene at any time in the conduct or performance of work under an award.
- ARPA-E does not limit its involvement to the administrative requirements of an award. Instead, ARPA-E has substantial involvement in the direction and redirection of the technical aspects of the project as a whole.
- During award negotiations, ARPA-E Program Directors and Prime Recipients mutually establish an aggressive schedule of quantitative milestones and deliverables that must be met every quarter. In addition, ARPA-E will negotiate and establish "Go/No-Go" milestones for each project. If the Prime Recipient fails to achieve any of the "Go/No-Go" milestones or technical milestones and deliverables as determined by the ARPA-E Contracting Officer, ARPA-E may – at its discretion - renegotiate the statement of project objectives or schedule of technical milestones and deliverables for the project. In the alternative, ARPA-E may suspend or terminate the award in accordance with 2 C.F.R. §§ 200.338 and 200.339.

- ARPA-E may provide guidance and/or assistance to the Prime Recipient to accelerate the commercial deployment of ARPA-E-funded technologies. Guidance and assistance provided by ARPA-E may include coordination with other Government agencies and nonprofits to provide mentoring and networking opportunities for Prime Recipients. ARPA-E may also organize and sponsor events to educate Prime Recipients about key barriers to the deployment of their ARPA-E-funded technologies. In addition, ARPA-E may establish collaborations with private and public entities to provide continued support for the development and deployment of ARPA-E-funded technologies.

III. ELIGIBILITY INFORMATION

A. ELIGIBLE APPLICANTS

This FOA is open to U.S. universities, national laboratories, industry, and individuals.

1. INDIVIDUALS

U.S. citizens or permanent residents may apply for funding in their individual capacity as a Standalone Applicant,[39] as the lead for a Project Team,[40] or as a member of a Project Team. However, ARPA-E will only award funding to an entity formed by the Applicant.

2. DOMESTIC ENTITIES

For-profit entities, educational institutions, and nonprofits[41] that are incorporated in the United States, including U.S. territories, are eligible to apply for funding as a Standalone Applicant, as the lead organization for a Project Team, or as a member of a Project Team.

FFRDCs/DOE Labs are eligible to apply for funding as the lead organization for a Project Team or as a member of a Project Team that includes institutions of higher education, companies, research foundations, or trade and industry research collaborations, but not as a Standalone Applicant.

State, local, and tribal government entities are eligible to apply for funding as a member of a Project Team, but not as a Standalone Applicant or as the lead organization for a Project Team.

39 A Standalone Applicant is an Applicant that applies for funding on its own, not as part of a Project Team.

40 The term "Project Team" is used to mean any entity with multiple players working collaboratively and could encompass anything from an existing organization to an ad hoc teaming arrangement. A Project Team consists of the Prime Recipient, Subrecipients, and others performing or otherwise supporting work under an ARPA-E funding agreement.

41 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 as a Prime Recipient or Subrecipient.

Federal agencies and instrumentalities (other than DOE) are eligible to apply for funding as a member of a Project Team, but not as a Standalone Applicant or as the lead organization for a Project Team.

3. FOREIGN ENTITIES

U.S.-incorporated foreign entities, whether for-profit or otherwise, are eligible to apply for funding under this FOA as a Standalone Applicant, as the lead organization for a Project Team, or as a member of a Project Team, subject the requirements in 2 C.F.R. § 910.124, which includes requirements that the entity's participation in the MEITNER Program be in the economic interest of the U.S. The Full Application must state the nature of the corporate relationship between the foreign entity and domestic subsidiary or affiliate.

Foreign entities not incorporated in the U.S., whether for-profit or otherwise, are not eligible to apply for funding, but may be proposed by an Applicant as a member of a Project Team.

Note Section VIII.G.3, which addresses U.S. manufacturing requirements for inventions arising from MEITNER research projects. Additionally, work under an ARPA-E award must be conducted in the U.S. The Applicant may request a waiver of this requirement in the Business Assurances & Disclosures Form, which is submitted with the Full Application and can be found at https://arpa-e-foa.energy.gov/. Please refer to the Business Assurances & Disclosures Form for guidance on the content and form of the request.

4. CONSORTIUM ENTITIES

Consortia, which may include domestic and foreign entities, must designate one member of the consortium as the consortium representative to the Project Team. The consortium representative must be incorporated in the United States. The eligibility of the consortium will be determined by reference to the eligibility of the consortium representative under Section III.A of the FOA. Each consortium must have an internal governance structure and a written set of internal rules. Upon request, the consortium entity must provide a written description of its internal governance structure and its internal rules to the Contracting Officer (ARPA-E-CO@hq.doe.gov).

Unincorporated consortia must provide the 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 collaboration agreement binds the individual consortium members together and shall include the consortium's:

- Management structure;
- Method of making payments to consortium members;
- Means of ensuring and overseeing members' efforts on the project;

- Provisions for members' cost sharing contributions; and
- Provisions for ownership and rights in intellectual property developed previously or under the agreement.

B. COST SHARING[42]

Applicants are bound by the cost share proposed in their Full Applications.

1. BASE COST SHARE REQUIREMENT

ARPA-E generally uses Cooperative Agreements to provide financial and other support to Prime Recipients (see Section II.B.1 of the FOA). Under a Cooperative Agreement or Grant, the Prime Recipient must provide at least 20% of the Total Project Cost[43] as cost share, except as provided in Sections III.B.2 or III.B.3 below.[44]

2. INCREASED COST SHARE REQUIREMENT

Large businesses are strongly encouraged to provide more than 20% of the Total Project Cost as cost share. ARPA-E may consider the amount of cost share proposed when selecting applications for award negotiations (see Section V.B.1 of the FOA).

Under a Technology Investment Agreement, the Prime Recipient must provide at least 50% of the Total Project Cost as cost share. ARPA-E may reduce this minimum cost share requirement, as appropriate.

3. REDUCED COST SHARE REQUIREMENT

ARPA-E has reduced the minimum cost share requirement for the following types of projects:

- A domestic educational institution or domestic nonprofit applying as a Standalone Applicant is required to provide at least 5% of the Total Project Cost as cost share.
- Small businesses – or consortia of small businesses - will provide 0% cost share from the outset of the project through the first 12 months of the project (hereinafter the "Cost Share Grace Period").[45] If the project is continued beyond the Cost Share

42 Please refer to Section VI.B.3-4 of the FOA for guidance on cost share payments and reporting.

43 The Total Project Cost is the sum of the Prime Recipient share and the Federal Government share of total allowable costs. The Federal Government share generally includes costs incurred by GOGOs and FFRDCs.

44 Energy Policy Act of 2005, Pub.L. 109-58, sec. 988.

45 Small businesses are generally defined as domestically incorporated entities that meet the criteria established by the U.S. Small Business Administration's (SBA) "Table of Small Business Size Standards Matched to North American Industry

Grace Period, then at least 10% of the Total Project Cost (including the costs incurred during the Cost Share Grace Period) will be required as cost share over the remaining period of performance.

- Project Teams where a small business is the lead organization and small businesses perform greater than or equal to 80%, but less than 100%, of the total work under the funding agreement (as measured by the Total Project Cost) the Project Team are entitled to the same cost share reduction and Cost Share Grace Period as provided above to Standalone small businesses or consortia of small businesses.[46]
- Project Teams composed exclusively of domestic educational institutions, domestic nonprofits, and/or FFRDCs are required to provide at least 5% of the Total Project Cost as cost share.
- Project Teams where domestic educational institutions, domestic nonprofits, small businesses, and/or FFRDCs perform greater than or equal to 80%, of the total work under the funding agreement (as measured by the Total Project Cost) are required to provide at least 10% of the Total Project Cost as cost share. However, any entity (such as a large business) receiving patent rights under a class waiver, or other patent waiver, that is part of a Project Team receiving this reduction must continue to meet the statutory minimum cost share requirement (20%) for its portion of the Total Project Cost.
- Projects that do not meet any of the above criteria are subject to the minimum cost share requirements described in Sections III.B.1 and III.B.2 of the FOA.

4. LEGAL RESPONSIBILITY

Although the cost share requirement applies to the Project Team as a whole, the funding agreement makes the Prime Recipient legally responsible for paying the entire cost share. The Prime Recipient's cost share obligation is expressed in the funding 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 period of performance, 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 obligations assumed by Project Team members in subawards or related agreements.

5. COST SHARE ALLOCATION

Classification System Codes" (NAICS) (http://www.sba.gov/content/small-business-size-standards). Applicants that are small businesses will be required to certify in the Business Assurances & Disclosures Form that their organization meets the SBA's definition of a small business under at least one NAICS code.

46 See the information provided in previous footnote.

Each Project Team is free to determine how much each Project Team member will contribute towards the cost share requirement. 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.

6. COST SHARE TYPES AND ALLOWABILITY

Every cost share contribution must be allowable under the applicable Federal cost principles, as described in Section IV.G.1 of the FOA.

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 or property 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:

- Revenues or royalties from the prospective operation of an activity beyond the period of performance;
- 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.

In addition, Project Teams may not use independent research and development (IR&D) funds[47] to meet their cost share obligations under cooperative agreements. However, Project Teams may use IR&D funds to meet their cost share obligations under Technology investment Agreements.

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. 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.

47 As defined in Federal Acquisition Regulation Subsection 31.205-18.

Applicants may wish to refer to 2 C.F.R. Parts 200 and 910, and 10 C.F.R Part 603 for additional guidance on cost sharing, specifically 2 C.F.R. §§ 200.306 and 910.130, and 10 C.F.R. §§ 603.525-555.

7. COST SHARE CONTRIBUTIONS BY FFRDCS AND GOGOS

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 a non-Federal source.

Because GOGOs/Federal Agencies are funded by the Federal Government, GOGOs/Federal Agencies may not provide cost share for the proposed project. However, the GOGO/Agency costs would be included in Total Project Costs for purposes of calculating the cost-sharing requirements of the Applicant.

8. COST SHARE VERIFICATION

Upon selection for award negotiations, Applicants are required to provide information and documentation regarding their cost share contributions. Please refer to Section VI.B.3 of the FOA for guidance on the requisite cost share information and documentation.

C. OTHER

1. COMPLIANT CRITERIA

Concept Papers are deemed compliant if:

- The Applicant meets the eligibility requirements in Section III.A of the FOA;
- The Concept Paper complies with the content and form requirements in Section IV.C of the FOA; and
- The Applicant entered all required information, successfully uploaded all required documents, and clicked the "Submit" button in ARPA-E eXCHANGE by the deadline stated in the FOA.

Concept Papers found to be noncompliant may not be merit reviewed or considered for award. ARPA-E may not review or consider noncompliant Concept Papers, including Concept Papers submitted through other means, Concept Papers submitted after the applicable deadline, and incomplete Concept Papers. A Concept Paper is incomplete if it does not include required information. ARPA-E will not extend the submission deadline for Applicants that fail to submit required information and documents due to server/connection congestion.

Full Applications are deemed compliant if:

- The Applicant submitted a compliant and responsive Concept Paper;
- The Applicant meets the eligibility requirements in Section III.A of the FOA;
- The Full Application complies with the content and form requirements in Section IV.D of the FOA; and
- The Applicant entered all required information, successfully uploaded all required documents, and clicked the "Submit" button in ARPA-E eXCHANGE by the deadline stated in the FOA.

Full Applications found to be noncompliant may not be merit reviewed or considered for award. ARPA-E may not review or consider noncompliant Full Applications, including Full Applications submitted through other means, Full Applications submitted after the applicable deadline, and incomplete Full Applications. A Full Application is incomplete if it does not include required information and documents, such as Forms SF-424 and SF-424A. ARPA-E will not extend the submission deadline for Applicants that fail to submit required information and documents due to server/connection congestion.

Replies to Reviewer Comments are deemed compliant if:

- The Applicant successfully uploads its response to ARPA-E eXCHANGE by the deadline stated in the FOA; and
- The Replies to Reviewer Comments comply with the content and form requirements of Section IV.E of the FOA.

ARPA-E will not review or consider noncompliant Replies to Reviewer Comments, including Replies submitted through other means and Replies submitted after the applicable deadline. ARPA-E will not extend the submission deadline for Applicants that fail to submit required information due to server/connection congestion. ARPA-E will review and consider each compliant and responsive Full Application, even if no Reply is submitted or if the Reply is found to be noncompliant.

2. RESPONSIVENESS CRITERIA

ARPA-E performs a preliminary technical review of Concept Papers and Full Applications. The following types of submissions may be deemed nonresponsive and may not be reviewed or considered:

- Submissions that fall outside the technical parameters specified in this FOA.
- Submissions that have been submitted in response to other currently issued ARPA-E FOAs.
- Submissions that are not scientifically distinct from applications submitted in response to other currently issued ARPA-E FOAs.
- Submissions for basic research aimed solely at discovery and/or fundamental knowledge generation.
- Submissions for large-scale demonstration projects of existing technologies.
- Submissions for proposed technologies that represent incremental improvements to existing technologies.
- Submissions for proposed technologies that are not based on sound scientific principles (e.g., violates a law of thermodynamics).
- Submissions for proposed technologies that are not transformational, as described in Section I.A of the FOA.
- Submissions for proposed technologies that do not have the potential to become disruptive in nature, as described in Section I.A of the FOA. Technologies must be scalable such that they could be disruptive with sufficient technical progress.
- Submissions that are not scientifically distinct from existing funded activities supported elsewhere, including within the Department of Energy.
- Submissions that describe a technology but do not propose a R&D plan that allows ARPA-E to evaluate the submission under the applicable merit review criteria provided in Section V.A of the FOA.

3. SUBMISSIONS SPECIFICALLY NOT OF INTEREST

Submissions that propose the following will be deemed nonresponsive and will not be merit reviewed or considered:

- Incremental improvement to LWRs including Generation III or III+ LWR designs.
- Technology development that is not distinct in approach or objective from activities currently supported by or actively under consideration for funding by the Office of Nuclear Energy or any other office within Department of Energy.
- Exploratory work in new nuclear core concepts.
- Full reactor plant designs.
- Reactor designs that perform only as well as the state of the art listed in Table 1.
- Designs of components only—such as power conversion systems, fuel technologies, materials developments, construction methods, instrumentation

and controls, etc.—as standalone applications without putting them in the context of an overall nuclear power plant design.
- Nuclear reactors that are based on fuels that are not expected to be available for large-scale commercial deployment in the foreseeable future (i.e., 15-20 years).
- Major software developments only.
- Regulatory approaches.
- Nuclear batteries[48] without practical refueling options.

4. LIMITATION ON NUMBER OF SUBMISSIONS

ARPA-E is not limiting the number of submissions from Applicants. Applicants may submit more than one application to this FOA, provided that each application is scientifically distinct.

48 https://www.slideshare.net/saurabhnandy007/seminar-on-nuclear-batteries

IV. APPLICATION AND SUBMISSION INFORMATION

A. APPLICATION PROCESS OVERVIEW

1. REGISTRATION IN ARPA-E eXCHANGE

The first step in applying to this FOA is registration in ARPA-E eXCHANGE, ARPA-E's online application portal. For detailed guidance on using ARPA-E eXCHANGE, please refer to Section IV.H.1 of the FOA and the "ARPA-E eXCHANGE User Guide" (https://arpa-e-foa.energy.gov/Manuals.aspx).

2. CONCEPT PAPERS

Applicants must submit a Concept Paper by the deadline stated in the FOA. Section IV.C of the FOA provides instructions on submitting a Concept Paper.

ARPA-E performs a preliminary review of Concept Papers to determine whether they are compliant and responsive, as described in Section III.C of the FOA. Concept Papers found to be noncompliant or nonresponsive may not be merit reviewed or considered for award. ARPA-E makes an independent assessment of each compliant and responsive Concept Paper based on the criteria and program policy factors in Sections V.A.1 and V.B.1of the FOA.

ARPA-E will encourage a subset of Applicants to submit Full Applications. Other Applicants will be discouraged from submitting a Full Application in order to save them the time and expense of preparing an application submission that is unlikely to be selected for award negotiations. By discouraging the submission of a Full Application, ARPA-E 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. Unsuccessful Applicants should continue to submit innovative ideas and concepts to future FOAs.

3. FULL APPLICATIONS

Applicants must submit a Full Application by the deadline stated in the FOA. Applicants will have approximately 45 days from receipt of the Encourage/Discourage notification to prepare and submit a Full Application. Section IV.D of the FOA provides instructions on submitting a Full Application.

ARPA-E performs a preliminary review of Full Applications to determine whether they are compliant and responsive, as described in Section III.C of the FOA. Full Applications found to be noncompliant or nonresponsive may not be merit reviewed or considered for award. ARPA-E makes an independent assessment of each compliant and responsive Full Application based on the criteria and program policy factors in Sections V.A.2 and V.B.1 of the FOA.

4. REPLY TO REVIEWER COMMENTS

Once ARPA-E has completed its review of Full Applications, reviewer comments on compliant and responsive Full Applications are made available to Applicants via ARPA-E eXCHANGE. Applicants may submit an optional Reply to Reviewer Comments, which must be submitted by the deadline stated in the FOA. Section IV.E of the FOA provides instructions on submitting a Reply to Reviewer Comments.

ARPA-E performs a preliminary review of Replies to determine whether they are compliant, as described in Section III.C.1 of the FOA. ARPA-E will review and consider compliant Replies only. ARPA-E will review and consider each compliant and responsive Full Application, even if no Reply is submitted or if the Reply is found to be non-compliant.

5. PRE-SELECTION CLARIFICATIONS AND "DOWN-SELECT" PROCESS

Once ARPA-E completes its review of Full Applications and Replies to Reviewer Comments, it may, at the Contracting Officer's discretion, conduct a pre-selection clarification process and/or perform a "down-select" of Full Applications. Through the pre-selection clarification process or down-select process, ARPA-E may obtain additional information from select Applicants through pre-selection meetings, webinars, videoconferences, conference calls, written correspondence, or site visits that can be used to make a final selection determination. ARPA-E will not reimburse Applicants for travel and other expenses relating to pre-selection meetings or site visits, nor will these costs be eligible for reimbursement as pre-award costs.

ARPA-E may select applications for award negotiations and make awards without pre-selection meetings and site visits. Participation in a pre-selection meeting or site visit with ARPA-E does not signify that Applicants have been selected for award negotiations.

6. SELECTION FOR AWARD NEGOTIATIONS

ARPA-E carefully considers all of the information obtained through the application process and makes an independent assessment of each compliant and responsive Full Application based on the criteria and program policy factors in Sections V.A.2 and V.B.1 of the FOA. The Selection Official may select all or part of a Full Application for award negotiations. The Selection Official may also postpone a final selection determination on one or more Full Applications until a later date, subject to availability of funds and other factors. ARPA-E will enter into award negotiations only with selected Applicants.

Applicants are promptly notified of ARPA-E's selection determination. ARPA-E may stagger its selection determinations. As a result, some Applicants may receive their notification letter in advance of other Applicants. Please refer to Section VI.A of the FOA for guidance on award notifications.

7. MANDATORY WEBINAR

All selected Applicants, including the Principal Investigator and the financial manager for the project, are required to participate in a webinar that is held within approximately one week of the selection notification. During the webinar, ARPA-E officials present important information on the award negotiation process, including deadlines for the completion of certain actions.

B. APPLICATION FORMS

Required forms for Full Applications are available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov), including the SF-424 and Budget Justification Workbook/SF-424A. A sample Summary Slide is available on ARPA-E eXCHANGE. Applicants may use the templates available on ARPA-E eXCHANGE, including the template for the Concept Paper, the template for the Technical Volume of the Full Application, the template for the Summary Slide, the template for the Summary for Public Release, the template for the Reply to Reviewer Comments, and the template for the Business Assurances & Disclosures Form. A sample response to the Business Assurances & Disclosures Form is available on ARPA-E eXCHANGE.

C. CONTENT AND FORM OF CONCEPT PAPERS

The Concept Paper is mandatory (i.e. in order to submit a Full Application, a compliant and responsive Concept Paper must have been submitted) and must conform to the following formatting requirements:

- The Concept Paper must not exceed 6 pages in length (5 pages with a schematic up to 1 page) including graphics, figures, and/or tables, but excluding the Bibliography.
- The Concept Paper must be submitted in Adobe PDF format.
- The Concept Paper must be written in English.
- All pages must be formatted to fit on 8-1/2 by 11 inch paper with margins not less than one inch on every side. Single space all text and use Times New Roman typeface, a black font color, and a font size of 12 point or larger (except in figures and tables).
- The ARPA-E assigned Control Number, the Lead Organization Name, and the Principal Investigator's Last Name 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.
- The first paragraph must include the Lead Organization's Name and Location, Principal Investigator's Name, Technical Category, and Project Duration. Proposed Funding (Federal and Cost Share) is optional.

Concept Papers found to be noncompliant or nonresponsive may not be merit reviewed or considered for award (see Section III.C of the FOA).

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

A fillable Concept Paper template is available on ARPA-E eXCHANGE at https://arpa-e-foa.energy.gov.

Concept Papers must conform to the content requirements described below. If Applicants exceed the maximum page length indicated above, ARPA-E will review only the authorized number of pages and disregard any additional pages.

1. CONCEPT PAPER

a. CONCEPT AND INNOVATION

- Provide a concise description of the proposed technology with minimal jargon, and explain the technical considerations that make this technology new and innovative. Specifically include how this technology will be incorporated into an existing advanced reactor concept "walkaway" safe, quickly-deployable, safeguardable, cost-competitive, and commercially-viable.
- Include a schematic identifying all major components relevant to how the technology operates in the reactor plant, with further description of critical subcomponents that are complex by themselves, e.g. the reactor core or the electricity generating sub-plant. There is no need to include non-essential components or details like types and quantities of fittings or valves, pipe materials, heat exchanger sizes, and concrete specifications, unless these details are critical to the proposed technology.
- Explain how design choices made throughout the entire plant fit together to achieve Program goals rather than focusing primarily on the design of the reactor core.
- Describe how the plant design will perform, because of the incorporation of the technology, in the Technical Design Target Areas listed in Table 1 in Section I.D of the FOA.

b. PROPOSED WORK

- Describe the background, theory, simulation, modeling, experimental data, or other sound engineering and scientific practices or principles that support the proposed technology. Provide specific examples of supporting data and/or appropriate citations to the scientific and technical literature.

- Outline a plan to perform modeling and simulation (M&S) to assess the performance of the technology in the reactor and power plant under normal operations and for various accident scenarios.
- Describe how and how much the technology and its impact in a plant design would improve during this Program, including an explicit assessment of technical gaps and what critical areas remain to be de-risked as well as how uncertainties in safety and cost can be reduced.
- Describe how the Applicant will leverage the Resource Team, including what M&S is needed and an estimate of the amount of computing resources that might be needed to use the software tools as well as what areas of subject matter expertise will be most impactful.
- Describe why the proposed effort is a significant technical challenge and the key technical risks to the project. Does the approach require one or more entirely new technical developments to succeed? How will technical risk be mitigated?
- Identify techno-economic challenges to be overcome for the proposed technology to be commercially relevant and how cost modeling will feed back into the technology development and use strategy.
- Outline any experiments to be conducted and how the results of those experiments will improve or validate the technology.
- Discuss what would be accomplished with both the requested financial assistance through this FOA as well as access to the Resource Team.
- Discuss how participating in the ARPA-E MEITNER Program will substantially enhance the Applicant's ability to more rapidly, safely, and cost-effectively build test or demonstration plants, raise new or additional private capital, or both.

c. TEAM ORGANIZATION(S), CAPABILITIES, AND BUDGET BREAKDOWN

- Indicate the roles and responsibilities of the organization(s) and key personnel that comprise the Applicant's team.
- Provide the name, position, and institution of each key team member and describe in 1-2 sentences the skills and experience that he/she brings to the team.
- Identify key capabilities provided by the organization(s) comprising the Applicant team and how those key capabilities will be used in the proposed effort.
- Identify (if applicable) previous collaborative efforts among project team members relevant to the proposed effort.
- Describe in 1-2 sentences a breakdown of the project budget by organizations if multiple organizations are involved with the Applicant team (not including the budget for the proposed assistance from the Resource Team).

d. BIBLIOGRAPHY (NOT INCLUDED IN 6-PAGE LIMIT)

- List the references.

D. CONTENT AND FORM OF FULL APPLICATIONS

[TO BE INSERTED BY FOA MODIFICATION IN JANUARY 2018]

E. CONTENT AND FORM OF REPLIES TO REVIEWER COMMENTS

[TO BE INSERTED BY FOA MODIFICATION IN JANUARY 2018]

F. INTERGOVERNMENTAL REVIEW

This program is not subject to Executive Order 12372 (Intergovernmental Review of Federal Programs).

G. FUNDING RESTRICTIONS

[TO BE INSERTED BY FOA MODIFICATION IN JANUARY 2018]

H. OTHER SUBMISSION REQUIREMENTS

1. USE OF ARPA-E eXCHANGE

To apply to this FOA, Applicants must register with ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov/Registration.aspx). Concept Papers, Full Applications, and Replies to Reviewer Comments must be submitted through ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov/login.aspx). ARPA-E will not review or consider applications submitted through other means (e.g., fax, hand delivery, email, postal mail). For detailed guidance on using ARPA-E eXCHANGE, please refer to the "ARPA-E eXCHANGE User Guide" (https://arpa-e-foa.energy.gov/Manuals.aspx).

Upon creating an application submission in ARPA-E eXCHANGE, Applicants will be assigned a Control Number. If the Applicant creates more than one application submission, a different Control Number will be assigned for each application.

Once logged in to ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov/login.aspx), Applicants may access their submissions by clicking the "My Submissions" link in the navigation on the left side of the page. Every application that the Applicant has submitted to ARPA-E and the corresponding Control Number is displayed on that page. If the Applicant submits more than one application to a particular FOA, a different Control Number is shown for each application.

Applicants are responsible for meeting each submission deadline in ARPA-E eXCHANGE. **Applicants are strongly encouraged to submit their 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, or Full Application. In addition, Applicants should allow at least 15 minutes to submit a Reply to Reviewer Comments. Once the application is submitted in ARPA-E eXCHANGE, Applicants may revise or update their application until the expiration of the applicable deadline.

Applicants should not wait until the last minute to begin the submission process. During the final hours before the submission deadline, Applicants may experience server/connection congestion that prevents them from completing the necessary steps in ARPA-E eXCHANGE to submit their applications. **ARPA-E will not extend the submission deadline for Applicants that fail to submit required information and documents due to server/connection congestion.**

ARPA-E will not review or consider incomplete applications and applications received after the deadline stated in the FOA. Such applications will be deemed noncompliant (see Section III.C.1 of the FOA). The following errors could cause an application to be deemed "incomplete" and thus noncompliant:

- Failing to comply with the form and content requirements in Section IV of the FOA;
- Failing to enter required information in ARPA-E eXCHANGE;
- Failing to upload required document(s) to ARPA-E eXCHANGE;
- Failing to click the "Submit" button in ARPA-E eXCHANGE by the deadline stated in the FOA;
- Uploading the wrong document(s) or application(s) to ARPA-E eXCHANGE; and
- Uploading the same document twice, but labeling it as different documents. (In the latter scenario, the Applicant failed to submit a required document.)

ARPA-E urges Applicants to carefully review their applications and to allow sufficient time for the submission of required information and documents.

V. APPLICATION REVIEW INFORMATION

A. CRITERIA

ARPA-E performs a preliminary review of Concept Papers and Full Applications to determine whether they are compliant and responsive (see Section III.C of the FOA). ARPA-E also performs a preliminary review of Replies to Reviewer Comments to determine whether they are compliant.

ARPA-E considers a mix of quantitative and qualitative criteria in determining whether to encourage the submission of a Full Application and whether to select a Full Application for award negotiations.

1. CRITERIA FOR CONCEPT PAPERS

(1) *Impact of the Proposed Technology Relative to FOA Targets* (50%) - This criterion involves consideration of the following:

- The potential for a transformational and disruptive (not incremental) advancement compared to existing or emerging technologies;
- Achievement over the state of the art, as targeted by the Applicant's response in Table 1, ("Performance to be achieved by using the new technology"), and feasibility of, and Applicant's capability for, achieving the proposed new design; and
- Identification of techno-economic challenges that must be overcome for the proposed technology to be commercially relevant.

(2) *Overall Scientific and Technical Merit* (50%) - This criterion involves consideration of the following:

- The feasibility of the proposed work, as justified by appropriate background, theory, simulation, modeling, experimental data, or other sound scientific and engineering practices;
- Sufficiency of technical approach to accomplish the proposed R&D objectives, and how technical risk will be mitigated;
- Clearly defined project outcomes and final deliverables; and
- The demonstrated capabilities of the individuals performing the project, the key capabilities of the organizations comprising the Project Team, the roles and responsibilities of each organization and (if applicable) previous collaborations among team members supporting the proposed project.

Submissions will not be evaluated against each other since they are not submitted in accordance with a common work statement. The above criteria will be weighted as follows:

Impact of the Proposed Technology Relative to FOA Targets	50%
Overall Scientific and Technical Merit	50%

2. CRITERIA FOR FULL APPLICATIONS

[TO BE INSERTED BY FOA MODIFICATION IN JANUARY 2018]

3. CRITERIA FOR REPLIES TO REVIEWER COMMENTS

[TO BE INSERTED BY FOA MODIFICATION IN JANUARY 2018]

B. REVIEW AND SELECTION PROCESS

1. PROGRAM POLICY FACTORS

In addition to the above criteria, ARPA-E may consider the following program policy factors in determining which Concept Papers to encourage to submit a Full Application and which Full Applications to select for award negotiations:

I. **ARPA-E Portfolio Balance**. Project balances ARPA-E portfolio in one or more of the following areas:
   a. Diversity (including gender) of technical personnel in the proposed Project Team;
   b. Technological diversity;
   c. Organizational diversity;
   d. Geographic diversity;
   e. Technical or commercialization risk; or
   f. Stage of technology development.

II. **Relevance to ARPA-E Mission Advancement.** Project contributes to one or more of ARPA-E's key statutory goals:
   a. Reduction of US dependence on foreign energy sources;
   b. Stimulation of domestic manufacturing/U.S. Manufacturing Plan;
   c. Reduction of energy-related emissions;
   d. Increase in U.S. energy efficiency;
   e. Enhancement of U.S. economic and energy security; or
   f. Promotion of U.S. advanced energy technologies competitiveness.

III. **Synergy of Public and Private Efforts**.
   a. Avoids duplication and overlap with other publicly or privately funded projects;
   b. Promotes increased coordination with nongovernmental entities for demonstration of technologies and research applications to facilitate technology transfer; or
   c. Increases unique research collaborations.

IV. **Low likelihood of other sources of funding.** High technical and/or financial uncertainty that results in the non-availability of other public, private or internal funding or resources to support the project.

V. **High-Leveraging of Federal Funds**. Project leverages Federal funds to optimize advancement of programmatic goals by proposing cost share above the required minimum or otherwise accessing scarce or unique resources.

VI. **High Project Impact Relative to Project Cost.**

2. ARPA-E REVIEWERS

By submitting an application to ARPA-E, Applicants consent to ARPA-E's use of Federal employees, contractors, and experts from educational institutions, nonprofits, industry, and governmental and intergovernmental entities as reviewers. ARPA-E selects reviewers based on their knowledge and understanding of the relevant field and application, their experience and skills, and their ability to provide constructive feedback on applications.

ARPA-E requires all reviewers to complete a Conflict-of-Interest Certification and Nondisclosure Agreement through which they disclose their knowledge of any actual or apparent conflicts and agree to safeguard confidential information contained in Concept Papers, Full Applications, and Replies to Reviewer Comments. In addition, ARPA-E trains its reviewers in proper evaluation techniques and procedures.

Applicants are not permitted to nominate reviewers for their applications. Applicants may contact the Contracting Officer by email (ARPA-E-CO@hq.doe.gov) if they have knowledge of a potential conflict of interest or a reasonable belief that a potential conflict exists.

3. ARPA-E SUPPORT CONTRACTOR

ARPA-E utilizes contractors to assist with the evaluation of applications and project management. To avoid actual and apparent conflicts of interest, ARPA-E prohibits its support contractors from submitting or participating in the preparation of applications to ARPA-E.

By submitting an application to ARPA-E, Applicants represent that they are not performing support contractor services for ARPA-E in any capacity and did not obtain the assistance of ARPA-E's support contractor to prepare the application. ARPA-E will not consider any applications that are submitted by or prepared with the assistance of its support contractors.

C. ANTICIPATED ANNOUNCEMENT AND AWARD DATES

[TO BE INSERTED BY FOA MODIFICATION IN JANUARY 2018]

VI. AWARD ADMINISTRATION INFORMATION

A. AWARD NOTICES

1. REJECTED SUBMISSIONS

Noncompliant and nonresponsive Concept Papers and Full Applications are rejected by the Contracting Officer and are not merit reviewed or considered for award. The Contracting Officer sends a notification letter by email to the technical and administrative points of contact designated by the Applicant in ARPA-E eXCHANGE. The notification letter states the basis upon which the Concept Paper or Full Application was rejected.

2. CONCEPT PAPER NOTIFICATIONS

ARPA-E promptly notifies Applicants of its determination to encourage or discourage the submission of a Full Application. ARPA-E sends a notification letter by email to the technical and administrative points of contact designated by the Applicant in ARPA-E eXCHANGE. ARPA-E provides feedback in the notification letter in order to guide further development of the proposed technology.

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, ARPA-E 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.G.2 of the FOA for guidance on pre-award costs.

3. FULL APPLICATION NOTIFICATIONS

[TO BE INSERTED BY FOA MODIFICATION IN JANUARY 2018]

B. ADMINISTRATIVE AND NATIONAL POLICY REQUIREMENTS

[TO BE INSERTED BY FOA MODIFICATION IN JANUARY 2018]

C. REPORTING

[TO BE INSERTED BY FOA MODIFICATION IN JANUARY 2018]

VII. AGENCY CONTACTS

A. COMMUNICATIONS WITH ARPA-E

Upon the issuance of a FOA, only the Contracting Officer may communicate with Applicants. ARPA-E personnel and our support contractors are prohibited from communicating (in writing or otherwise) with Applicants regarding the FOA. This "quiet period" remains in effect until ARPA-E's public announcement of its project selections.

During the "quiet period," Applicants are required to submit all questions regarding this FOA to ARPA-E-CO@hq.doe.gov. Questions and Answers (Q&As) about ARPA-E and the FOA are available at http://arpa-e.energy.gov/faq. For questions that have not already been answered, please send an email with the FOA name and number in the subject line to ARPA-E-CO@hq.doe.gov. Due to the volume of questions received, ARPA-E will only answer pertinent questions that have not yet been answered and posted at the above link.

- ARPA-E will post responses on a weekly basis to any questions that are received that have not already been addressed at the link above. ARPA-E may re-phrase questions or consolidate similar questions for administrative purposes.
- ARPA-E will cease to accept questions approximately 10 business days in advance of each submission deadline. Responses to questions received before the cutoff will be posted approximately one business day in advance of the submission deadline. ARPA-E may re-phrase questions or consolidate similar questions for administrative purposes.
- Responses are published in a document specific to this FOA under "CURRENT FUNDING OPPORTUNITIES – FAQS"" on ARPA-E's website (http://arpa-e.energy.gov/faq).

Applicants may submit questions regarding ARPA-E eXCHANGE, ARPA-E's online application portal, to ExchangeHelp@hq.doe.gov. ARPA-E will promptly respond to emails that raise legitimate, technical issues with ARPA-E eXCHANGE. ARPA-E will refer any questions regarding the FOA to ARPA-E-CO@hq.doe.gov.

ARPA-E will not accept or respond to communications received by other means (e.g., fax, telephone, mail, hand delivery). Emails sent to other email addresses will be disregarded.

During the "quiet period," only the Contracting Officer may authorize communications between ARPA-E personnel and Applicants. The Contracting Officer may communicate with Applicants

as necessary and appropriate. As described in Section IV.A of the FOA, the Contracting Officer may arrange pre-selection meetings and/or site visits during the "quiet period."

B. DEBRIEFINGS

ARPA-E does not offer or provide debriefings. ARPA-E provides Applicants with a notification encouraging or discouraging the submission of a Full Application based on ARPA-E's assessment of the Concept Paper. In addition, ARPA-E provides Applicants with reviewer comments on Full Applications before the submission deadline for Replies to Reviewer Comments.

VIII. OTHER INFORMATION

A. FOAS AND FOA MODIFICATIONS

FOAs are posted on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov/), Grants.gov (http://www.grants.gov/), and FedConnect (https://www.fedconnect.net/FedConnect/). Any modifications to the FOA are also posted to these websites. You can receive an e-mail when a modification is posted by registering with FedConnect as an interested party for this FOA. It is recommended that you register as soon as possible after release of the FOA to ensure that you receive timely notice of any modifications or other announcements. More information is available at https://www.fedconnect.net.

B. OBLIGATION OF PUBLIC FUNDS

The Contracting Officer is the only individual who can make awards on behalf of ARPA-E or obligate ARPA-E to the expenditure of public funds. A commitment or obligation by any individual other than the Contracting Officer, either explicit or implied, is invalid.

ARPA-E awards may not be transferred, assigned, or assumed without the prior written consent of a Contracting Officer.

C. REQUIREMENT FOR FULL AND COMPLETE DISCLOSURE

Applicants are required to make a full and complete disclosure of the information requested in the Business Assurances & Disclosures Form. Disclosure of the requested information is mandatory. Any failure to make a full and complete disclosure of the requested information may result in:

- The rejection of a Concept Paper, Full Application, and/or Reply to Reviewer Comments;
- 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.

D. RETENTION OF SUBMISSIONS

ARPA-E 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 ARPA-E for funding, Applicants consent to ARPA-E's retention of their submissions.

E. MARKING OF CONFIDENTIAL INFORMATION

ARPA-E will use data and other information contained in Concept Papers, Full Applications, and Replies to Reviewer Comments strictly for evaluation purposes.

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

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

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

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

F. TITLE TO SUBJECT INVENTIONS

Ownership of subject inventions is governed pursuant to the authorities listed below. Typically, either by operation of law or under the authority of a patent waiver, Prime Recipients and Subrecipients may elect to retain title to their subject inventions under ARPA-E funding agreements.

- 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. If they elect to retain title, they must file a patent application in a timely fashion.

- All other parties: The Federal Non-Nuclear Energy Research and Development 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 Waiver: Under 42 U.S.C. § 5908, title to subject inventions vests in the U.S. Government and large businesses and foreign entities do not have the automatic right to elect to retain title to subject inventions. However, ARPA-E typically issues "class patent waivers" under which large businesses and foreign entities that meet certain stated requirements, such as cost sharing of at least 20%, may elect to retain title to their subject inventions. If a large business or foreign entity elects to retain title to its subject invention, it must file a patent application in a timely fashion. If the class waiver does not apply, a party may request a waiver in accordance with 10 C.F.R. §784.
- GOGOs are subject to the requirements of 37 C.F.R. Part 501.
- Determination of Exceptional Circumstances (DEC): Each Applicant is required to submit a U.S. Manufacturing Plan as part of its Full Application. The U.S. manufacture provision included in Attachment 2 of an award is included as part of the U.S. Manufacturing Plan. If selected, the U.S. Manufacturing Plan may 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. The DEC is dated September 9, 2013 and is available at the following link: http://energy.gov/gc/downloads/determination-exceptional-circumstances-under-bayh-dole-act-energy-efficiency-renewable.

G. 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. In addition, the Government may grant licenses for use of the subject invention when Prime Recipients, Subrecipients, or their assignees and exclusive licensees refuse to do so.

The U.S. Government may exercise its march-in rights 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 satisfactory manner;
- The owner has not met public use requirements specified by Federal statutes in a reasonably satisfactory manner; or
- The U.S. Manufacturing requirement has not been met.

3. U.S. MANUFACTURING REQUIREMENT

ARPA-E requires that awards address whether products embodying or produced through the use of subject inventions (i.e., inventions conceived or first actually reduced to practice under ARPA-E funding agreements) are to be substantially manufactured in the United States by Project Teams and their licensees. The requirement varies depending upon whether an awardee is a small business, University or other type of awardee. The Applicant may request a modification or waiver of the U.S. Manufacturing Requirement.

H. RIGHTS IN TECHNICAL DATA

Agreements by the Government or on behalf of the Government by which the Resource Team members are engaged ("RT Agreements") must require maintaining strict confidentiality regarding (1) the proprietary technical details of the MEITNER Awardee's design provided to the Resource Team members for evaluation, and (2) to the fullest extent allowable by statute and regulation, the results that are generated by the Resource Team when properly marked, realizing that the protection for some types of data produced by the Resource Team may be time-limited. Data to be generated by Resource Team members about individual MEITNER designs under the RT Agreements will only be provided to the specific MEITNER Awardee team whose system is being evaluated and to ARPA-E. The RT Agreements must also specify that Resource Team members will not obtain data rights or other intellectual property rights in any MEITNER Awardee's designs submitted to the Resource Team for evaluation. An appropriate legal arrangement between the Resource Team member with which an Awardee is working will

also be required ("DT-RT Arrangement"), such as a CRADA, Nondisclosure Agreement, or Intellectual Property Management Agreement as appropriate for the entities involved. Each DT-RT Arrangement must specifically address intellectual property issues.

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

- Background or "Limited Rights Data": The U.S. Government will not normally require delivery of 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.
- Generated Data: The U.S. Government normally retains very broad 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 ARPA-E awards may be protected from public disclosure for up to five years in accordance with provisions that will be set forth 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.

I. PROTECTED PERSONALLY IDENTIFIABLE INFORMATION

Applicants may not include any Protected Personally Identifiable Information (Protected PII) in their submissions to ARPA-E. Protected PII is defined as 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 their submissions.

- 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;
- 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; and
- Security clearance history or related information (not including actual clearances held).

J. COMPLIANCE AUDIT REQUIREMENT

A prime recipient organized as a for-profit entity expending $750,000 or more of DOE funds in the entity's fiscal year (including funds expended as a Subrecipient) must have an annual compliance audit performed at the completion of its fiscal year. For additional information, refer to Subpart F of: (i) 2 C.F.R. Part 200, and (ii) 2 C.F.R. Part 910.

If an educational institution, non-profit organization, or state/local government is either a Prime Recipient or a Subrecipient, and has expended $750,000 or more of Federal funds in the entity's fiscal year, the entity must have an annual compliance audit performed at the completion of its fiscal year. For additional information refer to Subpart F of 2 C.F.R. Part 200.

K. RESOURCE TEAM CONSIDERATIONS

MEITNER Awardee and sub-awardee personnel and consultants will be excluded from the Resource Team. Resource Team members will not obtain data rights or other IP rights in any MEITNER Awardee's designs submitted to the Resource Team for evaluation.

IX. GLOSSARY

Applicant: The entity that submits the application to ARPA-E. In the case of a Project Team, the Applicant is the lead organization listed on the application.

Application: The entire submission received by ARPA-E, including the Concept Paper, Full Application, and Reply to Reviewer Comments.

ARPA-E: is the Advanced Research Projects Agency – Energy, an agency within the U.S. Department of Energy.

Cost Sharing: is the portion of project costs from non-Federal sources that are borne by the Prime Recipient (or non-Federal third parties on behalf of the Prime Recipient), rather than by the Federal Government.

Deliverable: A deliverable is the quantifiable goods or services that will be provided upon the successful completion of a project task or sub-task.

DOE: U.S. Department of Energy.

DOE/NNSA: U.S. Department of Energy/National Nuclear Security Administration

FFRDCs: Federally Funded Research and Development Centers.

FOA: Funding Opportunity Announcement.

GOCOs: U.S. Government Owned, Contractor Operated laboratories.

GOGOs: U.S. Government Owned, Government Operated laboratories.

Milestone: A milestone is the tangible, observable measurement that will be provided upon the successful completion of a project task or sub-task.

Prime Recipient or Awardee: The signatory to the funding agreement with ARPA-E.

PI: Principal Investigator.

Project Team: A Project Team consists of the Prime Recipient, Subrecipients, and others performing inventive supportive work that is part of an ARPA-E project.

Standalone Applicant: An Applicant that applies for funding on its own, not as part of a Project Team.

Subject Invention: Any invention conceived or first actually reduced to practice under an ARPA-E funding agreement.

Task: A task is an operation or segment of the work plan that requires both effort and resources. Each task (or sub-task) is connected to the overall objective of the project, via the achievement of a milestone or a deliverable.

Total Project Cost: The sum of the Prime Recipient share and the Federal Government share of total allowable costs. The Federal Government share generally includes costs incurred by GOGOs, FFRDCs, and GOCOs.

TT&O: Technology Transfer and Outreach. (See Section IV.G.8 of the FOA for more information).