FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT

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

RAPID ENCAPSULATION OF PIPELINES AVOIDING INTENSIVE REPLACEMENT (REPAIR)

Announcement Type: ~~Initial Announcement~~ Modification 01
Funding Opportunity No. DE-FOA-0002289
CFDA Number 81.135

Funding Opportunity Announcement (FOA) Issue Date:	Tuesday, February 18, 2020
Deadline for Questions to ARPA-E-CO@hq.doe.gov:	5 PM ET, Friday, ~~April 10, 2020~~ April 24, 2020
Submission Deadline for Full Applications:	9:30 AM ET, Monday, ~~April 20, 2020~~ May 4, 2020
Submission Deadline for Replies to Reviewer Comments:	5 PM ET, ~~Friday, June 12, 2020~~ Wednesday, June 24, 2020
Expected Date for Selection Notifications:	July 2020
Total Amount to Be Awarded	Approximately $38.5 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 $250,000 and $10 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.G.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).

MODIFICATIONS

All modifications to the Funding Opportunity Announcement (FOA) are highlighted in yellow in the body of the FOA.

Mod. No.	Date	Description of Modifications
01	04/03/2020	• Updated certain deadlines, including the deadlines for submitting questions, Full Applications, and the Submission Deadline for Replies to Reviewer Comments. See Cover Page and Required Documents Checklist. • Updated expected start date for funding agreements. Sec Sections II.A and V.C. • Inserted an additional Program Policy Factor in Section V.B.1.

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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 Full Applications and Replies to Reviewer Comments, see Sections IV.C and IV.D of the FOA.

SUBMISSION	COMPONENTS	OPTIONAL/ MANDATORY	FOA SECTION	DEADLINE
Full Application	• Each Applicant must submit a Technical Volume in Adobe PDF format by the stated deadline. The Technical Volume must include the following: ○ Executive Summary (1 page max.) ○ Sections 1-5 (30 pages max.) • 1. Innovation and Impact • 2. Proposed Work • 3. Team Organization and Capabilities • 4. Technology to Market • 5. Budget ○ Bibliographic References (no page limit) ○ Personal Qualification Summaries (each PQS limited to 3 pages in length, no cumulative page limit) • The Technical Volume must be accompanied by: ○ SF-424 (no page limit, Adobe PDF format); ○ Budget Justification Workbook/SF424A (no page limit, Microsoft Excel format) ○ Summary for Public Release (250 words max., Adobe PDF format); ○ Summary Slide (1 page limit, Microsoft PowerPoint format); and ○ Completed and signed Business Assurances & Disclosures Form (no page limit, Adobe PDF format). ○ U.S. Manufacturing Plan (1 page limit, Adobe PDF format) ○ Preliminary Economic Model (no page limit, Microsoft Excel format)	Mandatory	IV.C	9:30 AM ET, ~~Monday, April 20, 2020~~ Monday, May 4, 2020
Reply to Reviewer Comments	• Each Applicant may submit a Reply to Reviewer Comments in Adobe PDF format. This submission is optional. The Reply may include: ○ Up to 2 pages of text; and ○ Up to 1 page of images.	Optional	IV.D	5 PM ET, ~~Friday, June 12, 2020~~ Wednesday, June 24, 2020

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 "experimental development" as "creative and systematic work, drawing on knowledge gained from research and practical experience, which is directed at producing new products or 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 early-stage R&D for the improvement of technology along defined roadmaps may be more appropriate for support through the DOE applied energy offices including: 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

REPAIR seeks to develop the suite of technologies required to rehabilitate cast iron, wrought iron, and bare steel natural gas distribution pipes by developing technologies that will enable the automated construction of a new pipe inside the old pipe. In order for the program to be successful, the new pipe must meet utilities' and regulatory agencies' requirements, have a minimum life of 50 years, and have sufficient material properties to operate throughout its service life without reliance on the exterior pipe. Today, older gas distribution pipes are typically excavated and replaced at costs up to $10 million per mile.

REPAIR will advance the state of gas distribution pipelines by incorporating smart functionality into structural coating materials and developing new integrity/inspection tools. It will also create 3D maps that integrate natural gas pipe and adjacent underground infrastructure

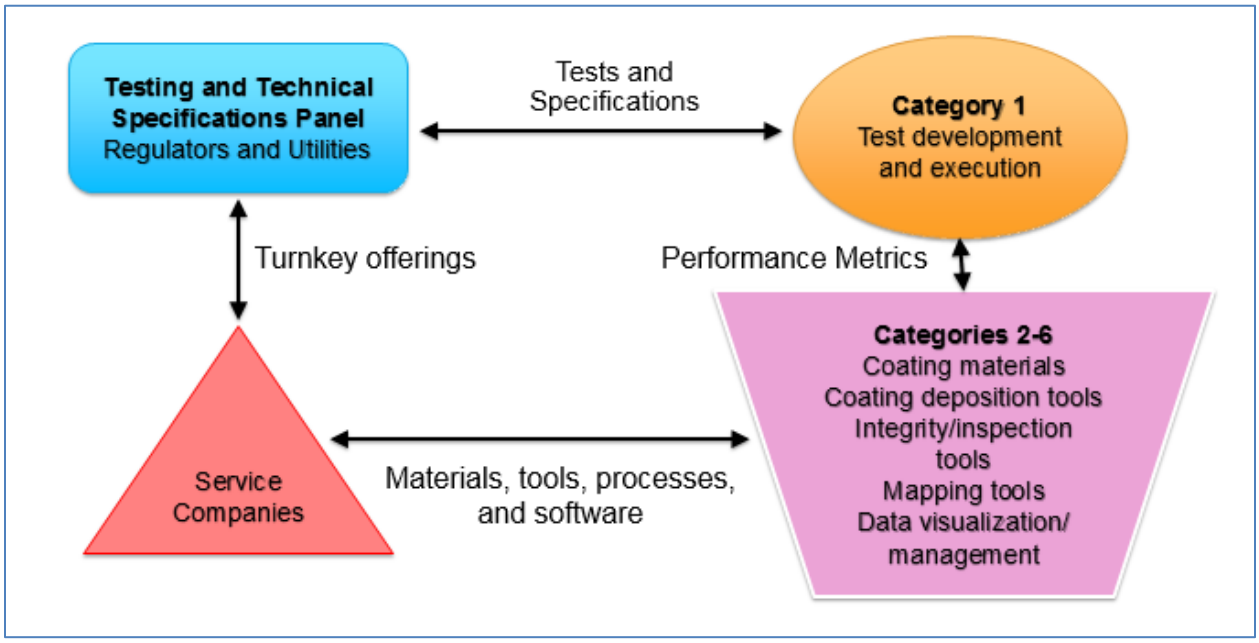
[1] OMB Circular A-11 (https://www.whitehouse.gov/wp-content/uploads/2018/06/a11_web_toc.pdf), Section 84, pg. 3.

geospatial information with integrity, leak, and coating deposition data. The cost target is $500k to $1 million per mile, including gas service disruption costs.

Gas distribution pipes are regulated by the Department of Transportation's (DOT) Pipeline and Hazardous Materials Safety Administration (PHMSA), as well as state regulatory agencies. Consequently the suite of technologies developed under REPAIR will ultimately need regulatory approval consistent with 49 Code of Federal Regulations Part 192. In parallel with this FOA, ARPA-E will establish a Testing and Technical Specifications Panel (TTSP) to advise ARPA-E and facilitate regulatory approval for the technologies and cost recovery for the rehabilitation process. The TTSP will include PHMSA; state regulators and their association, the National Association of Pipeline State Regulators (NAPSR); representatives of ASTM International F17 committee; gas utilities; and ARPA-E.

The REPAIR program will require coordination among multiple stakeholders, and collaboration within research programs, to achieve commercial success. Figure 1 summarizes the REPAIR ecosystem, the FOA categories, and the path to market. It is intended to show the inter-relationships among the critical program contributors: The TTSP will provide inputs to ARPA-E regarding test methods and performance specifications that regulators and utilities will require REPAIR technologies to demonstrate. In Category 1 these requirements are reduced to specific tests and performance metrics for the "pipe in pipe". Categories 2-4 address the individual system components: coating materials, coating deposition tools, and integrity/inspection tools. Category 5 is an integrated test of all of the components. Category 6 addresses mapping tools and software. The FOA breaks out requirements for each system component. However, it is essential that these components be integrated to create comprehensive service offerings. As shown in Figure 1, utilities typically execute turn-key contracts with service companies when rehabilitating pipelines. Consequently, Applicants for Categories 2-4 will need to describe their plans for integrating their products into comprehensive service offerings, through partnering or other commercialization plans.

Figure 1: Repair Ecosystem, FOA Categories, and Path to Market



2. BACKGROUND

Natural gas is an abundant domestic energy resource that benefits the US economy. Shale gas production increased by a factor of 15 between 2007 and 2017.[2] The "shale revolution" has increased domestic gas production by 50%.[3] Today natural gas provides 31% of U.S. primary energy and supplies record gas exports.[4] U.S. gas prices are among the lowest in the developed world,[5] providing a competitive advantage.

More than 1,400 gas utilities provide natural gas service to 75 million residential and 5 million commercial customers[6] through a network of 1.2 million miles (1.9 million km) of distribution mains and 900,000 miles (1.4 million km) of service lines.[7] Gas utilities began operations in the United States in the early 1800s. Cast iron, and later wrought iron, was used in construction of the early gas distribution grid. Approximately 60,000 miles (96,000 km) of cast and wrought iron pipe were installed, which will be collectively called cast iron in this document. Cast iron pipes operate at low pressures, typically below 3 psi (20 kPa) and always below 36 psi (250 kPa).

[2] EIA Shale gas production, https://www.eia.gov/dnav/ng/hist/res_epg0_r5302_nus_bcfa.htm
[3] EIA dry gas production, https://www.eia.gov/dnav/ng/hist/n9070us2a.htm
[4] EIA Annual Energy Outlook 2019 with projections to 2050, https://www.eia.gov/outlooks/aeo/pdf/aeo2019.pdf
[5] International Gas Union Wholesale Gas Price Survey 2019
[6] Energy Information Administration. "Distribution of Natural Gas: The Final Step in the Transmission Process." 2008
[7] Department of Transportation, Pipeline and Hazardous Materials Safety Administration. "Annual Report Mileage for Gas Distribution Systems." July 1, 2014

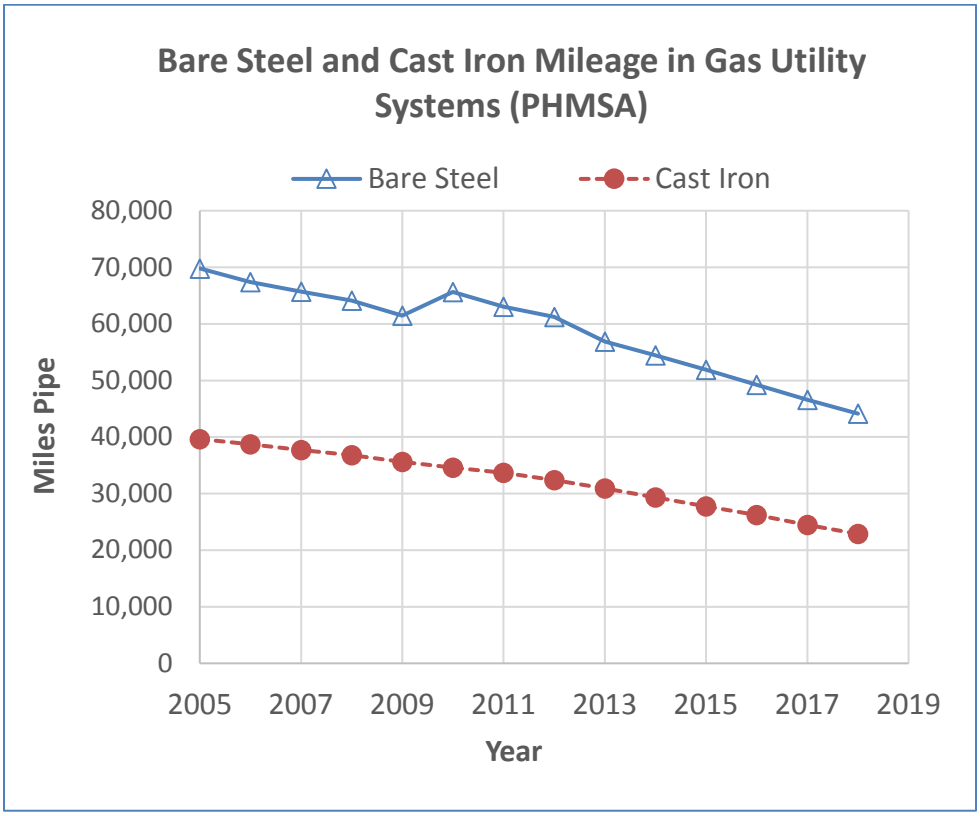
Steel pipe began replacing cast iron in the 1930s. These early steel lines did not have a protective coating or cathodic protection, and are referred to as bare steel. Approximately 100,000 miles (160,000 km) of bare steel was installed in gas distribution systems. DOT banned the use of bare steel for new gas distribution pipes after July 31, 1971.[8] Bare steel distribution pipes typically operate below 60 psi (450 kPa), although some may operate at up to 200 psi (1,400 kPa).

Cast iron and bare steel pipes, collectively referred to as legacy pipes, account for 3% of the 2 million miles (3 million km) of utility pipes. However, they account for a disproportionate number of leaks[9]and failures.[10] Many studies have investigated methane leaks from gas distribution systems, using top down and bottom up methods. DOE[9]and the EPA Gas Star program[11] list several reports. While the emission factors, number, and mass flux of gas distribution leaks are an area of active debate, there is consensus that distribution systems with legacy pipes have higher leak rates. Methane leaks and pipe failures create operating risk and legal liability for utilities; negatively impact the financial performance of system owners; and are a cost burden to gas consumers.[12] Cast iron pipes are held together by mechanical joints which are prone to leaking. The material is brittle, and can fail, typically as circumferential cracks. Bare steel pipes are prone to pitting and general corrosion/wall loss.

Over the last several decades the Federal government has taken several actions to track, and promote replacement, of these legacy cast iron and bare steel pipes. State regulators and utilities have developed accelerated pipeline replacement programs, and have removed more than half of the legacy pipes. The 2015 Quadrennial Review previously highlighted the need to address the legacy pipe problem.[13] Per Figure 2 below, there are still approximately 20,000 miles of cast iron and 40,000 miles of bare steel pipes in the PHMSA inventory of gas utility pipelines.[9,14]

[8] U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration, "Fact Sheet: Cathodic Protection," http://primis.phmsa.dot.gov/comm/FactSheets/FSCathodicProtection.htm
[9] Natural Gas Infrastructure Modernization Programs at Local Distribution Companies: Key Issues and Considerations, Office of Energy Policy and Systems Analysis, US DOE January, 2017
[10] PHMSA Cast and Wrought Iron Inventory https://www.phmsa.dot.gov/data-and-statistics/pipeline-replacement/cast-and-wrought-iron-inventory
[11] EPA Gas Star Program https://www.epa.gov/natural-gas-star-program/reports-and-technical-resources#emissions
[12] Natural Gas Infrastructure Modernization Programs at Local Distribution Companies: Key Issues and Considerations, Office of Energy Policy and Systems Analysis, US DOE January, 2017
[13]Chapter 2 INCREASING THE RESILIENCE, RELIABILITY, SAFETY, AND ASSET SECURITY OF TS&D INFRASTRUCTURE, QER Report: Energy Transmission, Storage, and Distribution Infrastructure | April 2015
[14] PHMSA Bare Steel Inventory https://www.phmsa.dot.gov/data-and-statistics/pipeline-replacement/bare-steel-inventory

Figure 2: Miles of Legacy Gas Distribution Pipe[10,15]



The current approach for addressing legacy pipes is to excavate and replace them, typically with high density polyethylene pipe. The replacement cost ranges from $1-10 million per mile, depending on their location (e.g, rural vs urban), the degree of complexity of the excavation, such as congestion due to adjacent underground infrastructure, and the costs for restoring roads.

These costs are passed through to gas customers. Specifically, they are capitalized, and included in the utility's rate base. Public utility commissions typically approve multi-year to multi-decade pipeline replacement programs to moderate rate increases. However, replacement programs using current practices and costs could make natural gas unaffordable for some utility customers. In 2013, the American Gas Associated (AGA) estimated replacement costs for cast iron pipes to range from $600 to $16,000 per customer, depending on system size and customer count.[15] People's Gas in Chicago recently filed an update with their commission, noting costs to replace cast iron pipes has increased from an estimated $1 billion to $10 billion, with the potential to raise gas rates significantly.[16] The 2013 AGA report estimated the cost to replace cast iron gas pipes in the US at $82 billion in 2013. We have not found an industry-wide

[15] https://www.aga.org/sites/default/files/managing_the_nations_cast_iron_inventory.pdf
[16] Crain's Business Daily, Peoples Gas blows the pipe-replacement budget again, February 27, 2019

estimate for bare steel replacement costs, which have more than twice the mileage of cast iron pipes.

Legacy pipe materials are also found in gas gathering systems. Gathering systems connect wells to gas processing plants or gas transmission pipelines. Gas utilities began building out gathering systems around 1900, when some utilities owned wells, gathering, and distribution systems. The utilities connected customers to gathering systems, particularly in rural areas. Some of these gathering systems were subsequently sold to third parties. In other cases independently owned gathering systems provide gas supply to utility customers. While the mileage of legacy material in gathering systems is not tracked by PHMSA, these older gathering systems are similar to legacy gas distribution systems because they include operate at low pressure and include cast iron and bare steel pipes. The Appalachian Basin is an example. Today, there are thousands of miles of older gathering systems, some with relatively high leak rates. One example is in the filings by Columbia Gas Transmission.[17] Another example is discussed in filings by Peoples Gas of Pennsylvania.[18] Although gathering accounts for less than 15% of their pipeline mileage, it accounts for more than 60% of their methane losses, with a loss rate of 9.5%. The filing with the Pennsylvania Public Utilities Commission indicate some gathering pipes will ultimately be abandoned. It is possible other older gathering systems could be abandoned, requiring customers to switch to more expensive energy sources and forcing oil and gas wells to be abandoned. The technologies developed during REPAIR will be applicable to legacy materials in gathering systems.

REPAIR seeks to eliminate the highest cost components, excavation and restoration, by rehabilitating pipes without their removal. In congested areas, most of the current costs for replacing pipes is associated with excavation and restoration, as opposed to the cost of the pipe itself.

REPAIR also seeks to minimize gas service disruption costs. Utilities incur costs whenever gas service is disrupted. Disruptions result in additional operations categories, such as venting and purging gas lines taken out of service; providing temporary gas service to customers; and/or interrupting and then restarting gas service. There are many operations that could disrupt gas service, such as the need to take pipes offline to access pipes, clean pipes, operate tools, or retrieve tools. Cleaning has additional cost implications, including disposal costs and possible environmental inspections, particularly for legacy pipes that were exposed to manufactured gas. Applicants will need to specify the number and duration of gas service disruption(s) for their processes, and these costs will be included in the techno-economic evaluation of proposed processes.

In addition to reducing costs, REPAIR seeks to provide new functionality and data for rehabilitated pipes. Coating materials will incorporate “smart” features. New integrity/inspection tools will assess pre- and post-coated pipes, and can be incorporated into

[17] Columbia Gas Transmission, LLC, FERC Docket No. RP15-555-Compliance Report on the Status of Ongoing Efforts to Reduce LAUF.

[18] PENNSYLVANIA PUBLIC UTILITY COMMISSION Docket No. R-2018-3006818

integrity management programs. New mapping tools will create 3D maps for rehabilitated mains and locate other pipeline components such as laterals, service lines, and elbows that are connected to the mains. The tools will also locate adjacent underground infrastructure. These maps will incorporate leak data, integrity/inspection data, coating parameters and allow material traceability. This information will allow utilities to plan and prioritize rehabilitation projects, track changes that impact pipeline integrity, and create accurate records for material traceability and locations of rehabilitated pipes. In the past, gas utilities needed to replace pipes that failed prematurely due to material defects (for example, Aldyl-A and polybutylene plastic pipe), in some cases with limited data on the locations of defective materials. REPAIR maps will allow utilities to track material lot number and coating parameters by location, as well as integrity/inspection data. This location-rich data will allow utilities to forecast potential integrity issues, and provide precise locations if intervention is required.

Enhanced pipe location data will also reduce third party damage. The Common Ground Alliance (CGA) linked improperly located or undetected subsurface utilities to 1,906 injuries, 421 fatalities, and $1.7 billion in damages during the last 20 years.[19] The report noted that deficiencies in pipeline locating practices were responsible for 21% of excavation damage to natural gas distribution pipelines in California. Gas utilities and regulators continue to seek better hardware and software tools for pipeline mapping, inspection, and data management. A recent CGA report highlights many issues regarding locating, mapping, and data integration that REPAIR will address.[20]

Developing the suite of technologies required for pipeline rehabilitation will improve operations and maintenance for gas utilities, reduce costs for gas customers, and allow the United States to retain its natural gas cost advantage. These rehabilitation technologies may also create an opportunity for U.S. companies to serve international markets. For example, in 2013 the UK still had over 50,000 miles (80,000 km) of cast iron pipe in high consequence areas which were targeted for replacement by 2032.[21] MarcoGas reports that cast iron accounts for 2.5% of EU gas distribution pipes, about twice the percentage of cast iron in the U.S. distribution system.[22]

For additional background and event information please visit the ARPA-E REPAIR workshop website (https://arpa-e.energy.gov/?q=events/rapid-encapsulation-pipelines-avoiding-intensive-

[19] Common Ground Alliance, Damage Incident Reporting Tool Report 2015, https://commongroundalliance.com/sites/default/files/publications/DIRT_Analysis_and_Recommendations_2015_Report_Final.pdf

[20] Common Ground Alliance Technology Advancements & Gaps in Underground Safety, March 2018 https://commongroundalliance.com/sites/default/files/publications/Annual%20Technology%20Report%2017_02.27.18_FINAL.pdf

[21] Energy UK Gas Retail Group Study into the effect of shrinkage on domestic customers Final Report https://gasgov-mst-files.s3.eu-west-1.amazonaws.com/s3fs-public/ggf/Energy%20UK%20GRG%20shrinkage%20study%20FINAL.pdf

[22] Marcogaz "SURVEY METHANE EMISSIONS FOR GAS DISTRIBUTION IN EUROPE, update 2017"

replacement-workshop) and the REPAIR industry day website (https://arpa-e.energy.gov/?q=site-page/2020-repair-industry-day).

C. METRICS AND BENEFITS

REPAIR will focus on distribution mains, the larger diameter pipes that feed smaller laterals and service lines. The PHMSA database, based on PHMSA Form 7100.1-1, indicates there are approximately 2000 miles (3200 km) of cast iron mains with 10 inch (250 cm) or larger diameter. Bare steel mileage/diameter information is not included in the PHMSA database, but we estimate a comparable mileage for larger-diameter pipe. ARPA-E will work with the TTSP to provide more detailed mileage/diameter data for cast iron and bare steel pipes.

The goal of the REPAIR program is to develop technologies to rehabilitate gas distribution mains at a cost of less than $1 million per mile, including gas service disruption costs.

The Preliminary Economic Model, the eighth component of the Full Application (see Section IV.C.8) outlines inputs for the economic assessment of system components. Applicants are given broad discretion in choosing coating material, coating deposition tools, integrity/inspection tools, and mapping tools. However, these components must form the basis for an integrated turn-key solution. As discussed in Section I.D, components will be evaluated for technical and economic performance in an integrated test at the end of the program.

Applicants may elect to have their components operate on live pipes, or require gas service to be disrupted during part or all of their operations. Applicants must quantify the number and duration of gas service disruption(s) required for their components in the Preliminary Economic Spreadsheet.

The goal of the REPAIR program to achieve rehabilitation at a cost of less than $1 million per mile comes with a constraint. The technologies developed in REPAIR must meet utilities' and regulatory agencies' requirements in order to be deployed and achieve real-world impact. As mentioned above, the TTSP will provide inputs to ARPA-E regarding test methods and specifications. Initial requirements are discussed in Category 1 below. ARPA-E will work with the TTSP to ensure REPAIR targets are consistent with meet utilities' and regulatory agencies' requirements and regulatory approval processes.

REPAIR will create several benefits:

- Accelerate legacy pipeline replacement while reducing cost.
- Advance the state of art for gas distribution pipelines by deploying smart materials and new integrity/inspection tools with real-time data processing.
- Produce 3D maps and data management/visualization tools that integrate geospatial data for leak testing, integrity/inspection data, coating deposition data, and locations of pipes and adjacent underground infrastructure.
- Facilitate approval by utilities and regulatory agencies by engaging these stakeholders throughout the project.

D. PROGRAM CATEGORIES

ARPA-E is open to all rehabilitation technologies that meet the $500k to $1 million/mile metric discussed above. Target pipelines are 10-inch (25 cm) and larger diameter gas distribution mains made of cast iron or bare steel. As noted above, ARPA-E will work with the TTSP to provide more detailed mileage/diameter data for cast iron and bare steel pipes. REPAIR has multiple categories, each of which requires diverse technical skills. Applicants may respond to an individual category or multiple categories. **However, to ensure the integrity of the Category 1 tests/testing process and to protect the confidentiality of test results, Category 1 Applicantions must a) address how data/records and test results of Categories 2, 3, 4 and 5 Awardees will be treated confidentially, and 2) demonstrate full mitigation of any conflict of interest – real or apparent – arising from that Category 1 Applicant's proposed participation – if any - in any Categories 2, 3, 4, or 5 awards.**

ARPA-E encourages diverse teams for all categories. As noted above, Applicants will need to address plans for integrating Category 2-4 system components into comprehensive offerings.

The categories are:

- Categories 1 -Testing models/protocols/hardware
- Categories 2-5 System component development and system integration:
    - Category 2 - Structural coating materials
    - Category 3 - Coating deposition tools
    - Category 4 - Coating integrity/inspection tools
    - Category 5 - Integrated coating, deposition tool, and integrity/inspection tool Pipe Tests
- Category 6 - 3D mapping hardware, data management, and data visualization

Detailed descriptions for each category are in the sections below. These descriptions should be considered minimum requirements.

Category 1. "Pipe in Pipe" Testing and Analysis

Regulations and codes and standards document test methods, test rigs, and performance targets for polyethylene and steel pipes used to replace legacy pipes in gas distribution systems. There are no comparable regulations or standards for a "coated" pipe in pipe. Category 1 addresses this gap.

Category 1 Awardees will conduct tests on Category 5 Awardee's pipe samples.

Models, test methods and equipment design generated by a Category 1 Awardee must be publicly releasable without restriction on further use or disclosure unless otherwise agreed to by ARPA-E. TTSP members will be advising ARPA-E with regard to developing models, test

methods and equipment design. Any recommendations, innovations, or contributions from TTSP members will be publicly releasable without restriction on further use or disclosure unless otherwise agreed to by ARPA-E.

Category 1.1 Define failure modes and establish the performance criteria for "pipe in pipe" with cast iron and bare steel pipes

In order to validate a 50-year life, we need to define the failure modes for cast iron and bare steel pipes that have an internal structural coating. We anticipate the Category 1 Awardees will conduct literature reviews for related technologies (pipeline liners, pipeline coatings, composite pipes, etc.), and collaborate with ARPA-E and the TTSP to identify the potential failure modes, which may differ for cast iron and bare steel. ARPA-E also encourages Applicants for Categories 2-4 to recommend testing techniques/protocols appropriate for their technologies. A preliminary list of failure mechanisms is listed below, based on prior experience with cure in place pipeline liners (CIPP liners):

- Deflection (lateral deformation), due to undermining, frost heave, ground subsidence, possibly earthquakes (i.e., liquefaction, lateral spreading).
- Axial deformation (axial displacement), due to thermal expansion/contraction, adjacent construction activity, and possibly earthquakes (i.e., transient wave propagation, permanent deformation from lateral spreading or landsliding)
- Vibrational loads, due to overhead traffic, which may cause fatigue failure
- Bonding/de-bonding at coating/pipe interface, due to differences in the thermal expansion of metal and coating or mechanical loads. Debonding could result in gas pockets at the composite/pipe interface, which may cause damage to the coating if the pipe is rapidly depressurized. Note that debonding may be advantageous in responding to some mechanical loads.
- Compatibility with current and future gas compositions with regard to corrosion and permeability, especially for hydrogen
- Cross-section ovalisation – this maybe critical for low modulus coatings
- Bends, tees, valves, and service connections - The presence of pipe fixtures and service connections may create stress concentrations and localized failures, in conjunction with the above failure mechanisms.

Category 1.2 Modelling failure modes, identification of critical physical properties, and development of test methods

Each failure mechanism will be modelled, for two purposes:

- Translate the failure modes into predictive models to estimate the required structural coating material properties, particularly for failure mechanisms that may require long-duration testing.

- Develop test methods, including inputs on quality control statistics, for each failure mechanism. Address potential issues for testing failure mechanisms that are difficult to reproduce, or require accelerated testing.

These models are expected to use fundamental principles to relate critical mechanical properties of the structural coating and pipe to the failure mechanism for each failure mode. Parametric investigations using a range of input values (pipe size, materials, coating thickness, material properties) will be used to develop approximate correlations between failure modes and critical physical properties for different types of pipes and coatings (material and thickness). These correlations will be communicated to system component development teams to inform their research.

Models, test methods, and test equipment will be "calibrated" using known materials (i.e. cast iron, steel, and composite pipes) to assess how well the models and test methods correlate with prior art. Category 1 Awardees will be required to evaluate their models against the calibration tests and tests conducted in Category 5, and propose modifications to the models, test hardware, and/or test protocols as required.

Test methods and equipment development will follow ASTM and/or ISO 17025 practices and incorporate any existing/available protocols (domestic or international), since regulatory approval is ultimately required.

Category 1.3 Pipe testing and correlations for failure mechanisms

The pipe testing facility(ies) will test coated pipe-in-pipe samples fabricated by system integrators from Category 5 as described below. The pipe tests will use methods approved from Category 1.2. Category 1 Awardees will need to provide test rigs suitable for large-scale testing failure mechanisms for coated "pipe in pipe". We anticipate 10- to 20-inch (25-50 cm) pipe diameters, and 3 to 20 feet (1-6 meter) lengths for most tests.

ARPA-E anticipates that system component developers (Categories 2-4 Awardees) and system integrators (Category 5 Awardees) will conduct many screening tests on sample coupons and test pipes before submitting "pipe-in-pipe" samples from Category 5. Once their processes are sufficiently developed, system integrators will submit "pipe in pipe" samples from Category 5 for testing under Category 1.3.

ARPA-E will work with Category 1 Awardee to establish a testing schedule and budget. The scope of the testing will include calibration tests and the tests required for Category 5. As a starting point, ARPA-E is expecting Applicants to Category 1 to base their Full Applications on tests associated with the potential failures outlined in Category 1.1. A preliminary assumption can be made that Category 5 will include 5 Awardees, each submitting two "sample pipes" for testing. As an example, the Category 1.1 discussion outlines seven tests. The scope of testing in Category 1.3 would then be 70 tests total (7 tests X 5 Awardees X 2 samples). ARPA-E will allocate test times to Category 5 Awardees.

Test results will be provided directly only to the Category 5 Awardee that submitted the sample for testing, and to ARPA-E. Final reports for each test shall be communicated within a reasonable time (approximately four weeks). Category 1.2 Awardees shall compare their model calculations to the test results to refine models, develop correlations/extrapolations, and modify test methods, if required. Category 5 Awardee that submitted the sample System integrators and component developers have the right to witness all testing involving their technologies.

Category 2. Smart Coating Materials

REPAIR seeks to rehabilitate legacy pipes by applying a structural coating to the inside of the legacy pipe. Success requires identifying suitable coating materials (Category 2), developing a coating deposition tool to apply the coating (Category 3), and verifying the coating integrity (Category 4). Although Categories 2, 3, and 4 are distinct technology development efforts, all three categories need to be integrated and demonstrated in Category 5, "Integrated Category 2, 3, 4 Pipe Test." The later-stage milestones reflect the combined performance of the coating, deposition tools, and integrity/inspection tools in Category 5. Consequently ARPA-E expects Applicants for Category 2 to address how they intend to collaborate with coating deposition tool Awardees in Category 3 and integrity/inspection tool teams in Category 4, as well as a system integrator in Category 5.

Materials are expected to be consistent with the intent of CFR 192 Subpart B – Materials. Applicants need to address material traceability throughout the coating process. Note that PHMSA forbids the use of rework or regrind materials for plastic pipe. Applicants proposing to use recycled materials, such as reclaimed composite fibers, need to address quality control metrics and supply chain issues.

ARPA-E prefers coating materials that minimize impacts on gas pipeline operations. However, if technology requires gas service disruption, applicants must quantify the number and duration of disruptions to gas service required for their coating materials. Examples of disruptions include the need to take pipes offline for cleaning, such as blasting or reaming; deposition methods that generate particles or aerosols that might migrate and foul gas equipment such as meters, regulators, or burners; and formulations that use solvents or generate by-products in concentrations high enough to impact gas operations or downstream gas equipment.

Applicants need to address cleaning requirements. The primary reason for cleaning is to obtain bonding between the coating and the surface. However, an objective of REPAIR is that the "pipe in pipe" be able to provide service for 50 years without relying on the original pipe. Consequently there are questions about the importance of bonding. There are some indications that strong bonding may not be required, and could be disadvantageous in some failure modes. If bonding is essential, some coating systems have been formulated to work

under more extreme conditions than expected for this project. For example, some coatings can adhere and cure under water, or in the presence of dirt.[23]

Several structural coating technologies are commercially available to repair gas, water, or sewer pipelines. Structural coatings for gas pipelines have generally used fiber composites, given their high specific strength and stiffness; resistance to damage by fatigue loading; light weight; and resistance to corrosion. Cure in place pipeline liners (CIPP liners) typically use glass or aramid fibers with thermoset materials such as epoxy and polyurethane.

Applicants are expected to address estimated coating thickness for proposed materials. The coating layer will decrease the diameter of the original pipe, potentially reducing its delivery capacity. This effect can be minimized by using thin coatings of composite materials with robust mechanical properties. For example, Sirimanna[24] showed that a 5 mm coating of E-glass/epoxy composite material could compensate for 40% wall loss in a 168 mm pipe operating at 18,500 kPa. Given the much lower operating pressures for legacy gas distribution pipes (cast iron pipes < 250 kPa, bare steel <1,400 kPa), it appears that high-strength coating materials could rehabilitate pipes with minimal impact on inner diameter and hence delivery capacity.

Applicants may address the potential of their coating technology to increase pipeline delivery capacity. For example, coatings may reduce friction losses, or allow the operating pressure of the pipeline to increase to compensate for the loss of cross-sectional area. Please note that the practicality of increasing operating pressure will depend on each utility's system design.

Applicants are expected to incorporate smart features into the coating, which will provide enhanced functionality compared to polyethylene pipes typically used in replacement projects. Smart features can also reduce the risk of premature failure, which is heightened given the 50 year life expectancy for the rehabilitated pipe. Examples of smart features include:

- Self-healing (autogenous): Examples include autonomous and non-autonomous embedded microcapsules that release reagents in response to mechanical damage, and shape-memory enhanced self-healing, which may require an external force such as heating to restore performance.

- Passive and active health monitoring: There are multiple options for incorporating sensing mechanisms into the coating structure. Examples include microcapsules which

[23] https://www.wessex-resins.com/applications/specialist-underwater-epoxies
[24] Sirimanna, et al. ANALYSIS OF INTERNAL BONDED FIBRE REINFORCED COMPOSITE REPAIR SYSTEMS FOR CORRODED STEEL PIPELINES, *Fourth Asia-Pacific Conference on FRP in Structures (APFIS 2013)*

11-13 December 2013, Melbourne, Australia

release agents when subjected to stress/strain; digital image correlation, which measures the relative displacements of a random pattern of markers; embedded optical fiber; and piezoelectric transducers, such as Macro-Fiber Composite (MFC) transducers.

As part of the coating screening process, each Category 2 Awardee will be expected to perform their own lab-based performance tests consistent with the failure mechanisms identified in Category 1. These results, and post-mortem failure analysis, will be incorporated into the defect detection criteria for Category 4.2 for the Awardee's proposed coating materials.

Applicants may propose any structural coating material (including coatings with no fibers) that meet the criteria listed below:

- Material(s) can be deposited by a coating deposition tool from Category 3 in a cast iron or bare steel pipe
- Achieve the performance specifications set by the TTSP, including minimum 50 year life as determined by tests from Category 1
- Incorporates smart features, including self-healing and health monitoring
- Compatible with standard gas operations and maintenance (O&M) practices, such as connecting new services to mains while pipes are live
- No hazardous materials or personnel exposure issues during subsequent O&M activities
- Compatible with current and future gas compositions, especially high hydrogen content gas
- Optionally able to re-coat pipe, if necessary

Category 3. Coating deposition tool

As noted above, ARPA-E expects Category 3 Applicants to address how they intend to collaborate with Awardees developing coating materials and integrity/inspection tools, as well as a system integrator in Category 5.

There are several techniques for depositing structural coatings, such as spraying, casting, and printing/additive manufacturing, each of which has specific operating requirements and ranges.[25] All of these are used commercially in a wide range of industries. Critical issues include linear speed, deposition rate, uniformity of coating thickness, and impact on gas service during coating operations.

ARPA-E prefers coating deposition tools that minimize impacts on gas pipeline operations. However, if technology requires gas service disruption, applicants must quantify the number and duration of disruptions to gas service. Examples include downtime for excavating access points; tapping pipes; inserting and removing the deposition tool; and operating the tool. Applicants must estimate the projected cross-sectional area of their tool, and assess whether it will impair gas delivery.

[25] Fiber-Reinforced Polymer Composites: Manufacturing Properties Applications, Polymers-11-01667

Applicants must provide the target operating ranges for their deposition tools. Parameters include the linear speed of the tool in a straight pipe, viscosity and density ranges for coating materials, and maximum coating thickness per pass.

The coating tool will require access to the interior of the pipe. The range of the deposition tool will determine the number of access points. Applicants must specify the expected maximum travel distance between access points for a straight pipe. Applicants also need to specify excavation and pipe tapping requirements, and whether tapping and operations can be conducted on live pipes.

Applicants must specify if the deposition tool needs to be tethered for power, communications, and material supply. Applicants must address drag forces and traction for the deposition tool. If the deposition tools needs to use enhanced normal forces to overcome drag forces, Applicants need to provide a range for the normal forces. Applicants must also describe how they will retrieve a non-responsive coating tool from a gas pipe.

The coating deposition tool will record operating parameters, quality control metrics, and material traceability by location, with location precision within 10 cm over its operating range. As an option, the coating tool could use the in-pipe mapping tool developed in Category 6.1.

Category 4. Pipe Integrity/Inspection Tool

As noted above, ARPA-E expects Category 4 Applicants to address how they intend to collaborate with Awardees developing coating materials and coating deposition tools, as well as a system integrator in Category 5.

Integrity/inspection tools are needed to assess the legacy pipes prior to coating, and assess the coating after deposition. Category 4 Applicants are encouraged to collaborate with Category 2 Applicants to screen and select the optimal inspection technique(s) for specific coating materials or optionally a range of materials. Ideally the same techniques and tools can be used for pre- and post-coating inspections, implying the inspection technique can “see” through the coating. ARPA-E anticipates different techniques and tools may be required for cast iron and bare steel pipes.

Applicants must provide the target operating ranges for their integrity/inspection tools. Parameters include the linear speed of the tool in a straight pipe and expected maximum travel distance between access points for a straight pipe. Applicants also need to specify excavation and pipe tapping requirements, and whether tapping and operations can be conducted on live pipes. Ideally the integrity/inspection tool will use the same access points as the coating deposition tool.

Applicants must specify if the integrity/inspection tool needs to be tethered for power and communications. Applicants must address drag forces and traction for the integrity/inspection tool. If the integrity/inspection tool needs to use enhanced normal forces to overcome drag

forces, Applicants need to provide a range for the normal forces. Applicants must also describe how they will retrieve a non-responsive tool from a gas pipe.

The integrity/inspection will record data by location, with location precision within 10 cm over its operating range. The tool needs to be able to record locations within 10 cm over its operating range. As an option, the coating tool can integrate the in-pipe mapping tool developed in Category 6.1 so that mapping is coincident with pre-coating inspection.

ARPA-E prefers integrity/inspection tools that minimize impacts on gas pipeline operations. However, if technology requires gas service disruption applicants must quantify the number and duration of disruption(s) to gas service. Examples include downtime for excavating access points; tapping pipes; cleaning pipes prior to inspection; inserting and removing the integrity/inspection tool; and operating the tool. Applicants must estimate the projected cross-sectional area of their tool, and assess whether it will impair gas delivery.

Category 4.1 Pre-coating integrity/inspection measurements

The pre-coating inspection will assess the initial condition of the pipe. It must include a video camera.

Some key issues for pre-coating inspection:

- Identify any gross features that could hinder pipe rehabilitation, including obstructions such as debris, liquids, pipe joints, tight bends, reducers, valves, etc.
- Identify pipe defects that would limit the operation of the coating deposition tool, including cracks, excessive corrosion, dents, etc.
- Provide real-time information with data visualization for operators.

There are several commercially available techniques for assessing cast iron and bare steel pipes, such as calipers, which measure diameter and detect gross defects; ultrasonics (UT), which can detect weld discontinuities and general corrosion; and magnetic flux leakage (MFL), which can detect cracks, severe pitting, and general corrosion/wall loss. All three techniques require tools to have contact with the pipe wall, which can be problematic for pipe with no or only minimal cleaning. UT or MFL tools may experience poor signals due to dirt, and/or damage to the detectors/magnets due to roughness or tuberculation. Consequently Applicants proposing to use tools that contact the pipe wall will need to address performance and durability for pipes with minimal cleaning.

Alternatively, Applicants can propose non-contact inspection techniques. Several non-contact inspection techniques are commercially available for cast iron and bare steel pipes, such as Electromagnetic Acoustic Transmitter (EMAT), using Lamb, Shear, and Longitudinal waves; Remote Field Electromagnetic Technique (RFET); and Large Standoff Magnetometry (LSM), which inspects pipes from the surface.

The pipeline rehabilitation operation needs timely information on the pipe condition. Consequently, the inspection technique(s) will include software that can analyze inspection data and provide results within 48 hours. ARPA-E anticipates that 48-hr turn-arounds for

inspection results may require artificial intelligence, machine learning, or similar techniques. Applicants must specify how they will meet the turn-around requirement. The inspection report needs to identify location and characteristics of all anomalies.

Applicants may propose any contact or non-contact technique, or combination of techniques, that meet the criteria listed below:

- Detect general corrosion > 10% wall thickness
- Detect pits longer than 20 mm and deeper than 40% wall thickness on the inner diameter of the pipe
- Detect pits longer than 25 mm and deeper than 40% wall thickness on the outer diameter of the pipe
- Detect circumferential cracks deeper than 40% wall thickness
- Detect longitudinal cracks deeper than 20% wall thickness
- Detect graphitization >10% wall thickness (cast iron)
- Location accuracy within 10 cm over operating range
- Data analysis within 48 hours

Category 4.2 Post-coating integrity/inspection tool

The post-coating inspection tool has the same requirements as above, plus requirements to assess the integrity of the coating. Potential defects include holidays (areas with no coating); thickness variations, especially sagging across the perimeter; voids, especially at the pipe wall; delamination and cracks; and incomplete curing.

Many contact and non-contact integrity tests are commercially available for coating materials anticipated for REPAIR. Not all techniques have been demonstrated for operation inside a pipe. Applicants for Category 4 are encouraged to coordinate with Category 2 Applicants to ensure the integrity tool(s) will be relevant for the composition, thickness, and critical defect size for proposed coating(s). Examples of techniques potentially relevant for a wide range of polymer and composite coatings include:

- Ultrasonic testing (UT), which measures thickness and can detect cracks, delaminations, shrinkage cavities, pores, and debonding. 2-D images can be created form multiple A-scans or phased arrays.
- Acoustic Emission Technique (AET), which detects matrix cracking, delamination, debonding, and fiber fracture in composite materials
- Thermography, with many variants, including optically stimulated thermography, ultrasonic stimulated thermography, eddy current stimulated thermography, and microwave thermography
- Nuclear Magnetic Resonance (NMR), which can detect faults, debonding, and extent of curing in polymers and composite materials

Defect detection requirements are typically determined from damage tolerance analysis. This analysis assumes defects are present, and grow with time. Residual strength can be calculated

from defect size, and consequently can be predicted based on defect growth rates. The residual strength must match the highest load over the expected life of the coating. These loads are determined from failure mechanisms identified in Category 1. Defect growth rates and residual strength will be established during performance testing in Category 2. Consequently it is imperative that Category 4 Awardees collaborate with Category 2 Awardees.

Applicants may propose any coating integrity test method, or a combination of test methods. The test method must be able to meet the criteria for Category 4.1, including 48-hr turn-around time for data analysis, and be adaptable to operate in live pipes. ARPA-E anticipates that 48-hr turn-arounds for inspection results may require artificial intelligence, machine learning, or similar techniques. Applicants must specify how they will meet the turn-around requirement. In addition, the Applicants must be able to demonstrate that the testing tools can detect flaws consistent with damage tolerance analysis. We anticipate that Category 4 Awardees will be running tests on lab-scale samples generated from performance tests in Category 2 to define minimum flaw detection limits for the integrity test methods.

Category 5. Integrated 4Coating, Deposition tool, and Integrity/inspection tool Pipe Tests

Commercial success requires system integrators to develop "turnkey" offerings for gas utilities. Category 5 Applicants must demonstrate that their proposed system integrates the components described in Categories 2-4. These components may be developed outside of the REPAIR program. ARPA-E will assess the success of REPAIR based on the performance of integrated systems against the tests approved by the TTSP in Category 1.2, and conducted in Category 1.3. Category 5 Awardees will be responsible for selecting and integrating their system components. The final Category 5 tests will be run on a 10- to 20-inch diameter segment of field pipe removed from service. Awardees will demonstrate pre-coating inspection, coating deposition, and post-coating inspection to verify coating integrity. Each Category 5 Applicant will budget for testing of two sets of pipe samples, which can be duplicates or represent different conditions. If the coating does not pass the post-coating inspection, Awardees can budget to recoat the segment of pipe or repeat the process on a different segment of pipe. Pipe sample(s) will be submitted for testing per Category 1.3. System integrators will be responsible for post-testing analysis and disposal of all samples.

Category 6. Pipeline mapping, coating/integrity/leak detection data integration, and data management/visualization

The objective of Category 6 is to create 3D maps of the rehabilitated gas mains, pipeline components, and adjacent underground infrastructure. These maps will also incorporate data from leak reports, integrity/inspection tools, and coating deposition tools. These 3D maps support REPAIR efforts and utility O&M work. Objectives include:

- Location coordinates for the pipeline main targeted for rehabilitation, and other pipeline components connected to the main such as laterals, service lines, and elbows, to an accuracy of 10 cm in each of the X, Y, and Z coordinates and at a depth of up to 3 meters. Also locate valves, reducers, or foreign objects that may impede rehabilitation tools. 3D maps of these features will support pipeline replacement planning. Accurate 3D maps can also be incorporated into "Call-811 before-you dig" programs and support efforts to minimize third party damage.
- Location coordinates for other adjacent underground infrastructure, such as water, sewer, and electrical conduits within 60 cm of main, to an accuracy of 10 cm in each of the X, Y, and Z coordinates and at a depth of up to 3 meters. Locating adjacent infrastructure will facilitate planning to access mains and replace other pipeline components, as required.
- Incorporate locations for leaks, anomalies, and integrity/inspection results so utilities can prioritize mains targeted for REPAIR technologies. The data will also allow utilities to visualize changes in pipeline integrity with time, and support predictive maintenance programs.
- Provide location records for material traceability and structural coating QA/QC data so utilities can take proper action in the future if problems emerge with the coating materials or process.

Applicants can propose in-pipe or surface-based pipe mapping technologies, or a combination of technologies. ARPA-E will work with the TTSP to identify suitable locations for testing pipe mapping tools. Options include test loops and field tests with well-characterized sites.

Category 6.1 In-pipe mapping

Pipe mapping LIDAR, combined with inertial navigation system, is used extensively on the surface to create detailed 3-D maps of infrastructure. Several teams in the DARPA Subterranean (SubT) project have proposed to incorporate LIDAR with crawlers to map underground structures such as caves and tunnels.[26] LIDAR will give accurate measurements for the mains and other pipeline components. However, it will not detect adjacent underground infrastructure.

Ideally in-pipe mapping tools would be deployed on the coating tool and/or inspection tool from Categories 3 and 4. If a separate tool will be used to carry the mapping tool, Applicants must provide the target operating ranges for their in-pipe mapping tools. Parameters include the linear speed of the tool in a straight pipe and expected maximum travel distance between access points for a straight pipe. Applicants also need to specify excavation and pipe tapping requirements, and whether tapping and operations can be conducted on live pipes. Ideally the

[26] https://www.darpa.mil/program/darpa-subterranean-challenge

integrity/inspection tool will use the same access points as the coating deposition tools and integrity/inspection tools.

Applicants must specify if the in-pipe mapping tool needs to be tethered for power and communications, and address drag forces. Applicants must also describe how they will retrieve a non-responsive tool from a gas pipe.

ARPA-E prefers mapping tools that minimize impacts on gas pipeline operations. However, if technology requires disruption applicants must quantify the number and duration of disruptions to gas service. Examples include downtime for excavating access points; tapping pipes; cleaning pipes prior to inspection; inserting and removing the integrity/inspection tool; and operating the tool. Applicants must estimate the projected cross-sectional area of their tool, and assess whether it will impair gas delivery.

Category 6.2 Surface mapping

Several underground technologies have been investigated by the gas industry to detect adjacent infrastructure, primarily to locate pipes and prevent cross-bores.[27] Examples include:

- Electromagnetic induction, developed by DOD for detecting buried unexploded ordinance and improvised explosive devices. Electromagnetic induction technology has the potential to be able to determine pipe size, material of construction, and detect general corrosion. This technique only works on metal-containing objects.[28]
- Large Standoff Magnetometry (LSM), mentioned in Category 4. Capable of providing 3D maps as well as stress measurements. This technique only works on metal-containing objects.[29]
- Ground penetrating radar, which can detect metallic and non-metallic subsurface objects. The EU ORFEUS project highlights recent advances.[30] Tools are commercially available, but with limitations related to pavement/asphalt cover, soil type, and sensitivity to detecting pipes parallel vs crossing the plane of inspection. Varying the frequency can change sensitivity, but typically with a trade-off on detection depth.

Applicants must provide the target operating ranges for their surface mapping tools. Parameters include the linear speed of the tool in a straight line and per-pass detection width. Applicants should address ability to detect metallic and non-metallic objects, sensitivity to object orientation, and interferences from surface materials such as asphalt and concrete.

[27] New Technologies Build on Current Success for Utility Location and Cross Bore Elimination, http://crossboresafety.org/documents/New%20Technologies%20Build%20on%20Current%20Success%20for%20Utility%20Location%20and%20Cross%20Bore%20Elimination%20-%20Mark%20Wallbom%20May%202010.pdf

[28] Review of Magnetic Modeling for UXO and Applications to Small Items and Close Distances, JEEG, June 2012, Volume 17, Issue 2, pp. 53–73

[29] Jarram, P. (2016, June 14). NACE Corrosion 2016 - Final Paper - Remote Measurement of Stress in Carbon Steel Pipelines – Developments in Remote Magnetic Monitoring. NACE International.

[30] http://www.orfeus-project.eu/publications/deliverable_D15.pdf

Category 6.3 Coating/integrity/leak detection data integration, and data management/visualization

Gas utilities use GIS-enabled enterprise systems for tracking pipeline locations and attributes. REPAIR processes (e.g. inspections, coating, and mapping) will generate large data sets that need to be compatible with GIS-enabled enterprise systems used by gas utilities. Given the large data sets, real-time data visualization will be required to support real-time decisions in the field as mapping, coating, and inspection processes are underway. The goal of this category is to create a unified data management tool that can integrate all REPAIR information into the 3D pipeline maps, and provide an interface that allows users to manage and visualize the data in real time.

E. PRELIMINARY MILESTONES AND TECHNICAL REQUIREMENTS BY CATEGORY

Category 1.1 Define failure modes and establish the performance criteria for "pipe in pipe" with cast iron and bare steel pipes

- Provide a comprehensive list of failure mechanisms relevant to coated "pipe in pipe" operations for gas distribution to ARPA-E and the TTSP within the first 3 months of the program.
- Quarterly updates on failure mechanisms, as required

Category 1.2 Modelling failure modes, identification of critical physical properties, and development of test methods

- Initial screening models for each failure mechanism within the first 6 months of the program, and fundamental models (material and interaction models) for each failure mechanism within the first 12 months of the program
- Initial ranges for mechanical properties within the first 6 months. Quarterly updates on coating mechanical properties, based on advances in models and testing.
- Test protocols consistent with requirements to achieve ultimate approval by ASTM F17 or similar codes and standards organization.
- Test hardware functioning within the first 6 months, and all testing hardware calibrated using known materials within the first 12 months.

Category 1.3 Pipe testing and correlations for failure mechanisms for samples from Category 5

- Complete all tests within the allotted time, budget, and quality metrics
- Quarterly updates for model updates, test modification, and correlations

Categories 2-4 System Component Development

Components will be assessed no later than the 12, 18, and 24 month periods:

- By 12 months: Prototype proof of concept on a flat surface or pipe segment.
- By 18 months: Sequential testing of coating material, coating deposition, and integrity/inspection technique on a flat surface or pipe segment.
- By 24 month test: Sequential testing of coating, coating deposition tool, and integrity/inspection tool in a lab-based test in a pipe segment. Verify performance using Category 1 test methods at the lab scale.

ARPA-E anticipates that coating materials, coating deposition tools, and integrity/inspection techniques will perform best when developed as an integrated system. Awardees with integrated systems must still meet ARPA-E's expectations for each component technology in order to advance to Category 5. Consequently milestones for these Categories are linked, as shown in the following table. ARPA-E will review progress on component technology development as part of the 12, 18, and 24 month milestones. Depending on progress, ARPA-E may recommend incorporating "stand-alone" technologies for Applicants with integrated systems seeking to move to Category 5 testing. The "stand-alone" technologies may complement the team's components, or provide a substitute if a particular component is lagging.

Applicants may propose to work outside an integrated system team on Categories 2, 3 or 4. ARPA-E will work with Applicants to modify the 12, 18, and 24 month tests as required for "stand-alone" development efforts. However, the technologies for these proposals will not be permitted to move into Category 5 unless they are incorporated into an integrated system.

Category 5 Integrated System Testing

ARPA-E will collaborate with gas utilities to provide appropriate pipe samples from the field for Category 5 Awardees for the following test:

- By month 32 test: Integrated Performance testing of coating, deposition tool, and integrity/inspection tool(s) using the methods and equipment of Categories 1.2 and 1.3. The performance test will include the coating material, the coating deposition tool, and the integrity/inspection tool chosen for that material. The coating must pass the criteria set by the integrity/inspection tool, and meet the performance specifications as determined by tests from Category 1. For testing, the costs for coating material, deposition tool, and integrity/inspection tool must be consistent with a deployed cost of $500k to $1 million per mile, including gas service disruption costs.

Table 1: Milestones for Categories 2 - 6

Category	By 12 month Bench testing	By 18 month Bench testing	By 24 month Lab-based pipe test	By 32 month Performance testing in a field pipe
2. Coating Materials	Down-select candidate coating materials that meet mechanical requirements per Category 1 modelling	Performance tests and post-mortem testing to support minimum flaw detection criteria	REQUIRED	per Category 5
3. Deposition tool	Operate tool at the target linear speed with simulated drag forces. Not necessary to have a functioning coating device	Operate tool with required thickness using material from Category 2, and record location, coating operating parameters, and materials	REQUIRED	per Category 5
4. Integrity/ Inspection tool	Meet section 4.1 criteria, except 48 hour data analysis.	Meet section 4.1 criteria, except 48 hour data analysis. Measure thickness and detect cracks, delaminations, shrinkage cavities, pores, and debonding	REQUIRED	per Category 5
5. Integrated Category 2, 3, 4 Pipe Test	NONE	NONE	Preliminary identification of all system components and positive pipe test results in lab environment	Pass Category 1.3 tests in a 10- to 20-inch diameter field pipe removed from service
6. Mapping tools and data integration	NONE	Meet section 6 criteria for 3-D map of pipes in a lab or simulated environment	Meet section 6 criteria for 3-D map of pipes, other pipeline components, and adjacent infrastructure in a test loop or well-characterized field site	Demonstrate real-time 3D maps that incorporate data from integrity/inspection tool and coating deposition tool used in Category 5

II. AWARD INFORMATION

A. AWARD OVERVIEW

ARPA-E expects to make approximately $38.5 million available for new awards under this FOA, subject to the availability of appropriated funds. Under this FOA, ARPA-E anticipates making approximately up to four awards for Category 1, up to four awards for each of Categories 2-4 for Applicants that are not part of a Category 5 application, up to five awards for Category 5, and up to four Category 6 awards. ARPA-E may, at its discretion, issue one, multiple, or no awards.

Individual awards may vary between $250,000 and $10 million.

The period of performance for funding agreements may not exceed 36 months. ARPA-E expects the start date for funding agreements to be ~~October~~ November 2020, 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.

Submissions 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, submissions requiring proof-of-concept R&D can propose a project with the project end deliverable being an extremely creative, but partial solution. However, the 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 should 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 your negotiated budget at the time of award.

B. RENEWAL AWARDS

At ARPA-E's sole discretion, awards resulting from this FOA may be renewed by adding one or more budget periods, extending the period of performance of the initial award, or issuing new award. Renewal funding is contingent on: (1) availability of funds appropriated by Congress for the purpose of this program; (2) substantial progress towards meeting the objectives of the approved application; (3) submittal of required reports; (4) compliance with the terms and conditions of the award; (5) ARPA-E approval of a renewal application; and (6) other factors identified by the Agency at the time it solicits a renewal application.

C. ARPA-E FUNDING AGREEMENTS

Through cooperative agreements, other transactions, 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."[31] Accordingly, ARPA-E has substantial involvement in the direction of every Cooperative Agreement, as described in Section II.C below.

1. COOPERATIVE AGREEMENTS

ARPA-E generally uses Cooperative Agreements to provide financial and other support to Prime Recipients.[32]

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

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

[32] The Prime Recipient is the signatory to the funding agreement with ARPA-E.

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 similar terms and conditions as ARPA-E's Model Cooperative Agreement (https://arpa-e.energy.gov/?q=site-page/funding-agreements).

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. OTHER TRANSACTIONS AUTHORITY

ARPA-E may use its "other transactions" authority under the America COMPETES Reauthorization Act of 2010 to enter into an other transaction agreement with Prime Recipients, on a case-by-case basis.

ARPA-E may negotiate an other transaction agreement when it determines that the use of a standard cooperative agreement, grant, or contract is not feasible or appropriate for a project.

In general, an other transaction agreement would require a cost share of 50%. See Section III.B.2 of the FOA.

D. 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:

- Project Teams 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.
- ARPA-E may, at its sole discretion, modify or terminate projects that fail to achieve predetermined Go/No Go decision points or technical milestones and deliverables.
- 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[33] 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.

[33] The term "nonprofit organization" or "nonprofit" is defined in Section IX.

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,[34] as the lead for a Project Team,[35] 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,[36] and nonprofits[37] 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.

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

Foreign entities, whether for-profit or otherwise, are eligible to apply for funding as Standalone Applicants, as the lead organization for a Project Team, or as a member of a Project Team.

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

[35] A Project Team consists of the Prime Recipient, Subrecipients, and others performing any of the research and development work under an ARPA-E funding agreement, whether or not costs of performing the research and development work are being reimbursed under any agreement.

[36] The term "Institutions of Higher Education" or "educational institution" is defined in Section IX.

[37] 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.

Foreign entities must designate in the Full Application a subsidiary or affiliate incorporated (or otherwise formed or to be formed) under the laws of a State or territory of the United States to receive funding. The Full Application must state the nature of the corporate relationship between the foreign entity and domestic subsidiary or affiliate. All work under the ARPA-E award must be performed in the United States. 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/. 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[38]

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

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

1. BASE COST SHARE REQUIREMENT

ARPA-E generally uses Cooperative Agreements to provide financial and other support to Prime Recipients (see Section II.C.1 of the FOA). Under a Cooperative Agreement or Grant, the Prime Recipient must provide at least 20% of the Total Project Cost[39] as cost share, except as provided in Sections III.C.2 or III.C.3 below.[40]

2. INCREASED COST SHARE REQUIREMENT

Large businesses[41] 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 an "other transaction" agreement, the Prime Recipient must provide at least 50% of the Total Project Cost as cost share. ARPA-E may reduce this cost share requirement, as appropriate.

3. REDUCED COST SHARE REQUIREMENT

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

- A domestic educational institution or domestic nonprofit applying as a Standalone Applicant is not required to provide cost share.
- Project Teams composed exclusively of domestic educational institutions, domestic nonprofits, and/or FFRDCs/DOE Labs/Federal agencies and instrumentalities (other than DOE) are not required to provide cost share.
- Small businesses – or consortia of small businesses – may provide 0% cost share from the outset of the project through the first 12 months of the project (hereinafter the "Cost Share Grace Period").[42] If the project is continued beyond the Cost Share 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% of the total work under the funding agreement (as measured by the Total Project Cost) are entitled to the same cost

[39] 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.
[40] Energy Policy Act of 2005, Pub.L. 109-58, sec. 988(c)
[41] The term "For-Profit Organizations (Other than Small Businesses)" or "large business" is defined in Section IX.
[42] The term "small business" is defined in Section IX.

share reduction and Cost Share Grace Period as provided above to Standalone small businesses or consortia of small businesses.

- 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 base 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, or ensuring payment of 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

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.F 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[43] to meet their cost share obligations under Cooperative Agreements. However, Project Teams may use IR&D funds to meet their cost share obligations under "other transaction" 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.

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.

[43] As defined in Federal Acquisition Regulation 31.205-18.

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

Full Applications are deemed compliant if:

- 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.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.

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.D 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 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 currently issued ARPA-E FOAs.
- Submissions that are not scientifically distinct from applications submitted in response to 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 distinct in scientific approach or objective from activities currently supported by or actively under consideration for funding by any other office within Department of Energy.
- Submissions that are not distinct in scientific approach or objective from activities currently supported by or actively under consideration for funding by other government agencies or the private sector.
- Submissions that 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:

- Applications that propose the following:
    - Development of components (coatings, coating tools, inspection tools, etc.) without addressing how these will be integrated into an operating system
    - Approaches that require extensive excavation, or require pipe access for straight runs at intervals less than 200 m apart

- Approaches that use non-structural coatings; e.g. a coating that relies on the external pipe to meet the 50 year life requirement
- Approaches that address leaks, but do not create a new pipe with a 50 year life
- Approaches that require extensive downtime (e.g. more than 8 days for 500 m segment) for gas pipes, for example for cleaning, coating deposition, curing, etc.

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.

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.G.1 of the FOA and the "ARPA-E eXCHANGE User Guide" (https://arpa-e-foa.energy.gov/Manuals.aspx).

2. FULL APPLICATIONS

Applicants must submit a Full Application by the deadline stated in the FOA. Section IV.C 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.

3. 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.

4. 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.

5. 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.1 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.

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 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, the template for the U.S. Manufacturing Plan, 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 FULL APPLICATIONS

Full Applications must conform to the following formatting requirements:

- Each document must be submitted in the file format prescribed below.
- The Full Application 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.

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

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

Fillable Full Application template documents are available on ARPA-E eXCHANGE at https://arpa-e-foa.energy.gov.

Full Applications must conform to the content requirements described below.

Component	Required Format	Description and Information
Technical Volume	PDF	The centerpiece of the Full Application. Provides a detailed description of the proposed R&D project and Project Team.
SF-424	PDF	Application for Federal Assistance. Applicants are responsible for ensuring that the proposed costs listed in eXCHANGE match those listed on forms SF-424 and SF-424A. Inconsistent submissions may impact ARPA-E's final award determination.
Budget Justification Workbook/SF-424A	XLS	Budget Information – Non-Construction Programs
Summary for Public Release	PDF	Short summary of the proposed R&D project. Intended for public release.
Summary Slide	PPT	A four-panel project slide summarizing different aspects of the proposed R&D project.
Business Assurances & Disclosures Form	PDF	Requires the Applicant to make responsibility disclosures and disclose potential conflicts of interest within the Project Team. Requires the Applicant to describe the additionality and risks associated with the proposed project, disclose applications for funding currently pending with Federal and non-Federal entities, and disclose funding from Federal and non-Federal entities for work in the same technology area as the proposed R&D project. If the Applicant is a FFRDC/DOE Lab, requires the Applicant to provide written authorization from the cognizant Federal agency and, if a DOE/NNSA FFRDC/DOE Lab, a Field Work Proposal. Allows the Applicant to request a waiver or modification of the Performance of Work in the United States requirement and/or the Technology Transfer &

		Outreach (TT&O) spending requirement. A sample response to the Business Assurances & Disclosures Form is also available on ARPA-E eXCHANGE.
U.S. Manufacturing Plan	PDF	As part of the application, Applicants are required to submit a U.S. Manufacturing Plan. The U.S. Manufacturing Plan represents the Applicant's measurable commitment to support U.S. manufacturing as a result of its award.
Preliminary Economic Model	XLS	The Preliminary Economic Model is intended to provide guidance on the $500k to $1 million per mile cost metric. This example assumes no disruption of gas service. ARPA-E will collaborate with utility representatives to provide guidance on gas disruption costs.

ARPA-E provides detailed guidance on the content and form of each component below.

1. FIRST COMPONENT: TECHNICAL VOLUME

The Technical Volume must be submitted in Adobe PDF format. A Technical Volume template is available at https://arpa-e-foa.energy.gov. The Technical Volume must conform to the content and form requirements included within the template, including maximum page lengths. If Applicants exceed the maximum page lengths, ARPA-E will review only the authorized number of pages and disregard any additional pages.

Applicants must provide sufficient citations and references to the primary research literature to justify the claims and approaches made in the Technical Volume. ARPA-E and reviewers may review primary research literature in order to evaluate applications. However, ARPA-E and reviewers are under no obligation to review cited sources (e.g., Internet websites).

2. SECOND COMPONENT: SF-424

The SF-424 must be submitted in Adobe PDF format. This form is available on ARPA-E eXCHANGE at https://arpa-e-foa.energy.gov.

The SF-424 includes instructions for completing the form. Applicants are required to complete all required fields in accordance with the instructions.

Prime Recipients and Subrecipients are required to complete SF-LLL (Disclosure of Lobbying Activities), available at https://www.grants.gov/forms/post-award-reporting-forms.html, if any non-Federal funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any Federal agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with your application or funding agreement. The completed SF-LLL must be appended to the SF-424.

ARPA-E provides the following supplemental guidance on completing the SF-424:

- Each Project Team should submit only one SF-424 (i.e., a Subrecipient should not submit a separate SF-424).
- The list of certifications and assurances in Block 21 can be found at http://energy.gov/management/downloads/certifications-and-assurances-use-sf-424.
- The dates and dollar amounts on the SF-424 are for the entire period of performance (from the project start date to the project end date), not a portion thereof.
- Applicants are responsible for ensuring that the proposed costs listed in eXCHANGE match those listed on forms SF-424 and SF-424A. Inconsistent submissions may impact ARPA-E's final award determination.

3. THIRD COMPONENT: BUDGET JUSTIFICATION WORKBOOK/SF-424A

Applicants are required to complete the Budget Justification Workbook/SF-424A Excel spreadsheet. This form is available on ARPA-E eXCHANGE at https://arpa-e-foa.energy.gov. Prime Recipients must complete each tab of the Budget Justification Workbook for the project as a whole, including all work to be performed by the Prime Recipient and its Subrecipients and Contractors. The SF-424A form included with the Budget Justification Workbook will "auto-populate" as the Applicant enters information into the Workbook. Applicants should carefully read the "Instructions and Summary" tab provided within the Budget Justification Workbook. Subrecipient information must be submitted as follows:

- Each Subrecipient incurring greater than or equal to 10% of the Total Project Cost must complete a separate Budget Justification workbook to justify its proposed budget. These worksheets must be inserted as additional sheets within in the Prime Recipient's Budget Justification.
- Subrecipients incurring less than 10% of the Total Project Cost are not required to complete a separate Budget Justification workbook. However, such Subrecipients are required to provide supporting documentation to justify their proposed budgets. At a minimum, the supporting documentation must show which tasks/subtasks are being performed, the purpose/need for the effort, and a sufficient basis for the estimated costs.

ARPA-E provides the following supplemental guidance on completing the Budget Justification Workbook/SF-424A:

- Applicants may request funds under the appropriate object class category tabs as long as the item and amount requested are necessary to perform the proposed work, meet all the criteria for allowability under the applicable Federal cost principles, and are not prohibited by the funding restrictions described herein.
- If Patent costs are requested, they must be included in the Applicant's proposed budget (see Section IV.F.3 of the FOA for more information on Patent Costs).

- Unless a waiver is granted by ARPA-E, each Project Team must spend at least 5% of the Federal funding (i.e., the portion of the award that does not include the recipient's cost share) on Technology Transfer & Outreach (TT&O) activities to promote and further the development and deployment of ARPA-E-funded technologies.
- All TT&O costs requested must be included in the Applicant's proposed budget and identified as TT&O costs in the Budget Justification Workbook/SF-424A with the costs being requested under the "Other" budget category. All budgeted activities must relate to achieving specific objectives, technical milestones and deliverables outlined in Section 2.4 Task Descriptions of the Technical Volume.
- For more information, please refer to the ARPA-E Budget Justification Guidance document at https://arpa-e-foa.energy.gov.

4. FOURTH COMPONENT: SUMMARY FOR PUBLIC RELEASE

Applicants are required to provide a 250 word maximum Summary for Public Release. A Summary for Public Release template is available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov). The Summary for Public Release must be submitted in Adobe PDF format. This summary should not include any confidential, proprietary, or privileged information. The summary should be written for a lay audience (e.g., general public, media, Congress) using plain English.

250 Words	**SUMMARY FOR PUBLIC RELEASE**	Briefly describe the proposed effort, summarize its objective(s) and technical approach, describe its ability to achieve the "Program Objectives" (see Section I.C of the FOA), and indicate its potential impact on "ARPA-E Mission Areas" (see Section I.A of the FOA). The summary should be written at technical level suitable for a high-school science student and is designed for public release. **INSTRUCTIONS:** (1) The Summary for Public Release shall not exceed 250 words and one paragraph. (2) The Summary for Public Release shall consist only of text—no graphics, figures, or tables. (3) For applications selected for award negotiations, the Summary may be used as the basis for a public announcement by ARPA-E; therefore, **this Cover Page and Summary should not contain confidential or proprietary information**. See Section VIII.I of the FOA for additional information on marking confidential information

5. FIFTH COMPONENT: SUMMARY SLIDE

Applicants are required to provide a single PowerPoint slide summarizing the proposed project. The slide must be submitted in Microsoft PowerPoint format. This slide will be used during ARPA-E's evaluation of Full Applications. A summary slide template and a sample summary slide are available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov).

Summary Slides must conform to the content requirements described below:

- A Technology Summary;
  - Bullet points that describe novel aspects of the proposed technology and technology approach;
- A description of the technology's impact;
  - Quantitative description (through text or graphic) of the impact the proposed project will provide to the market and ARPA-E mission areas;
- Proposed Targets;
  - Including any important technical performance metrics and/or impact categories;
  - Including quantitative description of the state of the art;
  - Including quantitative descriptions of the proposed targets;
- Any key graphics (illustrations, charts and/or tables) summarizing technology development and/or impact;
- The project's key idea/takeaway;
- Project title and Principal Investigator information; and
- Requested ARPA-E funds and proposed Applicant cost share.

6. SIXTH COMPONENT: BUSINESS ASSURANCES & DISCLOSURES FORM

Applicants are required to provide the information requested in the Business Assurances & Disclosures Form. The information must be submitted in Adobe PDF format. A fillable Business Assurances & Disclosures Form template is available on ARPA-E eXCHANGE at https://arpa-e-foa.energy.gov. A sample response to the Business Assurances & Disclosures Form is also available on ARPA-E eXCHANGE.

As described in the Business Assurances & Disclosures Form, the Applicant is required to:

- Disclose conditions bearing on responsibility, such as criminal convictions and Federal tax liability;
- Disclose potential conflicts of interest within the Project Team;
- If the Applicant is a FFRDC/DOE Lab, submit written authorization from the cognizant Federal agency; and
- If the Applicant is a DOE/NNSA FFRDC/DOE Lab, submit a Field Work Proposal.

In addition, ARPA-E is required by statute to "accelerat[e] transformational technological advances in areas that industry is by itself not likely to undertake because of technical and financial uncertainty."[44] In accordance with ARPA-E's statutory mandate, the Applicant is required to:

[44] America COMPETES Act, Pub. L. No. 110-69, § 5012 (2007), as amended (codified at 42 U.S.C. § 16538).

- Describe the additionality and risks associated with the proposed R&D project;
- Disclose any applications for the same project or related work currently pending with any Federal or non-Federal entities; and
- Disclose all funding for work in the same technology area as the proposed project received from any Federal or non-Federal entity within the last 5 years.

Finally, the Applicant may use the Business Assurances & Disclosures Form to:

- Request authorization to perform some work overseas; and
- Request a waiver of the TT&O spending requirement.

7. SEVENTH COMPONENT: U.S. MANUFACTURING PLAN

As part of the application, Applicants are required to submit a U.S. Manufacturing Plan that should not exceed one page in length. The U.S. Manufacturing Plan represents the Applicant's measurable commitment to support U.S. manufacturing as a result of its award. U.S. Manufacturing Plans are a Program Policy Factor during the review and selection process. See Section V.B.1 of the FOA. A U.S. Manufacturing Plan must contain a commitment to the U.S manufacturing requirements stated in Section VI.B.8 below.

In addition, the plan should include other specific and measurable commitments. For example, an Applicant may commit particular types of products to be manufactured in the U.S. These plans should not include requirements regarding the source of inputs used during the manufacturing process. In addition to or instead of making a commitment tied to a particular product, the Applicant may make other types of commitments still beneficial to U.S. manufacturing. An Applicant may commit to a particular investment in a new or existing U.S. manufacturing facility, keep certain activities based in the U.S. (i.e., final assembly), or support a certain number of jobs in the U.S. related to the technology and manufacturing.

When an Applicant is selected for an award, the U.S. Manufacturing Plan submitted by the Applicant will become part of the terms and conditions of the award. It is important to note that the U.S. Manufacturing Plan is in support of and not a replacement for the U.S. Manufacturing Requirement described in Section VI.B.8. The Applicant/Awardee may request a waiver or modification of the U.S. Manufacturing Plan from DOE/ARPA-E upon a showing that the original U.S. Manufacturing Plan is no longer economically feasible.

Class patent waivers usually apply to domestic large businesses as set forth in Section VIII.A of the FOA. Under this class patent waiver, domestic large businesses may elect title to their subject inventions similar to the right provided to the domestic small businesses, educational institutions, and nonprofits by law. In order to avail itself of the class patent waiver, a domestic large business must agree that any products embodying or produced through the use of an invention conceived or first actually reduced to practice under the award will be substantially manufactured in the United States, unless a waiver is granted by DOE/ARPA-E. The U.S.

Manufacturing Plan submitted by the Applicant will become part of the terms and conditions of the award in addition to the requirements attaching to subject inventions.

8. EIGHTH COMPONENT: PRELIMINARY ECONOMIC MODEL

Required only for Applicants to Categories 2-6. The Preliminary Economic Model is intended to provide guidance on the $500k - $1 million per mile cost metric. Applicants are required to provide the information set forth in the Excel template available at https://arpa-e-foa.energy.gov. The information requested therein may be provided in a form of the Applicant's choosing. ARPA-E has prepared the aforementioned Excel template for the Applicants' convenience and encourages its use. The Model's input values are for example only. This example assumes no disruption of gas service. ARPA-E will collaborate with utility representatives to provide guidance on gas disruption costs.

D. CONTENT AND FORM OF REPLIES TO REVIEWER COMMENTS

Written feedback on Full Applications is made available to Applicants before the submission deadline for Replies to Reviewer Comments. Applicants have a brief opportunity to prepare a short Reply to Reviewer Comments responding to one or more comments or supplementing their Full Application. A fillable Reply to Reviewer Comments template is available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov).

Replies to Reviewer Comments must conform to the following requirements:

- The Reply to Reviewer Comments must be submitted in Adobe PDF format.
- The Reply to Reviewer Comments 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. Use Times New Roman typeface, a black font color, and a font size of 12 points or larger (except in figures and tables).
- The Control Number must be prominently displayed on the upper right corner of the header of every page. Page numbers must be included in the footer of every page.

ARPA-E may not review or consider noncompliant Replies to Reviewer Comments (see Section III.C.1 of the FOA). 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.

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

SECTION	PAGE LIMIT	DESCRIPTION
Text	2 pages maximum	• Applicants may respond to one or more reviewer comments or supplement their Full Application.
Images	1 page maximum	• Applicants may provide graphs, charts, or other data to respond to reviewer comments or supplement their Full Application.

E. INTERGOVERNMENTAL REVIEW

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

F. FUNDING RESTRICTIONS

1. ALLOWABLE COSTS

All expenditures must be allowable, allocable, and reasonable in accordance with the applicable Federal cost principles. Pursuant to 2 C.F.R. § 910.352, the cost principles in the Federal Acquisition Regulations (48 C.F.R. Part 31.2) apply to for-profit entities. The cost principles contained in 2 C.F.R. Part 200, Subpart E apply to all entities other than for-profits.

2. PRE-AWARD COSTS

ARPA-E will not reimburse any pre-award costs incurred by Applicants before they are selected for award negotiations. Please refer to Section VI.A of the FOA for guidance on award notices.

Upon selection for award negotiations, Applicants may incur pre-award costs at their own risk, consistent with the requirements in 2 C.F.R. Part 200, as modified by 2 C.F.R. Part 910, and other Federal laws and regulations. ARPA-E generally does not accept budgets as submitted with the Full Application. Budgets are typically reworked during award negotiations. ARPA-E is under no obligation to reimburse pre-award costs if, for any reason, the Applicant does not receive an award or the award is made for a lesser amount than the Applicant expected, or if the costs incurred are not allowable, allocable, or reasonable.

3. PATENT COSTS

For Subject Inventions disclosed to DOE under an award, ARPA-E will reimburse the Prime Recipient – in addition to allowable costs associated with Subject Invention disclosures - up to $30,000 of expenditures for filing and prosecution of United States patent applications, including international applications ("PCT application") submitted to the United States Patent and Trademark Office (USPTO).

The Prime Recipient may request a waiver of the $30,000 cap. Because all patent costs are considered to be Technology Transfer & Outreach (TT&O) costs (see Section IV.F.8 of the FOA below), the waiver request is subject to approval by ARPA-E.

4. CONSTRUCTION

ARPA-E generally does not fund projects that involve major construction. Recipients are required to obtain written authorization from the Contracting Officer before incurring any major construction costs.

5. FOREIGN TRAVEL

ARPA-E generally does not fund projects that involve foreign travel. Recipients are required to obtain written authorization from the ARPA-E Program Director before incurring any foreign travel costs and provide trip reports with their reimbursement requests.

6. PERFORMANCE OF WORK IN THE UNITED STATES

ARPA-E strongly encourages interdisciplinary and cross-sectoral collaboration spanning organizational boundaries. Such collaboration enables the achievement of scientific and technological outcomes that were previously viewed as extremely difficult, if not impossible.

ARPA-E requires all work under ARPA-E funding agreements to be performed in the United States – i.e., Prime Recipients must expend 100% of the Total Project Cost in the United States. However, Applicants may request a waiver of this requirement where their project would materially benefit from, or otherwise requires, certain work to be performed overseas.

Applicants seeking a waiver of this requirement are required to include an explicit request in the Business Assurances & Disclosures Form, which is part of the Full Application submitted to ARPA-E. Such waivers are granted where there is a demonstrated need, as determined by ARPA-E.

7. PURCHASE OF NEW EQUIPMENT

All equipment purchased under ARPA-E funding agreements must be made or manufactured in the United States, to the maximum extent practicable. This requirement does not apply to used or leased equipment. The Prime Recipients are required to notify the ARPA-E Contracting Officer reasonably in advance of purchasing any equipment that is not made or manufactured in the United States with a total acquisition cost of $250,000 or more. The ARPA-E Contracting Officer will provide consent to purchase or reject within 30 calendar days of receipt of the Recipient's notification.

8. TECHNOLOGY TRANSFER AND OUTREACH

ARPA-E is required to contribute a percentage of appropriated funds to Technology Transfer and Outreach (TT&O) activities. In order to meet this mandate every Project Team must spend at least 5% of the Federal funding (i.e., the portion of the award that does not include the recipient's cost share) provided by ARPA-E on TT&O activities to promote and further the development and deployment of ARPA-E-funded technologies. Project Teams must also seek a waiver from ARPA-E to spend less than the minimum 5% TT&O expenditure requirement.

All TT&O expenditures are subject to the applicable Federal cost principles (i.e., 2 C.F.R. 200 Subpart E and 48 C.F.R. Subpart 31). Examples of TT&O expenditures are as follows:

- Documented travel and registration for the ARPA-E Energy Innovation Summit and other energy-related conferences and events;
- Documented travel to meet with potential suppliers, partners, or customers;
- Documented work by salaried or contract personnel to develop technology-to-market models or plans;
- Documented costs of acquiring industry-accepted market research reports; and
- Approved patent costs.

ARPA-E will not reimburse recipients for TT&O costs considered to be unallowable in accordance with the applicable cost principles. Examples of unallowable TT&O expenditures include:

- Meals or entertainment;
- Gifts to potential suppliers, partners, or customers;
- TT&O activities that do not relate to the ARPA-E-funded technologies;
- Undocumented TT&O activities; and
- TT&O activities unrelated and/or unallocable to the subject award.

Applicants may seek a waiver of the TT&O requirement by including an explicit request in the Business Assurances & Disclosures Form. Please refer to the Business Assurances & Disclosures Form for guidance on the content and form of the waiver request. ARPA-E may waive or modify the TT&O requirement, as appropriate.

For information regarding incorporation of TT&O costs into budget documentation, see Section IV.C.3 of the FOA.

9. LOBBYING

Prime Recipients and Subrecipients may not use any Federal funds, directly or indirectly, to influence or attempt to influence, directly or indirectly, congressional action on any legislative or appropriation matters pending before Congress, other than to communicate to Members of

Congress as described in 18 U.S.C. § 1913. This restriction is in addition to those prescribed elsewhere in statute and regulation.

Prime Recipients and Subrecipients are required to complete and submit SF-LLL, "Disclosure of Lobbying Activities" (http://www.whitehouse.gov/sites/default/files/omb/grants/sflllin.pdf) if any non-Federal funds have been paid or will be paid to any person for influencing or attempting to influence any of the following in connection with your application:

- An officer or employee of any Federal agency,
- A Member of Congress,
- An officer or employee of Congress, or
- An employee of a Member of Congress.

10. CONFERENCE SPENDING

Prime Recipients and Subrecipients may not use any Federal funds to:

- Defray the cost to the United States Government of a conference held by any Executive branch department, agency, board, commission, or office which is not directly and programmatically related to the purpose for which their ARPA-E award is made and for which the cost to the United States Government is more than $20,000; or
- To circumvent the required notification by the head of any such Executive Branch department, agency, board, commission, or office to the Inspector General (or senior ethics official for any entity without an Inspector General), of the date, location, and number of employees attending such a conference.

11. INDEPENDENT RESEARCH AND DEVELOPMENT COSTS

ARPA-E does not fund Independent Research and Development (IR&D) as part of an indirect cost rate under its financial assistance awards. IR&D, as defined at FAR 31.205-18(a), includes cost of effort that is not sponsored by an assistance agreement or required in performance of a contract, and that consists of projects falling within the four following areas: (i) basic research, (ii) applied research, (iii) development, and (iv) systems and other concept formulation studies.

ARPA-E's goals are to enhance the economic and energy security of the United States through the development of energy technologies and ensure that the United States maintains a technological lead in developing and deploying advanced energy technologies. ARPA-E accomplishes these goals by providing financial assistance for energy technology projects, and has well recognized and established procedures for supporting research through competitive financial assistance awards based on merit review of proposed projects. Reimbursement for independent research and development costs through the indirect cost mechanism could circumvent this competitive process.

To ensure that all projects receive similar and equal consideration, eligible organizations may compete for direct funding of independent research projects they consider worthy of support by submitting proposals for those projects to ARPA-E. Since proposals for these projects may be submitted for direct funding, costs for independent research and development projects are not allowable as indirect costs under ARPA-E awards. IR&D costs, however, would still be included in the direct cost base that is used to calculate the indirect rate so as to ensure an appropriate allocation of indirect costs to the organization's direct cost centers.

G. 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). 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 Applicant 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 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 may not review or consider incomplete applications and applications received after the deadline stated in the FOA. Such applications may 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 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 select a Full Application for award negotiations.

1. CRITERIA FOR FULL APPLICATIONS

Full Applications are evaluated based on the following criteria:

(1) *Impact of the Proposed Technology* (30%) - This criterion involves consideration of the following:

- The potential for a transformational and disruptive (not incremental) advancement in one or more energy-related fields;
- Thorough understanding of the current state-of-the-art and presentation of an innovative technical approach to significantly improve performance over the current state-of-the-art;
- Awareness of competing commercial and emerging technologies and identification of how the proposed concept/technology provides significant improvement over these other solutions; and
- A reasonable and effective strategy for transitioning the proposed technology from the laboratory to commercial deployment.

(2) *Overall Scientific and Technical Merit* (30%) - This criterion involves consideration of the following:

- Whether the proposed work is unique and innovative;
- Clearly defined project outcomes and final deliverables;
- Substantiation that the proposed project is likely to meet or exceed the technical performance targets identified in this FOA;
- Feasibility of the proposed work based upon preliminary data or other background information and sound scientific and engineering practices and principles;
- A sound technical approach, including appropriately defined technical tasks, to accomplish the proposed R&D objectives; and
- Management of risk, to include identifying major technical R&D risks and feasible, effective mitigation strategies.

(3) *Qualifications, Experience, and Capabilities of the Proposed Project Team* (30%) - This criterion involves consideration of the following**:**

- The PI and Project Team have the skill and expertise needed to successfully execute the project plan, evidenced by prior experience that demonstrates an ability to perform R&D of similar risk and complexity; and
- Access to the equipment and facilities necessary to accomplish the proposed R&D effort and/or a clear plan to obtain access to necessary equipment and facilities.

(4) *Soundness of Management Plan* (10%) - This criterion involves consideration of the following:

- Plausibility of plan to manage people and resources;
- Allocation of appropriate levels of effort and resources to proposed tasks;
- Reasonableness of the proposed project schedule, including major milestones; and
- Reasonableness of the proposed budget to accomplish 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	30%
Overall Scientific and Technical Merit	30%
Qualifications, Experience, and Capabilities of the Proposed Project Team	30%
Soundness of Management Plan	10%

2. CRITERIA FOR REPLIES TO REVIEWER COMMENTS

ARPA-E has not established separate criteria to evaluate Replies to Reviewer Comments. Instead, Replies to Reviewer Comments are evaluated as an extension of the Full Application.

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 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 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 U.S. 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.**

VII. **Qualified Opportunity Zone (QOZ).** Whether the entity is located in an urban and economically distressed area including a Qualified Opportunity Zone (QOZ) or the proposed project will occur in a QOZ or otherwise advance the goals of QOZ. The goals include spurring economic development and job creation in distressed communities throughout the United States. For a list or map of QOZs go to: https://www.cdfifund.gov/Pages/Opportunity-Zones.aspx.

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 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

ARPA-E expects to announce selections for negotiations in approximately July 2020 and to execute funding agreements in approximately ~~October~~ November 2020.

VI. AWARD ADMINISTRATION INFORMATION

A. AWARD NOTICES

1. REJECTED SUBMISSIONS

Noncompliant and nonresponsive 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 Full Application was rejected.

2. FULL APPLICATION NOTIFICATIONS

ARPA-E promptly notifies Applicants of its determination. ARPA-E 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 may inform the Applicant that its Full Application was selected for award negotiations, or not selected. Alternatively, ARPA-E may notify one or more Applicants that a final selection determination on particular Full Applications will be made at a later date, subject to the availability of funds and other factors.

Written feedback on Full Applications is made available to Applicants before the submission deadline for Replies to Reviewer Comments. By providing feedback, ARPA-E intends to guide the further development of the proposed technology and to provide a brief opportunity to respond to reviewer comments.

a. SUCCESSFUL APPLICANTS

ARPA-E has discretion to select all or part of a proposed project for negotiation of an award. A notification letter selecting a Full Application for award negotiations does not authorize the Applicant to commence performance of the project. **ARPA-E selects Full Applications for award negotiations, not for award.** Applicants do not receive an award until award negotiations are complete and the Contracting Officer executes the funding agreement. ARPA-E may terminate award negotiations at any time for any reason.

Please refer to Section IV.F.2 of the FOA for guidance on pre-award costs.

b. POSTPONED SELECTION DETERMINATIONS

A notification letter postponing a final selection determination until a later date does not authorize the Applicant to commence performance of the project. ARPA-E may ultimately determine to select or not select the Full Application for award negotiations.

Please refer to Section IV.F.2 of the FOA for guidance on pre-award costs.

c. UNSUCCESSFUL APPLICANTS

By not selecting 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. ARPA-E hopes that unsuccessful Applicants will submit innovative ideas and concepts for future FOAs.

B. ADMINISTRATIVE AND NATIONAL POLICY REQUIREMENTS

The following administrative and national policy requirements apply to Prime Recipients. The Prime Recipient is the responsible authority regarding the settlement and satisfaction of all contractual and administrative issues, including but not limited to disputes and claims arising out of any agreement between the Prime Recipient and a FFRDC contractor. Prime Recipients are required to flow down these requirements to their Subrecipients through subawards or related agreements.

1. DUNS NUMBER AND SAM, FSRS, AND FEDCONNECT REGISTRATIONS

Prime Recipients and Subrecipients are required to obtain a Dun and Bradstreet Data Universal Numbering System (DUNS) number at http://fedgov.dnb.com/webform and to register with the System for Award Management (SAM) at https://www.sam.gov/portal/public/SAM/.
Prime Recipients and Subrecipients should commence this process as soon as possible in order to expedite the execution of a funding agreement. Obtaining a DUNS number and registering with SAM could take several weeks.

Prime Recipients are also required to register with the Federal Funding Accountability and Transparency Act Subaward Reporting System (FSRS) at https://www.fsrs.gov/.[45] Prime Recipients are required to report to FSRS the names and total compensation of each of the Prime Recipient's five most highly compensated executives and the names and total compensation of each Subrecipient's five most highly compensated executives. Please refer to https://www.fsrs.gov/ for guidance on reporting requirements.

ARPA-E may not execute a funding agreement with the Prime Recipient until it has obtained a DUNS number and completed its SAM and FSRS registrations. In addition, the Prime Recipient may not execute subawards with Subrecipients until they obtain a DUNS number and complete their SAM registration. Prime Recipients and Subrecipients are required to keep their SAM and FSRS data current throughout the duration of the project.

Finally, Prime Recipients are required to register with FedConnect in order to receive notification that their funding agreement has been executed by the Contracting Officer and to

[45] The Federal Funding Accountability and Transparency Act, P.L. 109-282, 31 U.S.C. 6101 note.

obtain a copy of the executed funding agreement. Please refer to https://www.fedconnect.net/FedConnect/ for registration instructions.

2. NATIONAL POLICY ASSURANCES

Project Teams, including Prime Recipients and Subrecipients, are required to comply with the National Policy Assurances attached to their funding agreement in accordance with 2 C.F.R. 200.300. Please refer to Attachment 6 of ARPA-E's Model Cooperative Agreement (https://arpa-e.energy.gov/?q=site-page/funding-agreements) for information on the National Policy Assurances.

3. PROOF OF COST SHARE COMMITMENT AND ALLOWABILITY

Upon selection for award negotiations, the Prime Recipient must confirm in writing that the proposed cost share contribution is allowable in accordance with applicable Federal cost principles.

The Prime Recipient is also required to provide cost share commitment letters from Subrecipients or third parties that are providing cost share, whether cash or in-kind. Each Subrecipient or third party that is contributing cost share must provide a letter on appropriate letterhead that is signed by an authorized corporate representative.

4. COST SHARE PAYMENTS[46]

All proposed cost share contributions must be reviewed in advance by the Contracting Officer and incorporated into the project budget before the expenditures are incurred.

The Prime Recipient is required to pay the "Cost Share" amount as a percentage of the total project costs in each invoice period for the duration of the period of performance. Small Businesses see Section III.B.3 of the FOA.

ARPA-E may deny reimbursement requests, in whole or in part, or modify or terminate funding agreements where Prime Recipients (or Project Teams) fail to comply with ARPA-E's cost share payment requirements.

5. ENVIRONMENTAL IMPACT QUESTIONNAIRE

By law, ARPA-E is required to evaluate the potential environmental impact of projects that it is considering for funding. In particular, ARPA-E must determine before funding a project whether the project qualifies for a categorical exclusion under 10 C.F.R. § 1021.410 or whether it requires further environmental review (i.e., an environmental assessment or an environmental impact statement).

[46] Please refer to Section III.B of the FOA for guidance on cost share requirements.

To facilitate and expedite ARPA-E's environmental review, Prime Recipients are required to complete an Environmental Impact Questionnaire during award negotiations. This form is available at https://arpa-e.energy.gov/?q=site-page/required-forms-and-templates. The Environmental Impact Questionnaire is due within 21 calendar days of the selection announcement.

6. TECHNOLOGY-TO-MARKET PLAN

During award negotiations, Prime Recipients are required to negotiate and submit an initial Technology-to-Market Plan to the ARPA-E Program Director, and obtain the ARPA-E Program Director's approval prior to the execution of the award. Prime Recipients must show how budgeted Technology Transfer and Outreach (TT&O) costs relate to furthering elements of the Technology-to-Market Plan. During the period of performance, Prime Recipients are required to provide regular updates on the initial Technology-to-Market plan and report on implementation of Technology-to-Market activities. Prime Recipients may be required to perform other actions to further the commercialization of their respective technologies.

ARPA-E may waive or modify this requirement, as appropriate.

7. INTELLECTUAL PROPERTY AND DATA MANAGEMENT PLANS

ARPA-E requires every Project Team to negotiate and establish an Intellectual Property Management Plan for the management and disposition of intellectual property arising from the project. The Prime Recipient must submit a completed and signed Intellectual Property Management plan to ARPA-E within six weeks of the effective date of the ARPA-E funding agreement. All Intellectual Property Management Plans are subject to the terms and conditions of the ARPA-E funding agreement and its intellectual property provisions, and applicable Federal laws, regulations, and policies, all of which take precedence over the terms of Intellectual Property Management Plans.

ARPA-E has developed a template for Intellectual Property Management Plans (https://arpa-e.energy.gov/?q=site-page/project-management-reporting-requirements) so as to facilitate and expedite negotiations between Project Team members. ARPA-E does not mandate the use of this template. ARPA-E and DOE do not make any warranty (express or implied) or assume any liability or responsibility for the accuracy, completeness, or usefulness of the template. ARPA-E and DOE strongly encourage Project Teams to consult independent legal counsel before using the template.

Awardees are also required, post-award, to submit a Data Management Plan (DMP) that addresses how data generated in the course of the work performed under an ARPA-E award will be preserved and, as appropriate, shared publicly. The Prime Recipient must submit a completed and signed DMP - as part of the Team's Intellectual Property Management Plan - to ARPA-E within six weeks of the effective date of the ARPA-E funding agreement.

8. U.S. MANUFACTURING REQUIREMENT

As part of its Full Application, each applicant is required to submit a U.S. Manufacturing Plan that includes the following U.S. Manufacturing Requirements. For more information on the required U.S Manufacturing Plan, see Section IV.C.7 above.

a. SMALL BUSINESSES

Small businesses (and in rare cases where a nonprofit might manufacture) that are Prime Recipients or Subrecipients under ARPA-E funding agreements must agree that any products embodying any subject invention or produced through the use of any subject invention will be manufactured substantially in the United States for any use or sale anywhere in the world.

Small business must also agree that, for their exclusive and nonexclusive licensees, any products that embody any subject invention or that will be produced through the use of any subject invention will be manufactured substantially in the United States for any use or sale anywhere in the world.

Small businesses must require their assignees and entities acquiring a controlling interest in the small business to apply the same U.S. Manufacturing requirements to their licensees.

b. LARGE BUSINESSES

Large businesses that are Prime Recipients or Subrecipients (and in rare cases, foreign entities that are Subrecipients) under ARPA-E funding agreements are required to substantially manufacture the following products in the United States: (1) products embodying subject inventions, and (2) products produced through the use of subject inventions. This requirement applies to products that are manufactured for use or sale in the United States and outside the United States.

Large businesses (and in rare cases, foreign entities that are Subrecipients) must apply the same U.S. Manufacturing requirements to their assignees, licensees, and entities acquiring a controlling interest in the large business or foreign entity. Large businesses must require their assignees and entities acquiring a controlling interest in the large business to apply the same U.S. Manufacturing requirements to their licensees.

c. EDUCATIONAL INSTITUTIONS AND NONPROFITS

Domestic educational institutions and nonprofits that are Prime Recipients or Subrecipients under ARPA-E funding agreements must require their exclusive and nonexclusive licensees to substantially manufacture the following products in the United States for any use or sale anywhere in the world: (1) articles embodying subject inventions, and (2) articles produced

through the use of subject inventions. Educational institutions and nonprofits must require their assignees to apply the same U.S. Manufacturing requirements to their licensees.

d. FFRDCs/DOE Labs and State and Local Government Entities

FFRDCs/DOE Labs that are GOCOs and state and local government entities that are Prime Recipients or Subrecipients under ARPA-E funding agreements must require their exclusive licensees to substantially manufacture the following products in the United States for any use or sale in the United States: (1) products embodying subject inventions, and (2) products produced through the use of subject inventions. This requirement does not apply to products that are manufactured for use or sale overseas. They must also require their assignees to apply the same U.S. Manufacturing requirements to their exclusive licensees. GOGOs are subject to the requirements in 37 CFR § 404.5(a)(2).

e. Criteria for Waiving U.S. Manufacturing Requirements

ARPA-E seeks to "enhance the economic and energy security of the United States …" and "ensure that the United States maintains a technological lead in developing and deploying advanced energy technologies." The preferred benefit to the U.S. economy is the creation and maintenance of manufacturing capabilities and jobs within the United States. However, an applicant or awardee may request a modification or waiver of the standard U.S. Manufacturing Requirement, or its submitted U.S. Manufacturing Plan, if the applicant/awardee can demonstrate to the satisfaction of DOE/ARPA-E that it is not commercially feasible to comply with U.S. manufacturing requirements. In addition, such requests must include a description of specific economic or other benefits to the U.S. economy which are related to the commercial use by requestor of the technology being funded by ARPA-E and which are commensurate with the Government's contribution to the proposed work. These types of benefits are more easily measured and evaluated after technical advance has been made under an award, such as by the making of a subject invention.

Such benefits may include one or more of the following:

- Direct or indirect investment in U.S.-based plant and equipment.
- Creation of new and/or higher-quality U.S.-based jobs.
- Enhancement of the domestic skills base.
- Further domestic development of the technology.
- Significant reinvestment of profits in the domestic economy.
- Positive impact on the U.S. balance of payments in terms of product and service exports as well as foreign licensing royalties and receipts.
- Appropriate recognition of U.S. taxpayer support for the technology; e.g., a quid-pro-quo commensurate with the economic benefit that would be domestically derived by the U.S. taxpayer from U.S.-based manufacture.
- Cross-licensing, sublicensing, and reassignment provisions in licenses which seek to

maximize the benefits to the U.S. taxpayer.

- Any foreign manufacturing/use will occur in a country that protects U.S. patents/intellectual property.

9. CORPORATE FELONY CONVICTIONS AND FEDERAL TAX LIABILITY

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

- It is not a corporation that has been convicted of a felony criminal violation under any Federal law within the preceding 24 months; and
- It is not a corporation that has any unpaid Federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability.

For purposes of these representations the following definitions apply: A Corporation includes any entity that has filed articles of incorporation in any of the 50 states, the District of Columbia, or the various territories of the United States [but not foreign corporations]. It includes both for-profit and non-profit organizations.

10. APPLICANT RISK ANALYSIS

If selected for award negotiations, ARPA-E may evaluate the risks posed by the Applicant using the criteria set forth at 2 CFR §200.205(c), subparagraphs (1) through (4). ARPA-E may require special award terms and conditions depending upon results of the risk analysis.

11. RECIPIENT INTEGRITY AND PERFORMANCE MATTERS

Prior to making a Federal award with a total amount of Federal share greater than the simplified acquisition threshold (presently $250,000), ARPA-E is required to review and consider any information about Applicants that is contained in the Office of Management and Budget's designated integrity and performance system accessible through SAM (currently the Federal Awardee Performance and Integrity Information System or FAPIIS) (41 U.S.C. § 2313 and 2 C.F.R. 200.205).

Applicants may review information in FAPIIS and comment on any information about itself that a Federal awarding agency previously entered into FAPIIS.

ARPA-E will consider any written comments provided by Applicants during award negotiations, in addition to the other information in FAPIIS, in making a judgment about an Applicant's integrity, business ethics, and record of performance under Federal awards when reviewing potential risk posed by Applicants as described in 2 C.F.R. §200.205.

12. NONDISCLOSURE AND CONFIDENTIALITY AGREEMENTS REPRESENTATIONS

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

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

(2) **It does not and will not** use any Federal funds to implement or enforce any nondisclosure and/or confidentiality policy, form, or agreement it uses unless it contains the following provisions:

a. *"These provisions are consistent with and do not supersede, conflict with, or otherwise alter the employee obligations, rights, or liabilities created by existing statute or Executive order relating to (1) classified information, (2) communications to Congress, (3) the reporting to an Inspector General of a violation of any law, rule, or regulation, or mismanagement, a gross waste of funds, an abuse of authority, or a substantial and specific danger to public health or safety, or (4) any other whistleblower protection. The definitions, requirements, obligations, rights, sanctions, and liabilities created by controlling Executive orders and statutory provisions are incorporated into this agreement and are controlling."*

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

c. Notwithstanding provision listed in paragraph (a), a nondisclosure confidentiality policy form or agreement that is to be executed by a person connected with the conduct of an intelligence or intelligence-related activity, other than an employee or officer of the United States Government, may contain provisions appropriate to the particular activity for which such document is to be used. Such form or agreement shall, at a minimum, require that the person will not disclose any classified information received in the course of such activity unless specifically authorized to do so by the United States Government. Such nondisclosure or confidentiality forms shall also make it clear that they do not bar disclosure to congress, or to an authorized official of an executive agency or the Department of Justice, that are essential to reporting a substantial violation of law.

C. REPORTING

Recipients are required to submit periodic, detailed reports on technical, financial, and other aspects of the project, as described in Attachment 4 to ARPA-E's Model Cooperative Agreement (https://arpa-e.energy.gov/?q=site-page/funding-agreements).

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 reviewer comments on Full Applications before the submission deadline for Replies to Reviewer Comments.

VIII. OTHER INFORMATION

A. 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 Prime Recipients/Subrecipients elect to retain title, they must file a patent application in a timely fashion, generally one year from election of title, though: a) extensions can be granted, and b) earlier filing is required for certain situations ("statutory bars," governed by 35 U.S.C. § 102) involving publication, sale, or public use of the subject invention.
- 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): DOE has determined that exceptional circumstances exist that warrant the modification of the standard patent rights clause for small businesses and non-profit awardees under Bayh-Dole to maximize the manufacture of technologies supported by ARPA-E awards in the United States. The DEC, including a right of appeal, 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. Please see Section IV.C and VI.B for more information on U.S. Manufacturing Requirements.

B. 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.

C. RIGHTS IN TECHNICAL DATA

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

- 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.

D. 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).

E. 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.

F. 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.

G. 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 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.

H. RETENTION OF SUBMISSIONS

ARPA-E expects to retain copies of all 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.

I. MARKING OF CONFIDENTIAL INFORMATION

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

Full Applications, Replies to Reviewer Comments, and other submissions containing confidential, proprietary, or privileged information should 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 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.

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.

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 Full Application and Reply to Reviewer Comments.

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

Cost Sharing: is the portion of project costs not paid by Federal funds (unless otherwise authorized by Federal statue). Refer to 2 C.F.R. § 200.29.

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.

For-Profit Organizations (Other than Small Businesses) (or *large businesses*): Means entities organized for-profit other than small businesses as defined elsewhere in this Glossary.

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

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

Institutions of Higher Education (or *educational institutions*): Has the meaning set forth at 20 U.S.C. 1001.

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

Nonprofit Organizations (or *nonprofits*): Has the meaning set forth at 2 C.F.R. § 200.70.

Prime Recipient: 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 any of the research and development work under an ARPA-E funding agreement, whether or not costs of performing the research and development work are being reimbursed under any agreement.

Small Business: Small businesses are 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 Classification System Codes" (NAICS) (http://www.sba.gov/content/small-business-size-standards).

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.F.8 of the FOA for more information).