FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT

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

SOLICITATION ON TOPICS INFORMING NEW PROGRAM AREAS

Announcement Type: Modification ~~01~~ 02
Funding Opportunity No. DE-FOA-0001953
CFDA Number 81.135

FOA Issue Date:	December 20, 2018
FOA Close Date:	5 PM ET, December 19, 2019
Application Due Date:	See Targeted Topics Table for topic-specific application due dates.
Total Amount to Be Awarded	Approximately $~~23~~ 24 million, subject to the availability of appropriated funds to be shared between FOAs DE-FOA-0001953 and DE-FOA-0001954. See Targeted Topics Table for topic-specific information.
Anticipated Awards	ARPA-E may issue one, multiple, or no awards under this FOA. Awards may vary between $100,000 and $3.61 million. See Targeted Topics Table for topic-specific award amount requirements.

- For eligibility criteria, see Section III.A – III.C 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.F.1 of the FOA.
- Applicants are responsible for meeting the submission deadline associated with each Targeted Topic. Applicants are strongly encouraged to submit their applications at least 48 hours in advance of the Targeted Topic 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	2/13/2019	• Revised Full Application Deadlines for Topics A, B, & C. See Table 1. Targeted Topics and Appendices A, B & C. • Inserted information regarding Renewal Awards. See Section II.B of the FOA. • Inserted new Targeted Topic. Topic D: Diagnostic Resource Teams to Support the Validation of Potentially Transformative Fusion-Energy Concepts. See Table 1. Targeted Topics, Appendix D and Total Amount to be awarded on Cover Page.
02	3/12/2019	• Inserted new Targeted Topic. Topic E: Quantification of Effectiveness of Nutrient Bioextraction by Seaweed. See Table 1. Targeted Topics, Appendix E and Total Amount to be awarded on Cover Page.

TABLE 1. TARGETED TOPICS

Appendix	Targeted Topic Title	Issue Date	Deadline for Questions to ARPA-E CO	Full Application Submission Deadline	Total Amount to be Awarded (subject to the availability of funds)	Anticipated Awards	Max Period of Performance	Expected date for Notifications
A	EXTREMELY DURABLE CONCRETES AND CEMENTITIOUS MATERIALS	12/20/2018	5 PM ET, 2/8/2019	9:30 AM ET, 2/19/2019	Approximately $8M total	5-8 awards	24 months	May 2019
B	LEVERAGING INNOVATIONS SUPPORTING NUCLEAR ENERGY	12/20/2018	5 PM ET, 2/8/2019	9:30 AM ET, 2/19/2019	Approximately $8M total	3-5 awards	24 months	May 2019
C	DOWNHOLE TOOLS TO ENABLE ENHANCED GEOTHERMAL SYSTEMS	12/20/2018	5 PM ET, 2/8/2019	9:30 AM ET, 2/19/2019	Approximately $2M total	2-4 awards	24 months	May 2019
D	Diagnostic Resource Teams to Support the Validation of Potentially Transformative Fusion-Energy Concepts	2/13/2019	5 PM ET, 4/5/2019	9:30 AM ET, 4/15/2019	Approximately $5M total	3-5 awards	24 months	June 2019
E	Quantification of Effectiveness of Nutrient Bioextraction by Seaweed	3/12/2019	5 PM ET, 5/1/2019	9:30 AM ET, 5/13/2019	Approximately $1M total, maximum $300K per award	3-5 fixed amount grants	24 months	July 2019

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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 see Sections IV.C of the FOA.

SUBMISSION	COMPONENTS	OPTIONAL/ MANDATORY	FOA SECTION
Full Application	• Each Applicant must submit a Technical Volume in Adobe PDF format by the stated deadline. Applicants may use the Technical Volume template available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov). The Technical Volume must include the following: ○ Executive Summary (1 page max.) ○ Sections 1-5 (14 pages max.) • 1. Innovation and Impact • 2. Proposed Work • 3. Technology to Market • 4. Team Organization and Capabilities • 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) – Applicants may use the Summary Slide template available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov); ○ Completed and signed Business Assurances & Disclosures Form (no page limit, Adobe PDF format) ○ U.S. Manufacturing Plan (1 page limit, Adobe PDF format)	Mandatory	IV.C

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 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 and it can be spurred by early-stage R&D supported by the applied energy offices in DOE. By contrast, ARPA-E supports high-risk, potentially transformative research that has the potential to create fundamentally new learning curves. ARPA-E R&D projects typically start with cost/performance estimates for the proposed technology that are well above the level of the competitive 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 AND OBJECTIVES

This announcement is purposely broad in scope, and will cover a wide range of topics to encourage the submission of the most innovative and unconventional ideas in energy technology. The objective of this solicitation is to support high-risk R&D leading to the development of potentially disruptive new technologies across the full spectrum of energy applications. Topics under this FOA will explore new areas of technology development that, if successful, could establish new program areas for ARPA-E, or complement the current portfolio of ARPA-E programs.

Applications to this solicitation must have the potential for high impact — if successful, it could create a new class or new trajectory for an energy technology, with the potential to make a significant impact on ARPA-E's Mission Areas (see Section I.A).

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

Awards under this program may take the form of analyses or exploratory research that provides the agency with information useful for the subsequent development of focused technology programs. Alternatively, awards may support proof-of-concept research for a particular new technology, either in an area not currently supported by the agency or as a potential enhancement to an ongoing focused technology program.

C. TARGETED TOPICS OVERVIEW

This FOA will only accept applications in prespecified Targeted Topics. Specific areas of interest and relevant deadlines will be posted on the ARPA-E eXCHANGE website (https://arpa-e-foa.energy.gov). For your convenience you can subscribe to the ARPA-E mailing list to receive ARPA-E newsletters and news alerts, as well as updates on when new Targeted Topics are posted.

Each technology specific Targeted Topic announcement will be visible on ARPA-E eXCHANGE as a supporting FOA document. Targeted topic details will only be visible in eXCHANGE while the notice is accepting applications. Once the topic deadline has passed the notice will be taken down and ARPA-E will no longer be accepting applications in that area. ARPA-E will only review applications that are scientifically aligned with the Targeted Topic(s) open at the time the application is submitted.

II. AWARD INFORMATION

A. AWARD OVERVIEW

See Targeted Topic Table and Topic Appendices for total amounts and anticipated number of awards for each topic.

B. RENEWAL AWARDS

At ARPA-E's sole discretion, awards resulting from this FOA may be renewed by adding one or more budget periods and/or extending the period of performance of the initial 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 Grants, 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.

1. GRANTS

A Grant is a legal instrument that is used to provide Federal financial assistance or other things of value to carry out a public purpose of support or stimulation authorized by Federal statute. Grants are distinguished from Cooperative Agreements in that they do not provide for substantial involvement between the Federal awarding agency (in this case ARPA-E) and the Recipient. ARPA-E expects to award Grants for research funded under this FOA up to $300,000.

2. COOPERATIVE AGREEMENTS

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."[2] Accordingly, ARPA-E has substantial involvement in the direction of every Cooperative Agreement.

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

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 https://arpa-e.energy.gov/?q=site-page/funding-agreements.

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

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

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

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

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

4. 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. FEDERAL STEWARDSHIP

ARPA-E will exercise Federal stewardship in overseeing the project activities performed under this Award. Stewardship activities include, but are not limited to, conducting site visits; reviewing performance and financial reports; providing technical assistance and/or temporary intervention in unusual circumstances to correct deficiencies which develop during the project; assuring compliance with terms and conditions of the Award; and reviewing technical performance during and after project completion to ensure that the Award objectives are being/have been accomplished.

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,[3] as the lead for a Project Team,[4] or as a member of a Project Team. However, ARPA-E will only award funding to an entity formed by the Applicant.

2. DOMESTIC ENTITIES

For-profit entities, educational institutions, and nonprofits[5] 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

U.S. incorporated subsidiaries of foreign entities, whether for-profit or otherwise, are eligible to apply for funding under this FOA as a Standalone Applicant, as the lead organization for a Project Team, or as a member of a Project Team, subject to the requirements in 2 Code of

[3] A Standalone Applicant is an Applicant that applies for funding on its own, not as part of a Project Team.
[4] The term "Project Team" is used to mean any entity with multiple players working collaboratively and could encompass anything from an existing organization to an ad hoc teaming arrangement. A Project Team consists of the Prime Recipient, Subrecipients, and others performing or otherwise supporting work under an ARPA-E funding agreement.
[5] Nonprofit organizations described in section 501(c)(4) of the Internal Revenue Code of 1986 that engaged in lobbying activities after December 31, 1995 are not eligible to apply for funding as a Prime Recipient or Subrecipient.

Federal Regulation (CFR) 910.124, which includes requirements that the entity's participation in this FOA's Program be in the economic interest of the U.S. The Full Application must state the nature of the corporate relationship between the foreign entity and domestic subsidiary or affiliate.

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

All work under an ARPA-E award must be performed in the U.S. The Applicants may request a waiver of this requirement in the Business Assurances & Disclosures Form, which is submitted with the Full Application and can be found at https://arpa-e-foa.energy.gov/. Please refer to the Business Assurances & Disclosures Form for guidance on the content and form of the request.

Also, refer to Section VIII.B which addresses U.S. manufacturing requirements for inventions arising from research projects funded by this Program.

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[6]

Cost sharing will not be required for any project with Federal Project Funding of $300,000 or less. Otherwise, Applicants are bound by the cost share proposed in their Full Applications.

1. BASE COST SHARE REQUIREMENT

ARPA-E generally uses Cooperative Agreements to provide financial and other support to Prime Recipients (see Section II.C of the FOA). Under a Cooperative Agreement or Grant, the Prime Recipient must provide at least 20% of the Total Project Cost[7] as cost share, except as provided in Sections III.B.2 or III.B.3 below.[8]

2. INCREASED COST SHARE REQUIREMENT

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

Under 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 minimum cost share requirement, as appropriate.

3. REDUCED COST SHARE REQUIREMENT

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

- A domestic educational institution or domestic nonprofit applying as a Standalone Applicant is not required to provide cost share.

- Project Teams composed exclusively of domestic educational institutions, domestic nonprofits, FFRDCs/DOE Labs, and/or Federal agencies and instrumentalities (other than DOE) are not required to provide cost share.

- Small businesses – or consortia of small businesses – will provide 0% cost share from the outset of the project through the first 12 months of the project (hereinafter the

[6] Please refer to Section VI.B.3-4 of the FOA for guidance on cost share payments and reporting.
[7] 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.
[8] Energy Policy Act of 2005, Pub.L. No. 109-58, § 988.

"Cost Share Grace Period").[9] 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%, but less than 100%, of the total work under the funding agreement (as measured by the Total Project Cost) the Project Team are entitled to the same cost share reduction and Cost Share Grace Period as provided above to Standalone small businesses or consortia of small businesses.[10]

- Project Teams where domestic educational institutions, domestic nonprofits, small businesses, and/or FFRDCs perform greater than or equal to 80%, of the total work under the funding agreement (as measured by the Total Project Cost) are required to provide at least 10% of the Total Project Cost as cost share. However, any entity (such as a large business) receiving patent rights under a class waiver, or other patent waiver, that is part of a Project Team receiving this reduction must continue to meet the statutory minimum cost share requirement (20%) for its portion of the Total Project Cost.

- Projects that do not meet any of the above criteria are subject to the minimum cost share requirements described in Sections III.B.1 and III.B.2 of the FOA.

4. LEGAL RESPONSIBILITY

Although the cost share requirement applies to the Project Team as a whole, the funding agreement makes the Prime Recipient legally responsible for paying, 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.

[9] Small businesses are generally defined as domestically incorporated entities that meet the criteria established by the U.S. Small Business Administration's (SBA) "Table of Small Business Size Standards Matched to North American Industry Classification System Codes" (NAICS) (http://www.sba.gov/content/small-business-size-standards). Applicants that are small businesses will be required to certify in the Business Assurances & Disclosures Form that their organization meets the SBA's definition of a small business under at least one NAICS code.

[10] See the information provided in previous footnote.

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.E.1 of the FOA.

Project Teams may provide cost share in the form of cash or in-kind contributions. Cash contributions may be provided by the Prime Recipient or Subrecipients. Allowable in-kind contributions include but are not limited to personnel costs, indirect costs, facilities and administrative costs, rental value of buildings or equipment, and the value of a service, other resource, or third party in-kind contribution. Project Teams may use funding or property received from state or local governments to meet the cost share requirement, so long as the funding or property was not provided to the state or local government by the Federal Government.

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

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

In addition, Project Teams may not use independent research and development (IR&D) funds[11] 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.

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

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.

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 Targeted Topic submission deadline stated in Table 1 of this 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.

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 the Targeted Topic Appendix
- Submissions that have been submitted in response to other currently issued ARPA-E FOAs.
- Submissions that are not scientifically distinct from applications submitted in response to other currently issued ARPA-E FOAs.
- Submissions for basic research aimed solely at discovery and/or fundamental knowledge generation.
- Submissions for large-scale demonstration projects of existing technologies.
- Submissions for proposed technologies that represent incremental improvements to existing technologies.
- Submissions for proposed technologies that are not based on sound scientific principles (e.g., violates a law of thermodynamics).
- Submissions for proposed technologies that are not transformational, as described in Section I.A of the FOA.
- Submissions for proposed technologies that do not have the potential to become disruptive in nature, as described in Section I.A of the FOA. Technologies must be scalable such that they could be disruptive with sufficient technical progress.
- Submissions that are not 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.

Each Targeted Topic may also include a section entitled "Submissions Specifically not of Interest." Submissions that propose items contained within this section in each Targeted Topic may be deemed nonresponsive and may not be reviewed or considered.

3. LIMITATION ON NUMBER OF SUBMISSIONS

ARPA-E is not limiting the number of submissions from Applicants. Applicants may submit more than one application to each Targeted Topic attached 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.F.1 of the FOA and the "ARPA-E eXCHANGE Applicant Guide" (https://arpa-e-foa.energy.gov/Manuals.aspx).

2. FULL APPLICATIONS

Applicants must submit a Full Application by the Targeted Topic Full Application Submission Deadline stated in Table 1 of this 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.1 and V.B.1 of the FOA.

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

Once ARPA-E completes its review of Full Applications, 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.

4. 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, 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 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. A Technical Volume template is available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov).
SF-424	PDF	Application for Federal Assistance (https://arpa-e-foa.energy.gov). 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 (https://arpa-e-foa.energy.gov)

Summary for Public Release	PDF	Short summary of the proposed R&D project. Intended for public release. A Summary for Public Release template is available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov).
Summary Slide	PPT	A four-panel project slide summarizing different aspects of the proposed R&D project. A Summary Slide template is available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov).
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. This form 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.
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. See detailed U.S. Manufacturing Plan instructions and examples in the Seventh Component description below.

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.

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 specified for each section, 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.E.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.B 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:

- Targeted Topic Name
- 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."[12] In accordance with ARPA-E's statutory mandate, the Applicant is required to:

- 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 should contain the following or similar preamble: "If selected for funding, the Applicant agrees to the following commitments as a condition of that funding:" and, after the preamble, the plan should include one or more specific and 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[13] 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

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

[13] For purposes of this FOA, an input refers to something which is used during the manufacturing process which (1) was in existence prior to or first produced outside of an ARPA-E award; (2) does not embody a subject invention, or technology which is developed or improved under an ARPA-E award; and (3) was not produced through the use of a subject invention, or technology which is developed or improved under an ARPA-E award.

still beneficial to U.S. manufacturing. An Applicant may commit to a particular investment in a new or existing U.S. manufacturing facility, keep certain activities based in the U.S. (i.e., final assembly) or support a certain number of jobs in the U.S. related to the technology and manufacturing. For an Applicant which is likely to license the technology to others, especially universities for which licensing may be the exclusive means of commercialization the technology, the U.S. manufacturing plan may indicate the Applicant's plan and commitment to use a licensing strategy **for both exclusive and nonexclusive** licensing that would likely support U.S. manufacturing.

When an Applicant that is a domestic small business, domestic educational institution, or nonprofit organization is selected for an award, the U.S. Manufacturing Plan submitted by the Applicant may become part of the terms and conditions of the award **in addition to the requirements attaching to subject inventions described in VI.B.8 below.** See Section VI.B.8 of the FOA for U.S. Manufacturing Requirements applicable to large businesses. The Applicant/Awardee may request a waiver or modification of the U.S. Manufacturing Plan from DOE upon a showing that the original U.S. Manufacturing Plan is no longer economically feasible.

Class patent waivers usually apply to domestic large businesses as set forth in Section VIII.F 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 DOE agrees that the commitments proposed in the U.S. Manufacturing Plan are sufficient. The U.S. Manufacturing Plan submitted by the Applicant may become part of the terms and conditions of the award i**n addition to the requirements attaching to subject inventions**.

D. INTERGOVERNMENTAL REVIEW

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

E. 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.

Please refer to the "Applicants' Guide to ARPA-E Award Negotiations" (https://arpa-e.energy.gov/?q=arpa-e-site-page/pre-award-guidance) for additional guidance on pre-award costs.

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.E.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.

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.

Please refer to the "Applicants' Guide to ARPA-E Award Negotiations" (https://arpa-e.energy.gov/?q=arpa-e-site-page/pre-award-guidance) for additional guidance on TT&O requirements.

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.

F. 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 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 Targeted Topic Submission Deadline.** Under normal conditions (i.e., at least 48 hours in advance of the Close Date), Applicants should allow at least 1 hour to submit a Full Application. 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 Targeted Topic submission 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 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%

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 US dependence on foreign energy sources;
   b. Stimulation of domestic manufacturing/U.S. Manufacturing Plan;
   c. Reduction of energy-related emissions;
   d. Increase in U.S. energy efficiency;
   e. Enhancement of U.S. economic and energy security; or
   f. Promotion of U.S. advanced energy technologies competitiveness.

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

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

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

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

2. ARPA-E REVIEWERS

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

ARPA-E requires all reviewers to complete a Conflict-of-Interest Certification and Nondisclosure Agreement through which they disclose their knowledge of any actual or apparent conflicts and agree to safeguard confidential information contained in Full Applications. 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 on a rolling basis approximately 90 days after submission of a Full Application.

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.

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.E.2 of the FOA for guidance on pre-award costs. Please also refer to the "Applicants' Guide to ARPA-E Award Negotiations" (https://arpa-e.energy.gov/?q=arpa-e-site-page/pre-award-guidance) for guidance on the award negotiation process.

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.E.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/.[14] 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.

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

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 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. Please refer to the "Applicants' Guide to ARPA-E Award Negotiations" (https://arpa-e.energy.gov/?q=arpa-e-site-page/pre-award-guidance) for guidance on the contents of cost share commitment letters.

4. COST SHARE PAYMENTS[15]

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.

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

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.

Please refer to the "Applicants' Guide to ARPA-E Award Negotiations" (https://arpa-e.energy.gov/?q=arpa-e-site-page/pre-award-guidance) for additional guidance on cost share payment requirements.

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).

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. The DMP must meet the minimum requirements set forth in ARPA-E's "Applicant Guide to Award Negotiations" available at the following website: https://arpa-e.energy.gov/?q=arpa-e-site-page/pre-award-guidance."

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 (INCLUDING SMALL BUSINESS CONCERNS)

Small businesses (and in rare cases where a non-profit 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 $150,000), 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 Targeted Topic, 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 periodic 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 the Targeted Topic 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.

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 they elect to retain title, they must file a patent application in a timely fashion.
- All other parties: The Federal Non-Nuclear Energy Research and Development Act of 1974, 42. U.S.C. 5908, provides that the Government obtains title to new inventions unless a waiver is granted (*see below)*.
- Class Waiver: Under 42 U.S.C. § 5908, title to subject inventions vests in the U.S. Government and large businesses and foreign entities do not have the automatic right to elect to retain title to subject inventions. However, ARPA-E typically issues "class patent waivers" under which large businesses and foreign entities that meet certain stated requirements, such as cost sharing of at least 20%, may elect to retain title to their subject inventions. If a large business or foreign entity elects to retain title to its subject invention, it must file a patent application in a timely fashion. If the class waiver does not apply, a party may request a waiver in accordance with 10 C.F.R. §784.
- GOGOs are subject to the requirements of 37 C.F.R. Part 501.
- Determination of Exceptional Circumstances (DEC): 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.7 and VI.B.8 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, including Targeted Topic announcements, are also posted to these websites. For your convenience you can subscribe to the ARPA-E mailing list to receive ARPA-E newsletters and news alerts, as well as updates on when new Targeted Topics are posted. 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;
- 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. 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 strictly for evaluation purposes.

Full Applications containing confidential, proprietary, or privileged information must be marked as described below. Failure to comply with these marking requirements may result in the disclosure of the unmarked information under the Freedom of Information Act or otherwise.

The U.S. Government is not liable for the disclosure or use of unmarked information, and may use or disclose such information for any purpose.

The cover sheet of the Full Application, 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.

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

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

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

DOE: U.S. Department of Energy.

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

FFRDCs: Federally Funded Research and Development Centers.

FOA: Funding Opportunity Announcement.

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

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

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

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

PI: Principal Investigator.

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

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

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

Targeted Topic: A technical area of research that is detailed in a "Special Program Announcement" at the end of this FOA as an Appendix and visible on ARPA-E eXCHANGE as a supporting FOA document. Each targeted topic will have its own deadline. Once the topic deadline has passed the notice will be taken down and ARPA-E will no longer be accepting applications in that area. ARPA-E will only review applications that are scientifically aligned with the Targeted Topic(s) open at the time the application is submitted.

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

I. APPENDIX A: EXTREMELY DURABLE CONCRETES AND CEMENTITIOUS MATERIALS

Special Program Announcement for
Solicitation on Topics Informing New Program Areas (DE-FOA-0001953)
"Extremely Durable Concretes and Cementitious Materials"

Topic Issue Date	December 20, 2018
Deadline for Questions to ARPA-E-CO@hq.doe.gov	5 PM ET, February 8, 2019
Submission Deadline for Full Applications	9:30 AM ET, February 19, 2019
Expected Date for Selection Notifications	May 2019
Total Amount to be Awarded	Approximately $8M total funding
Anticipated Awards	5-8 awards
Maximum Period of Performance	24 Months

1. Introduction

This announcement describes a research thrust titled "Extremely Durable Concretes and Cementitious Materials." The purpose of this announcement is to (1) focus the attention of the scientific and technical community on specific areas of interest related to the advancement of concretes, precursors (*e.g*. cementitious & pozzolanic materials, aggregates, admixtures) and concrete structures, (2) encourage dialogue amongst those interested in this area, and (3) provide a timetable for the submission of Full Applications.

2. Topic Description

ARPA-E is interested in receiving Full Applications in support of advancing extremely durable concretes and cementitious materials. This topic seeks research towards concrete that outlasts conventional concrete, reduces lifetime O&M expenses and their associated energy requirements, and therefore greatly reduces cement/concrete. Work under this program will consist of early stage research.

A. Topic Overview

Concrete is second only to water as the most widely used substance in the world,[16] largely due to the material's low cost, abundance, and relative stability in myriad environments (e.g. marine; high temperature, pressure, salinity, radiation). The ubiquity of concrete comes with a significant energy and emissions footprint, [17] which threatens to grow as domestic

[16] Scrivener, Karen L., Vanderley M. John, and Ellis M. Gartner. "Eco-efficient cements: Potential economically viable solutions for a low-CO2 cement-based materials industry." (2016).
[17] EIA. The cement industry is the most energy intensive of all manufacturing industries. July 1, 2013. EIA: Today in Energy. https://www.eia.gov/todayinenergy/detail.php?id=11911

infrastructure degrades with age.[18] Concrete is also a critical material for U.S. energy production, one that can have a significant impact on the cost, productivity, and resilience of key resources such as nuclear, fossil, wind, and hydroelectric power.

Over the last century, alterations to concrete mixtures – namely, the increase in cement fineness and C3S content and concomitant C2S decrease[19] - have emphasized early strength gain to accommodate an increase in the rate of construction. Several surveys have uncovered an increasing rate of deterioration for these early-strength mixtures when compared to older, higher C2S concrete blends.[20] More specifically, modern (e.g. 1950 and beyond) concrete mixes have been found to crack more easily, primarily due to lower creep, higher shrinkage and a higher elastic modulus.20 Cracks present a critical vulnerability to any concrete structure, allowing harmful ions and gases to penetrate the structure's interior; in many cases, these harmful substances come in contact with the reinforcing steel used in most concrete structures. Corrosion of the steel rebar via the permeation of either water, air, and/or chlorine (such as from the marine environment or common de-icing salts), can result in a 12-27% reduction in usable life expectancy for the concrete structure.[21]

Rising demand for concrete – which, in the U.S., is largely driven by an aging infrastructure - could more than double the energy and emissions associated with its domestic production. Furthermore, the use of modern concrete mixtures in repair and replacement of infrastructure composed of older, more-durable concrete threatens to further drive energy use as the push for strength and speed comes at the cost of long-term durability. Without intervention, modern mixtures require more frequent repair and replacement, which translates to higher energy and emissions for both concrete production and the labor, equipment, *etc*., associated with operation and maintenance. At the same time, the low cost and operational simplicity of modern concrete represents a major hurdle to innovation as infrastructure projects face strong pressure towards low cost bids and complicated incentives between suppliers, builders, owners and operators. Attempts to introduce superior performance at a higher cost (*e.g.* materials, labor, curing time) – or without a clear value proposition - are unlikely to succeed on an impactful scale. In light of these market criteria, reverting to mixtures that improve durability at the cost of construction efficiency is not a viable option.

While previous efforts have seen some success in reducing the energy intensity of cement and concrete *production*, ARPA-E sees an opportunity to lower the energy devoted to concrete

[18] ASCE. 2017 Infrastructure Report Card. American Society of Civil Engineers (2017).
[19] C_3S is tricalcium silicate, also known as Alite; it is a component of cement which is largely responsible for the fast-setting and initial strength development of cement. Alite is also formed at the highest cement kiln temperatures (1300+ °C) and is a contributor to the high CO_2 emissions and energy requirements from cement production. C_2S is dicalcium silicate, also known as Belite; it is less reactive at early stages, contributing to strength development at later stages, and can be produced at lower kiln temperatures (up to 100 °C lower than Alite).
[20] Mehta, P. Kumar, and Richard W. Burrows. "Building durable structures in the 21st century." Indian Concrete Journal 75.7 (2001): 437-443.
[21] Jones, Scott, *et al.* "Simulation studies of methods to delay corrosion and increase service life for cracked concrete exposed to chlorides." *Cement and Concrete Composites* **58** (2015): 59-69.

materials and infrastructure by extending the *service life/use* stage of the material's lifecycle. **Therefore, the overarching objective of this research opportunity is to develop material and process improvements that would (1) significantly (*e.g.* 2X or more) improve the durability of concrete and cementitious materials, while (2) maintaining or lowering the energy and emissions related to production and deployment of the material, and (3) remaining cost competitive with traditional materials when accounting for the intended service life and maintenance cycle**.

More durable concrete can lower the overall energy input for concrete structures by significantly delaying the need for repair and replacement; for major concrete projects, and particularly for nuclear facilities, such developments could have tremendous economic potential. Finally, there may also be opportunities to lower infrastructure investment costs through advanced mixtures and manufacturing practices that improve durability while reducing material and/or time requirements for construction. If successful, these developments would produce high value, differentiated products and processes that would better position the U.S. concrete and construction industry to lead in a growing international market.

ARPA-E seeks input from researchers, manufacturers, suppliers and end-users of such technologies (*e.g.* the construction, manufacturers, specifiers, civil, and nuclear engineering communities). Consistent with the agency's mission, ARPA-E is seeking clearly disruptive, novel technologies, early in their R&D cycle. Incremental improvements and integration strategies for existing technologies are not of interest.

B. Technical Areas of Interest & Performance Targets

ARPA-E is specifically interested in technologies within one or more of the categories below that would:

(1) significantly (*e.g.* 2X or more) improve the durability of concrete and cementitious materials, while
(2) maintain or lower the energy and emissions related to production and deployment of the material, and
(3) remaining cost competitive with traditional materials when accounting for the intended service life and maintenance cycle.

CATEGORY 1 – Materials & Mixtures:

- Molecular design of more durable cementitious materials and concrete mixtures
  - Significantly reduce (*i.e.* ≤ 100µm), or eliminate, micro-cracking
  - Improve ductility (Target 0.75% - 2%)
  - Self-healing (*e.g.* w/wo chemical additives, fibers, active aggregate, pozzolans)
  - Extremely low permeability
  - Similar or reduced set-time while improving toughness and durability
- Materials and mixtures capable of enabling additive manufacturing techniques while preserving or enhancing durability

CATEGORY 2 – Advanced Processing:

- Advanced mixing and/or pre-blending systems to enable scale up of tailored mixtures
- Novel pathways toward low-temperature processing of highly-durable materials
- Novel methods of achieving and/or verifying uniformity of mixture designs and final structures
- Novel manufacturing and/or construction approaches that would result in reduced set-time while improving concrete toughness and durability
- Technologies to enable additive manufacturing for large-scale (> 125 m^3) construction (*e.g*. system controls, precise material delivery, in-field blending or compounding)

CATEGORY 3 – Modeling, Testing, Sensing, & Maintenance:

- Structure-process-property predictive models to define degradation pathways, enable more precise mixture evaluation, and identify optimal repair timing and materials
- Accelerated durability testing for concretes and cementitious materials
- Advanced non-destructive survey and sensing techniques for monitoring concrete structures
- Novel repair methods capable of significantly extending the lifetime of existing concrete structures

In addition to the requirements stated in the FOA, please include this table in the Technical Volume. Note that this table will count towards the 14 page limit of the Technical Volume. Please provide estimates of the durability improvement, embodied energy savings, and cost of the proposed technology:

Description	Response/Comments (include references where possible)
Estimated durability improvement: Provide the anticipated application, lifetime for SOA materials and expected improvement (*e.g.* %, years) for both maintenance frequency and replacement frequency.	
Estimated embodied energy savings: Provide the estimated energy intensity of the proposed solution, the anticipated demand and associated energy savings throughout the service life cycle.	
Estimated cost: Provide the target cost and associated assumptions for your proposed technology. Should the target cost exceed that of traditional materials or	

approaches, please justify the cost in the context of service life, maintenance schedule, user impact, *etc*.	

3. Submissions Specifically Not of Interest

Submissions that propose the following may be deemed nonresponsive and may not merit review or be considered:

- Approaches seeking incremental improvements to current cement and concrete materials, including OPC, geopolymers, and additives.
- Approaches seeking incremental improvements to concrete construction techniques, including marginal advances in pour-in-place and pre-casting techniques.
- Approaches seeking incremental improvements to additive manufacturing techniques, equipment and materials, including technologies specifically targeted to small-scale (<125 m^3) 'printed' structures.
- Demonstration projects that do not include a significant degree of technical risk.
- Approaches for which the capital, material, labor, and repair costs (life-cycle cost) exceed *current* life-cycle costs in the proposed application space.
- Technologies that are not suitable for use throughout the entire United States, including technologies that rely on a single, site-specific geologic material (*e.g*. limited, specific mineral only located in a particular region) are specifically not of interest.
- Primary application areas other than nuclear or infrastructure (*e.g*. commercial and residential buildings)

II. APPENDIX B: LEVERAGING INNOVATIONS SUPPORTING NUCLEAR ENERGY

Special Program Announcement for
Solicitation on Topics Informing New Program Areas (DE-FOA-0001953)
"Leveraging Innovations Supporting Nuclear Energy"

Topic Issue Date	December 20, 2018
Deadline for Questions to ARPA-E-CO@hq.doe.gov	5 PM ET, February 8, 2019
Submission Deadline for Full Applications	9:30 AM ET, February 19, 2019
Expected Date for Selection Notifications	May 2019
Total Amount to be Awarded	Approximately $8M total
Anticipated Awards	3-5 awards
Maximum Period of Performance	24 Months

1. Introduction

This announcement describes a research thrust titled "Leveraging Innovations Supporting Nuclear Energy." The purpose of this announcement is to (1) focus the attention of the scientific and technical community on specific areas of interest related to the development of enabling technologies which will reduce the cost of nuclear energy (2) provide a timetable for the submission of Full Applications.

2. Topic Description

For nuclear energy to support U.S. national interests in the coming decades, the next generation of nuclear reactor plants need to simultaneously achieve extremely low construction capital costs, short construction and commissioning times, and "walkaway" safe and secure operation. To attain these goals, innovative, enabling technologies for existing advanced reactor designs[22] are needed. There are many different advanced nuclear reactor designs being developed in the U.S.[23] The collection of these reactor designs has the potential to meet many different market needs of the future: flexible, dispatchable electricity generation; a variety of generation sizes; high-temperature heat; autonomous operations; etc. For these technologies to be successful, however, they need to avoid the challenges faced by the current fleet of nuclear reactors as well as domestic new build projects. Existing nuclear power plants are facing the significant challenge of having comparatively high operational and maintenance (O&M) costs that come from the high staffing level required for operation, maintenance, safety, and security.[24] Many of the Generation III+ reactors under construction have been plagued by

[22] Existing advanced reactor designs include classes of non-light water reactors that are being planned or have been used in the past. This includes designs that use as heat transfer media: gas, lead (or lead-bismuth alloy), molten salt, sodium, supercritical water, organics; and as nuclear fuel types: ceramic oxides, nitride, metal, triso clad, silicon carbide clad, metal clad, liquid eutectic.
[23] https://www.thirdway.org/graphic/keeping-up-with-the-advanced-nuclear-industry
[24] Nuclear Energy Institute. *Nuclear Costs in Context*. April 2016.

escalating capital costs and unpredictable construction schedules. Today, only two such Gen III+ Light Water Reactors (LWRs) are scheduled to come online in the U.S. by 2021, significantly behind schedule and over budget.[25]

It is clear that a substantial reduction of construction cost, O&M cost, and construction time, in combination with targeting reactor plant operation for commercial viability, is required to fundamentally enhance the competitiveness and attractiveness of nuclear energy. The ARPA-E MEITNER Program (DE-FOA-0001798)[26] is already investigating several innovative technologies that forward this goal. The purpose of this Targeted Topic is to address key technology gaps in the portfolio.

A. Technical Areas of Interest

- Approaches employing sensors, data analytics, robotics, and advanced controls (including autonomy and integration of machine learning) that limit or eliminate the need for humans to conduct regular monitoring and maintenance and enable early corrective action for abnormal conditions.
- High-performance moderators for gas-cooled reactors to enable increased power density.
- Advanced power conversion systems for ultra-high temperature (>1500 °C) reactors.
- Flexible power production via technologies that enable physically changing plant power output via sophisticated controls systems or management of reactor feedback behavior, or systems that enable variable output like storing heat for later use.
- Advanced construction techniques for faster, lower-cost construction.

B. Technical Performance Targets

Table 1 lists the design target areas for this research thrust and provides the current state-of-the-art. Note that these are the same targets as in the ARPA-E MEITNER (DE-FOA-0001798) Program. Applicants are required to address at *least one* area, providing their own targets if the entry is blank. Applicants must detail either (1) how their technology enables the performance specified, or, (2) in the case that this performance is not yet obtainable, a realistic pathway such that the performance may be obtained in a relevant timeframe. Technoeconomic analysis to support claims of impact is required.

In addition to the requirements stated in the FOA, please include this Table, along with supporting information and analysis in the Potential Impact Section of the Technical Volume. Note that this table will count towards the 14 page limit of the Technical Volume.

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

[26] https://arpa-e.energy.gov/?q=arpa-e-programs/MEITNER

Table 1. Enabling technologies sought by ARPA-E must improve reactor performance in *one or more* target areas.

ID	Metric	Units	State-of-the-Art	Performance with new technology
1	Overnight construction cost	$/$W_e$	2-7 [27]	< 2
2	On-site construction time	Months	> 60 [28]	
3	Total staffing level (on-site & off-site)	FTE/GW_e	450-750 [29]	< 50
4	Emergency planning zone (EPZ)[+]	Miles	10 and 50 [30]	
5	Time before human response required for an accident	Days	3 [31]	
6	Onsite backup power	kW_e	> 0 kW [32]	
7a	Ramp rate without steam bypass	power capacity/min	5% [33]	
7b	Process heat temperature	ºC	N/A	

[+] As measured from the center of the nuclear reactor core to the boundary: location where, during an accident, radiation levels are 0.25 millisieverts/month or less above the background level.

As indicated in the Technical Volume Template heading, specify a technical category: Autonomous Operation, Gas Reactor Moderators, Advanced Power Conversion, Load Following, Advanced Construction. In addition, specify a technical subcategory based on heat transfer medium: Multiple Types / General, Gas, Heat Pipe, Lead, Molten Salt, Sodium, Other.

3. Submissions Specifically Not of Interest

- Technologies specifically for LWRs, including Generation III or III+ LWR designs.
- Technology development that is not distinct in approach or objective from activities currently supported by or actively under consideration for funding by any office within the Department of Energy.
- Exploratory work in new nuclear reactor core concepts.

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

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

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

[30] https://www.nrc.gov/about-nrc/emerg-preparedness/about-emerg-preparedness/planning-zones.html

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

[32] https://www.nrc.gov/docs/ML1122/ML11229A062.pdf

[33] http://nuclear-economics.com/12-nuclear-flexibility/

- Technologies for reactors that require fuel enriched to >20% ^{235}U (if using uranium for fuel) or fuels that are not expected to be available for large-scale commercial deployment in the foreseeable future.
- Regulatory approaches.
- Heat exchangers.

III. APPENDIX C: DOWNHOLE TOOLS TO ENABLE ENHANCED GEOTHERMAL SYSTEMS

Special Program Announcement for
Solicitation on Topics Informing New Program Areas (DE-FOA-0001953)
"Downhole Tools to Enable Enhanced Geothermal Systems"

Notice Issue Date	December 20, 2018
Deadline for Questions to ARPA-E-CO@hq.doe.gov	5 PM ET, February 8, 2019
Submission Deadline for Full Applications	9:30 AM ET, February 19, 2019
Expected Date for Selection Notifications	May 2019
Total Amount to be Awarded	Approximately $2M total
Anticipated Awards	2-4 awards
Maximum Period of Performance	24 Months

1. Introduction

This announcement describes a research thrust titled "Downhole Tools to Enable Enhanced Geothermal Systems". The purpose of this announcement is to (1) focus the attention of the scientific and technical community on specific areas of interest related to the development of novel, ultra-high pressure and temperature sensors, (2) encourage dialogue amongst those interested in this area, and (3) provide a timetable for the submission of full applications.

2. Topic Description

The United States possesses a massive strategic asset in its supply of geothermal energy: deep, extremely hot (3-10 km, 150-350+ ºC) enhanced geothermal systems (EGS) represent a potential zero-carbon resource capable of delivering hundreds of gigawatts of baseload electricity with a small land footprint per unit power.[34,35] Moreover, utilizing this resource leverages many of the domestic oil & gas (O&G) industry's sophisticated subsurface techniques and sources of human capital. However, US geothermal production has been stagnant at 2-3 GW for decades, owing to difficult technical requirements, high risk profiles, long payback times, and geographic limitations for shallow (< 3 km), more easily accessible hydrothermal sites.

EGS has the potential to improve the economics and lessen the geographic restrictions on geothermal energy, but unlocking this resource will require step-changes in reservoir engineering capabilities. In particular, there is a strong need to measure rock stress state,

[34] Tester, J.W., Anderson, B.J., Batchelor, A.S., Blackwell, D.D., DiPippo, R., Drake, E., Garnish, J., Livesay, B., Moore, M.C., Nichols, K. and Petty, S., 2006. The future of geothermal energy: Impact of enhanced geothermal systems (EGS) on the United States in the 21st century. Massachusetts Institute of Technology, 209.

[35] Goldstein, B., Hiriart, G., Bertani, R., Bromley, C., Gutiérrez-Negrín, L., Huenges, E., Muraoka, H., Ragnarsson, A., Tester, J., Zui, V., 2011: Geothermal Energy. In IPCC Special Report on Renewable Energy Sources and Climate Change Mitigation [Edenhofer, O., Pichs-Madruga, R., Sokona, Y., Seyboth, K., Matschoss, P., Kadner, S., Zwickel, T., Eickemeier, P., Hansen, G., Schlömer, S., von Stechow, C. (eds)], Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

temperature, and permeability during reservoir development, as well as geofluid flow rates, temperatures, and steam fractions during operation.[36]

A wide variety of downhole sensing tools have been developed for O&G applications. Many of these tools are rated to 150–175 ºC and thus suitable for low-temperature geothermal systems, but there is a substantial technological gap in tools suitable to the high-temperature environments relevant to deep EGS. [37] Further complicating matters, when compared to traditional O&G, EGS rock formations are harder and less homogeneous, fluid compositions can be more corrosive, and operators work within tighter economic constraints.[38] Thus, while tools developed for O&G may provide sources of inspiration, they are far from uniformly transferable to EGS.

ARPA-E seeks novel low-cost sensor technologies capable of mitigating risks and lowering costs in EGS development by better characterizing rock formations and fluid enthalpy at depth. Technologies of interest include but are not limited to fiber-optic sensors and enthalpy measurement devices, as well as companion electronics and communications equipment. Successful projects will facilitate reservoir creation and maintenance, reduce unexpected reservoir behavior, and ultimately lower costs associated with EGS. Successful technologies developed for this purpose may also offer side benefits in applications including O&G, subsurface energy/CO_2 storage, aerospace and automotive engineering, nuclear energy, and space exploration.

A. Technical Areas of Interest

High-temperature downhole sensing tools for reservoir engineering, including but not limited to the following two categories:

A. Fiber-optic based sensors, such as distributed acoustic sensing (DAS), distributed temperature sensing (DTS), and distributed strain sensing (DSS).
B. Sensors that measure geofluid enthalpy; in particular, devices that measure real-time flowrate, temperature, steam fraction and pressure.

Integrated sensors that can serve more than one function over the course of operations (e.g. strain and flow measurements) are encouraged.

[36] Reinsch, T., Dobson, P., Asanuma, H., Huenges, E., Poletto, F. and Sanjuan, B., 2017. Utilizing supercritical geothermal systems: a review of past ventures and ongoing research activities. Geothermal Energy, 5(1), p.16.
[37] DeBruijn, G., Skeates, C., Greenaway, R., Harrison, D., Parris, M., James, S., Mueller, F., Ray, S., Riding, M., Temple, L., Wutherich, K., 2008. High Pressure, High Temperature Technologies. Oilfield Review p.46.
[38] Gehringer, M., Loksha, V., 2012. Geothermal Handbook: Planning and Financing Power Generation. ESMAP Technical Report 002/12. World Bank, Washington, DC.

B. Technical Performance Targets

Across both categories:

- Continuous (>100 hour) operation at >280 ºC/>100 bar/30,000 ppm total dissolved solids (TDS); ideally above >373 ºC/>221 bar/300,000 ppm TDS.
- Maximum diameter of 5".
- > 99% measurement accuracy over instrument lifetime.
- Compatibility with standard signal processing equipment.
- Measurement resolution and sensitivity matching or exceeding the state-of-the-art in analogous sensors made for oil & gas applications.
- Costs, once scaled up, that are no higher than those of analogous sensors made for oil & gas applications.

Specific to Category A:

- Spatial resolution of < 1 m in 10 km.
- Scalability to > 10 km fiber length.

Specific to Category B:

- Measurement location should be precisely known or easily derived.
- Quantification of both low flowrates characteristic of small fractures (Darcy regime) and high flowrates characteristic of wellbores (> 80 kg/s).
- Flow direction measurement capabilities.

3. Submissions Specifically Not of Interest

Submissions that propose the following may be deemed nonresponsive and may not merit review or be considered:

- Tools that have a maximum operating temperature of ≤ 280 ºC.
- Solutions applicable to only shallow (< 3km) depths.
- Incremental advances to existing tools.
- High-temperature electronics/optics without a downhole sensor.
- Models without developing a new technology.
- Development of new wells.
- Improvements to practice without developing a new technology.

IV. APPENDIX D: Diagnostic Resource Teams to Support the Validation of Potentially Transformative Fusion-Energy Concepts

Special Program Announcement for
Solicitation on Topics Informing New Program Areas
"Diagnostic Resource Teams to Support the Validation of Potentially Transformative Fusion-Energy Concepts"

Notice Issue Date	February 13, 2019
Deadline for Questions to ARPA-E-CO@hq.doe.gov	5 PM ET, April 5, 2019
Submission Deadline for Full Applications	9:30 AM ET, April 15, 2019
Expected Date for Selection Notifications	June 2019
Total Amount to be Awarded	Approximately $5M total
Anticipated Awards	3-5 awards
Maximum Period of Performance	24 Months

1. Introduction

This announcement describes a research thrust entitled "Diagnostic Resource Teams to Support the Validation of Potentially Transformative Fusion-Energy Concepts." The purpose of this announcement is to solicit submissions from experienced fusion researchers who have designed, implemented, and operated diagnostics for the characterization of high-temperature fusion plasmas. The immediate objectives of this Targeted Topic are:

a. Realizing plasma diagnostic systems, especially more costly or complex systems, that can be transported to and shared among different fusion experiments;
b. Enabling high-quality diagnostic measurements of plasma and fusion parameters on fusion-concept-exploration experiments supported by ARPA-E;
c. Leveraging the plasma diagnostic expertise of the entire fusion R&D community to advance potentially transformative fusion-concept research; and
d. Developing teams and experience to support a potential future expansion of diagnostic resource teams for fusion and private-public partnerships in general.

2. Topic Description

ARPA-E supports the exploration and development of potentially transformative fusion-energy concepts, with key aims of significantly lowering development costs and accelerating the timeline to commercial fusion energy. Most of the ARPA-E-supported fusion experiments would benefit from definitive diagnostic measurements to firmly establish the level of performance that has been achieved and/or to clearly identify issues if measured performance is worse than expected. In particular, several of these concepts are showing evidence of thermonuclear neutron production that could be consistent with ion temperatures above 1 keV (approximately 10 million degrees K). Measurements of key plasma parameters in these experiments are needed to confirm the observed neutron yields and determine whether they are consistent with

thermonuclear plasma conditions. Such measurements would improve our understanding of these concepts and help identify and correct any deficiencies, if necessary. All of the concepts, including those not yet at keV-level temperatures, would benefit from multi-point, spatially and temporally resolved measurements of plasma parameters and their spatial profiles to experimentally infer particle, energy, and magnetic-field transport.

Many of the needed diagnostics require significant expertise and/or expensive hardware that are beyond the typical resources available to an earlier-stage fusion project. The diagnostics (and the resources to operate them and analyze the data) can cost as much as or more than the fusion experiment itself, and typically these diagnostics are available only at national-scale fusion facilities. A primary aim of this Targeted Topic is to stretch limited resources such that multiple promising, earlier-stage fusion experiments can benefit from advanced measurements to validate their performance, uncover problems, and guide research priorities.

A. Technical Areas of Interest

This Targeted Topic prioritizes establishing baseline plasma and fusion performance of ARPA-E-supported fusion concepts with the characteristics listed in Table 1, especially using diagnostics that can be transported to and shared among multiple experiments. All credible fusion approaches with a plausible pathway to commercially viable fusion energy are potentially of interest to ARPA-E. However, the list in Table 1 represents the highest priority concepts for this Targeted Topic.

Table 2 provides the *approximate* range of parameters of interest, being achieved now or possibly within the next 1–2 years, for each class of concepts. Submissions in response to this Targeted Topic should target one or both of these concept classes and corresponding parameter ranges. Conclusive measurements of the peak equilibrium values of the plasma parameters of interest (given in Table 2) are the highest priority, followed closely by time-resolved, spatial profiles of the same quantities. For neutron measurements, the chief aims are to obtain an accurate value of the total yield and to determine whether the yield is thermonuclear- or beam-dominated. It is expected that some combination of measuring both neutron energy spectra as well as spatial isotropy may be needed, depending on the class of concept. In addition, detailed Monte-Carlo modeling of neutron scattering for each experimental environment will likely be required. Diagnosis of neutron energy spectra for fusion-burn durations of order 1–10 μs is highly desirable for pulsed, intermediate-density concepts but presents challenges.

More advanced measurements to provide a deeper understanding of equilibrium, stability, and confinement (e.g., fluctuating quantities, particle distribution functions, etc.) are lower priority at this time, but remain of interest for a potential future expansion of this program. Similarly, activities to generate synthetic data are low priority under this Targeted Topic, but may be of interest in the future.

Submissions including scopes of work to help facilitate more routine use of shared diagnostics in the future, e.g., design and implementation of standardized chamber-to-diagnostic port interfaces for use on all smaller-scale fusion experiments, are encouraged. It would be desirable for the fusion R&D community to agree on standard ports for particular diagnostics going into the future.

Table 1. Priority concepts for which diagnostic measurements are solicited under this Targeted Topic.

Concept	**Class**	**Plasma size/ duration**	**Priority measurements**
Flow-shear-stabilized Z pinch [1–3]	Pulsed, intermediate-density	L=50 cm r≈0.15 cm τ_{plasma}≈ 50 μs $\tau_{neutrons}$≈5 μs	T_e, neutron energy spectrum, internal B-field, ion velocity and T_i
Staged Z pinch (gas-puff liner compressing a gas-puff Z pinch) [4–6]	Pulsed, intermediate-density	L=1 cm r≈2→0.02 cm τ_{plasma}≈120 ns $\tau_{neutrons}$≈2 ns	Neutron isotropy and energy spectrum, T_e, T_i, n_e, internal B-field
Magnetic compression of merged FRCs [7,8]	Pulsed, intermediate-density	L=30 cm r≈4 cm τ_{plasma}≈ 100 μs $\tau_{neutrons}$≈10 μs	n_e , T_e , T_i, Z_{eff} (in D plasma), radiated power
FRC sustained and heated by rotating magnetic field [9,10]	Magnetically confined	L≈15 cm r≈5 cm τ_{plasma}≈300 ms	n_e and T_e profiles, B-field polarity and profile, density fluctuations (0.01–1 cm; 0.1–200 MHz)
Spheromak sustained by imposed dynamo current drive [11–14]	Magnetically confined	R≈34 cm r≈24 cm elong.≈1.2 τ_{plasma}≈2–5 ms	n_e , T_e , T_i profiles

B. Submissions Specifically Not of Interest

- Significant development to demonstrate diagnostic feasibility or new diagnostic approaches (i.e., successful proposals should focus on adapting or extending proven diagnostic methods to the ARPA-E fusion experiments and in "packaging" the diagnostic for versatility, adaptability, and transportability)
- Generation of synthetic diagnostic signals from numerical simulations that require significant effort.

Table 2. Parameters of interest and their approximate range of values for the two classes of priority concepts given in Table 1.

Parameter of interest	Magnetically confined	Pulsed, intermediate density
Ion and electron density	10^{13}–10^{14} cm^{-3}	10^{16}–10^{21} cm^{-3}
Electron temperature	10–2000 eV	100–3000 eV
Ion temperature	10–2000 eV	100–10000 eV
Magnetic field	0.1–3 T	1–1000 T
Neutron yields	N/A	10^{6}–10^{12} (DD)
Neutron energy	N/A	2.3–2.8 MeV w/few-keV resolution
Neutron duration	N/A	10 ns – 10 μs
Desired time resolution	< 100 μs	1–1000 ns
Desired spatial resolution	< 1 cm	< 1 mm

3. Modifications to Technical Volume Template

Due to the narrow focus of this Targeted Topic on diagnostics in support of ongoing ARPA-E-sponsored fusion experiments, please follow these instructions in using the required Technical Volume template.

- Address Sec. 1, Innovation and Impact, in the narrow context of the diagnostics and measurements being proposed, and not in the context of the fusion concept/experiment for which the measurements are intended. The innovation being sought (Sec. 1.3) is in packaging proven diagnostic technologies for versatility, adaptability, and transportability.
- In Sec. 2.2, please include diagnostic design and implementation, as well as involvement in fielding the diagnostic and performing data analysis on the remote experiment(s), with a commensurate budget request. Please include the following table summarizing your proposed measurements and diagnostics.

Quantity measured	Diagnostic method	Range and resolution	Concept(s)	Spatial/ temporal resolutions	How many spatial points?
#1		e.g., $T_{e,low}$–$T_{e,high}$ ($\pm\ \delta T_e$)	Sustained spheromak and FRC, etc.	$\delta \boldsymbol{x}$, δt	
#2					
etc…					

- In Sec. 2.3, please indicate the schedule to readiness for the first measurement, and the minimum interval time required between take-down and readiness for the next measurement at a different experiment. Proposing teams are strongly encouraged to aim for

very aggressive schedules, with first measurement in < 9 months and interval time measured in days or a few weeks, with a commensurate budget request.

- Skip Secs. 4.1 and 4.2, and address Sec. 4.3 as instructed in the Technical Volume template, with a commensurate reduction in overall length of Sec. 4 from the original suggested total of 2 pages.

Submissions are *not* expected to provide highly detailed diagnostic designs, as ARPA-E recognizes that this is possible only after an Award Recipient is able to work closely with a fusion-concept team to determine the details of the plasma parameters, port positions and access, etc. ARPA-E will facilitate interactions between Award Recipients and the fusion-concept groups. It is expected that a mutually agreeable arrangement to manage the treatment of existing data and to manage the data and intellectual property arising from those interactions will be developed between the Award Recipients and fusion-concept groups.

The merit review criteria is defined in Section V.A.1 of the FOA. The following will be considered as part of the evaluation under Merit Review Criteria (1), Impact of the Proposed Technology (30%): ability to enable measurements on the priority concepts listed in Table 1. The following will be considered as part of the evaluation under Merit Review Criteria (2), Overall Scientific and Technical Merit (30%): versatility, adaptability, and transportability of the proposed diagnostics per cost, aggressiveness of schedule to first and subsequent measurements, and minimum development with regard to diagnostic feasibility/principle. Funds for this potential Targeted Topic are limited so teams are encouraged to adopt strategies to limit costs, e.g., use of existing equipment is encouraged but not required.

References

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[2] U. Shumlak et al., Phys. Plasmas **24**, 055702 (2017).
[3] https://arpa-e.energy.gov/sites/default/files/03_SHUMLAK.pdf.
[4] J. Narkis et al., Phys. Plasmas 23, 122706 (2016).
[5] F. Conti et al., IEEE Trans. Plasma Sci. **46**, 3855 (2018).
[6] https://arpa-e.energy.gov/sites/default/files/04_WESSEL.pdf.
[7] J. Slough et al., Nucl. Fusion **51**, 053008 (2011).
[8] https://arpa-e.energy.gov/sites/default/files/05_KIRTLEY.pdf
[9] P. Jandovitz et al., Phys. Plasmas **25**, 030702 (2018).
[10] C. Swanson et al., AIP Advances **8**, 025222 (2018).
[11] T. R. Jarboe et al., Nucl. Fusion **52**, 083017 (2012).
[12] B. S. Victor et al., Phys. Plasmas **21**, 082504 (2014).
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[14] A. C. Hossack et al., Nucl. Fusion **57**, 076026 (2017).

V. APPENDIX E: QUANTIFICATION OF EFFECTIVENESS OF NUTRIENT BIOEXTRACTION BY SEAWEED

Special Program Announcement for
Solicitation on Topics Informing New Program Areas (DE-FOA-0001953)
"Quantification of Effectiveness of Nutrient Bioextraction by Seaweed"

Topic Issue Date	March 12, 2019
Deadline for Questions to ARPA-E-CO@hq.doe.gov	5 PM ET, May 1, 2019
Submission Deadline for Full Applications	9:30 AM ET, May 13, 2019
Expected Date for Selection Notifications	July 2019
Total Amount to be Awarded	Approximately $1M total, maximum $300K per award
Anticipated Awards	3-5 fixed-amount grants
Maximum Period of Performance	24 Months

1. Introduction

This announcement describes a research thrust titled "Quantification of Effectiveness of Nutrient Bioextraction by Seaweed". The purpose of this announcement is to (1) solicit proposals focused on the development of enabling solutions capable of quantifying fate and transport of biologically relevant nitrogen species with high-spatial and high-temporal resolution in the context of seaweed farms in the marine environment, and (2) provide a timetable for the submission of Full Applications.

2. Topic Description

Nitrogen migration from anthropogenic sources, such as agricultural runoff or wastewater discharge, is responsible for eutrophication of marine systems causing anoxia, ecological disruption and reduction in productivity of natural systems and fisheries. Eutrophication can result in widespread "dead zones" and contribute to proliferation of toxic microalgae and/or cyanobacteria, as recently seen on Florida's Gulf Coast.

One potential solution is the large-scale cultivation of nitrogen-fixing seaweeds in these eutrophic marine systems. Seaweeds are non-vascular macroalgae plants capable of rapid growth via carbon fixation and effective uptake of nitrogen, predominately in the form of nitrate. When deployed in eutrophic marine systems, cultivation of seaweeds on a large scale may provide local, and possibly regional, mitigation of excess nutrient concentration via bioextraction. ARPA-E's MARINER program targets the development and deployment of new technologies for the economically viable production of seaweeds on a scale sufficient for bioenergy production.

The effectiveness of deploying seaweed farms for nutrient concentration extraction will be significantly influenced by local and regional geographic conditions. It is therefore important to identify the geographies along US coastlines that are the most suitable candidates for testing and deploying this eutrophication mitigation strategy.

In addition to the revenue from the harvested seaweed, seaweed farms deployed in eutrophic marine areas could generate additional benefits – and potentially revenue – for the ecosystem services they provide. In order to appropriately value the nutrient mitigation services provided by seaweed cultivation, appropriate methodologies are needed for accurate, low-cost nitrogen monitoring within the context of seaweed farming systems to quantify the amount of nitrogen present and assimilated by seaweed cultivation. ARPA-E seeks solutions that will add value to the MARINER program and provide technology-to-market (T2M) opportunities for large scale seaweed cultivation.

A. Technical Areas of Interest

A proposal can cover one, two, or all three technical areas of interest outlined below.

1. Identification of geographies where seaweed farms could have a proximal positive impact on nitrogen removal, including empirical assessment of nitrogen loading on a temporal basis. Specifically, ARPA-E envisions that seaweed farms should have a "local" effect to remove nitrogen and improve water quality for enhancement of ecosystem productivity. With that goal in mind, geographic areas of high nitrogen inundation need to be assessed for seaweed farm production. Target geographic areas will require temporal nitrogen assessment to quantify and compare the seasonality of nitrogen influx with the biological growing season of seaweeds.

2. Concepts for real-time assessment and validation of nitrogen flux and uptake within and around macroalgae farms. Specifically, new solutions are required for accurately monitoring the transport and fate of nitrogen in and around individual seaweed farms with appropriate spatial and temporal resolution. Current monitoring techniques mostly rely on laborious manual sampling and analysis resulting in low-to-moderate spatial and temporal resolution. Such data is a challenge to interpret and less likely to influence management decisions. ARPA-E is therefore interested in the development of solutions that integrate spatially distributed analytical monitoring with computational modeling of nitrogen transport through and uptake by seaweed farms.

3. Validated methods for rapid and reliable determination of the nitrogen tissue content of seaweed. When seaweed is harvested, the amount of nitrogen contained in its tissue is the minimal amount of nitrogen removed from the local environment. In order to attribute a proper value for this removal service, accurate and reliable measurements of the nitrogen content are crititical. The desired quantification methods need to be able to take into account and appropriately standardize the timing and conditions of harvest, the storage conditions until analysis, and any required sample preparation procedures for the species of seaweed under consideration.

B. Technical Performance Targets

Proposed solutions must address the following performance parameters. Recognizing the tradeoffs that will exist between these performance parameters, ARPA-E is not providing specific quantitative guidance, but submissions should include a justification for why the performance targets chosen by the applicant are appropriate relative to the project goals.

1. Identification and assessment of coastal geographies where seaweed farming will have high potential to locally reduce nitrogen eutrophication and improve water quality and ecosystem productivity.
    - Temporal and spatial survey of nitrogen loads in marine geographic area(s) with high potential to benefit from large scale (100+ hectares) seaweed cultivation.
    - Quantification of localized nitrogen reduction targets that need to be achieved for meeting remediation goals.
2. System-level solutions for real-time assessment and validation of nitrogen flux and uptake within and around macroalgae farms, combining computational modeling and field measurements.
    - Modelling of the rate of nitrogen uptake by a large scale seaweed farm under nutrient conditions representative of typical problem zones, and the projected nutrient levels at equilibrium conditions in farmed areas at the regional level (1 ha resolution) and farm-level (1 m^3 resolution).
    - Integration of modelling with field data acquisition, including specification of sampling frequency and analytical accuracy required.
    - Credible experimental design, including mass balances incorporating nitrogen concentration in macroalgal biomass, for validation of projected net impact of a macroalgae farm on nitrogen levels in the water column.
    - Economic analysis evaluating the cost of the solution, when deployed on an actual farm
    - Easy to deploy and operate (either as a farm-installed system or as a service)
3. Method development for quantification of nitrogen content in macroalgal biomass:
    - Highly reproducible measurement of total nitrogen content of seaweed grown in eutrophic marine environments.
    - Procedures for sample collection, storage, and preparation that can be reliably conducted in marine farm operations.
    - Benchmarking of the proposed methods to well established and validated procedures.

3. Submissions Specifically Not of Interest

- New methods for large scale macroalgae cultivation and harvesting
- Macroalgae breeding and genetics
- Processing of harvested macroalgae
- Development of completely new sensor technologies

4. ARPA-E Funding Agreement

ARPA-E anticipates awarding fixed-amount grants resulting from this Targeted Topic. ARPA-E will only award a fixed-amount grant in instances where it can be assured that the prospective awardee will not realize any increment above the actual cost of performing work. Equal payments will be made, one each upon submission and acceptance by ARPA-E of the quarterly report demonstrating sufficient technical progress. The final payment also requires certification to ARPA-E that all project activity has been completed. For additional information about fixed-amount awards refer to 2 C.F.R. § 200.45 and 2 C.F.R. § 200.201.

In addition to the aforementioned certification, awardees will be required, *inter alia*, to submit a final technical report to ARPA-E and to obtain prior approval of the ARPA-E Contracting Officer for changes in principal investigator, project partner, or scope of project effort.

The maximum amount of any grant awarded under this Targeted Topic is $300,000. As set forth at FOA Section III.B, cost share is not required for awards resuting from this Targeted Topic.

5. Content and Form of Full Applications

Not withstanding the instructions at FOA Section IV.C, the content of Full Applications are limited to the following:

Component	Required Format	Description and Information
Technical Volume (Fixed-Amount Grant)	PDF	The centerpiece of the Full Application. Provides a detailed description of the proposed R&D project and Applicant Team. A Technical Volume template is available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov/).
SF-424	PDF	Application for Federal Assistance (https://arpa-e-foa.energy.gov/). Applicants are responsible for ensuring that the proposed amounts listed in eXCHANGE match those listed on forms SF-424 and SF-424A. Inconsistent submissions may impact ARPA-E's final award determination.
SF-424A (Fixed-Amount Grant)	XLS	Budget Information – Non-Construction Programs (https://arpa-e-foa.energy.gov/)
Business Assurances & Disclosures Form	PDF	Requires the Applicant to make responsibility disclosures and disclose potential conflicts of interest within the Applicant Team. Requires the Applicant to 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

Component	Required Format	Description and Information
		the Applicant to request a waiver or modification of the Performance of Work in the United States requirement. This form 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.
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. See detailed U.S. Manufacturing Plan instructions and examples in the Seventh Component description below.

Detailed guidance on the content of the Technical Volume, SF-424, Business Assurances & Disclosures Form, and U.S. Manufacturing Plan can be found in FOA Section IV.C at paragraphs One, Two, Six and Seven respectively. Guidance on the content of the SF-424A can be found on its p.2.

Templates for preparing Full Applications under this Targeted Topic may be found on ARPA-E Exchange at ARPA-E-CO@hq.doe.gov.

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