

**Plane FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT**



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

***PIONEERING RAILROAD, OCEANIC, AND PLANE
ELECTRIFICATION WITH 1K ENERGY STORAGE SYSTEMS
SBIR/STTR (PROPEL-1K SBIR/STTR)***

Announcement Type: Initial Announcement
Funding Opportunity No. DE-FOA-0003163
CFDA Number 81.135

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| Funding Opportunity Announcement (FOA) Issue Date: | September 1, 2023 |
| Deadline for Questions to ARPA-E-CO@hq.doe.gov: | 5 PM ET, October 6, 2023 |
| Submission Deadline for Full Applications: | 9:30 AM ET, October 17, 2023 |
| Submission Deadline for Replies to Reviewer Comments: | 5 PM ET, November 27, 2023 |
| Expected Date for Selection Notifications: | January 2024 |
| Total Amount to Be Awarded | Approximately \$30 million, subject to the availability of appropriated funds to be shared between FOAs DE-FOA-0003162 and DE-FOA-0006163. |
| Anticipated Awards | ARPA-E may issue one, multiple, or no awards under this FOA. Awards may vary between \$295,924 and \$4,241,580. |

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

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

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REQUIRED DOCUMENTS CHECKLIST

For an overview of the application process, see Section IV.A of the FOA. For guidance regarding requisite application forms, see Section IV.B of the FOA.

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

| SUBMISSION | COMPONENTS | OPTIONAL/ MANDATORY | FOA SECTION | DEADLINE |
|------------------|---|------------------------|----------------|------------------------------------|
| Full Application | <ul style="list-style-type: none">Each Applicant must submit a Technical Volume in Adobe PDF format by the stated deadline. The Technical Volume must include the following:<ul style="list-style-type: none">Executive Summary (1 page max.)Sections 1-5 (12 pages max.)<ul style="list-style-type: none">1. Innovation and Impact2. Proposed Work3. Team Organization and Capabilities4. Technology to Market5. BudgetBibliographic References (no page limit)Personal Qualification Summaries (each Personal Qualification Summary limited to 3 pages in length, no cumulative page limit)Appendix 1: Levelized Cost of Storage Table (1 page maximum). Applicants may use the LCOS Table template in Section I.H.; andAppendix 2 (only as required): Non-Electrochemical Justification (1 page maximum).The Technical Volume must be accompanied by:<ul style="list-style-type: none">Energy Density Workbook (no page limit, Microsoft Excel format) (optional, encouraged) – applicants may use the PROPEL-1K Energy Density Workbook template available on ARPA-E eXCHANGE (https://arpa-e-foa.energy.gov);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);SBA Company Registration Certificate generated in the SBA Company Registry; (http://sbir.gov/registration) (Adobe PDF format);If applicable, Certification for Applicants that are (a) Majority-Owned by Multiple Venture Capital Operating Companies, Hedge Funds, or Private Equity Firms; and/or (b) joint ventures minority-owned by a foreign entity (Adobe PDF format); | Mandatory | IV.C | 9:30 AM ET, October 17, 2023 |

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|----------------------------|---|----------|------|----------------------------|
| | <ul style="list-style-type: none">○ Summary Slide (1 page limit, Microsoft PowerPoint format); and○ Completed and signed Business Assurances & Disclosures Form (no page limit, Adobe PDF format). | | | |
| Reply to Reviewer Comments | <ul style="list-style-type: none">• Each Applicant may submit a Reply to Reviewer Comments in Adobe PDF format. This submission is optional. The Reply may include:<ul style="list-style-type: none">○ Up to 2 pages of text; and○ Up to 1 page of images. | Optional | IV.D | 5 PM ET, November 27, 2023 |

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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), as further amended by the Energy Act of 2020 (P.L. 116-260):

- “(A) to enhance the economic and energy security of the United States through the development of energy technologies that—
- (i) reduce imports of energy from foreign sources;
 - (ii) reduce energy-related emissions, including greenhouse gases;
 - (iii) improve the energy efficiency of all economic sectors;
 - (iv) provide transformative solutions to improve the management, clean-up, and disposal of radioactive waste and spent nuclear fuel; and
 - (v) improve the resilience, reliability, and security of infrastructure to produce, deliver, and store energy; 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 its authorizing statute codified at 42 U.S.C. § 16538. The FOA and any cooperative agreements or grants made under this FOA are subject to 2 C.F.R. Part 200 as supplemented by 2 C.F.R. Part 910.

ARPA-E funds research on, and the development of, transformative science and technology solutions to address the energy and environmental missions of the Department. 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 improvements to the cost/performance metric in a gradual fashion. This continual improvement of a technology is important to its increased commercial deployment and is appropriately the focus of the private sector or the applied technology offices within DOE. In contrast, ARPA-E supports transformative research that has the potential to create fundamentally new learning curves. ARPA-E technology projects typically start with cost/performance estimates well above the level of an incumbent technology. Given the high risk inherent in these projects, many will fail to progress, but some may succeed in generating a new learning curve with a projected cost/performance metric that is significantly better than that of the incumbent technology.

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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 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 (defined by the Office of Management and Budget as “experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundations of phenomena and observable facts”)² 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 and Carbon Management (<https://www.energy.gov/fecm/office-fossil-energy-and-carbon-management>), the Office of Nuclear Energy (<http://www.energy.gov/ne/office-nuclear-energy>), and the Office of Electricity (<https://www.energy.gov/oe/office-electricity>).

B. SBIR/STTR PROGRAM OVERVIEW

The Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) programs are Government-wide programs authorized under Section 9 of the Small Business Act (15 U.S.C. § 638). The objectives of the SBIR program are to (1) stimulate technological innovation in the private sector, (2) strengthen the role of Small Business Concerns in meeting Federal R&D needs, (3) increase private sector commercialization of innovations derived from Federal R&D activities, (4) foster and encourage participation by socially and economically disadvantaged and women-owned Small Business Concerns, and (5) improve the return on

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

² OMB Circular A-11 (https://www.whitehouse.gov/wp-content/uploads/2018/06/a11_web_toc.pdf), Section 84, pg. 3.

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investment from Federally funded research and economic benefits to the Nation. The objective of the STTR program is to stimulate cooperative partnerships of ideas and technologies between Small Business Concerns and partnering Research Institutions through Federally funded R&D activities.³

ARPA-E administers a joint SBIR/STTR program in accordance with the Small Business Act and the SBIR and STTR Policy Directive issued by the U.S. Small Business Administration (SBA).⁴ ARPA-E provides SBIR/STTR funding in three phases (Phase I, Phase II, and Phase IIS).

C. PROGRAM OVERVIEW

1. INTRODUCTION

In the United States (U.S.), transportation is responsible for approximately 29% of total greenhouse gas (GHG) emissions annually.⁵ Light-duty vehicles, i.e., passenger and small commercial vehicles, account for 58% of transportation GHG emissions, and battery-powered electric vehicles (EVs) have emerged as a lower-emission solution for many applications. In these cases, the energy density of existing battery technologies is sufficient while the priority areas for improvement include cost, safety, lifetime, charge time, and supply chain sustainability. The majority of the remaining 42% of transportation GHG emissions are attributed to long-distance trucking (23%), aviation (8%), railroads (2%), and maritime (3%). The contributions of individual transportation categories to GHG emissions according to the Environmental Protection Agency (EPA) are shown in Figure 1.

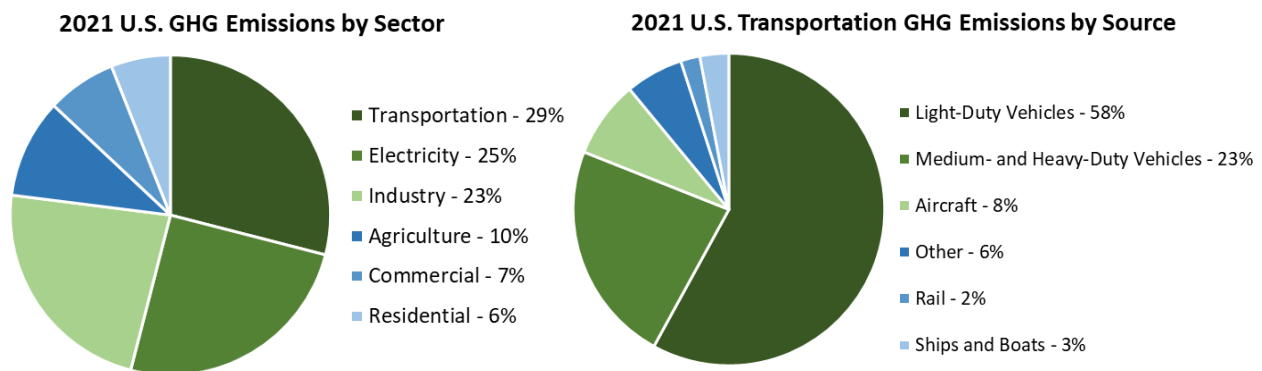


Figure 1. U.S. GHG emissions by sector (left) and transportation sector by type (right).⁶

³ Research Institutions include FFRDCs, nonprofit educational institutions, and other nonprofit research organizations owned and operated exclusively for scientific purposes. Eligible Research Institutions must maintain a place of business in the United States, operate primarily in the United States, or make a significant contribution to the U.S. economy through the payment of taxes or use of American products, materials, or labor.

⁴ See 85 Fed. Reg. 50062 (Aug. 17, 2020).

⁵ <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>

⁶ <https://www.epa.gov/greenvehicles/fast-facts-transportation-greenhouse-gas-emissions>

Global energy consumption is expected to increase by 50% between now and 2050.⁷ At the same time, attaining net zero or even negative GHG emissions is critical to our climate. Electrification of the transportation sector is a bold and essential strategy toward achieving net zero carbon emissions by 2050. A multitude of technologies and approaches will be required to achieve these ambitious goals.

Batteries and fuel cells represent potential solutions; however, for heavy-duty vehicles, vessels and aircraft, the maximum achievable energy density (by mass and by volume) for both existing and anticipated next-generation electrochemical energy storage technologies is impractically too low. This **Pioneering Railroad, Oceanic and Plane E**lectrification with **1K** Energy Storage Systems (**PROPEL-1K**) program aims to support the research and development of alternative approaches to energy storage to ultimately achieve a > 4x improvement compared to existing state-of-the-art (SoA) options. The technical scope encompasses electrochemical and/or chemical solutions that do not require hydrocarbon-based fuels (fossil or synthetic). The targets for these energy storage system (ESS) solutions are 1000 Watt-hour per kilogram (Wh/kg) and 1000 Watt-hour per liter (Wh/L) (so-called “1K” technologies) at the end of life (EOL) and at the net ESS level. Of particular interest are technologies that are not mere extensions of current mainstream electrochemical device thinking or short-term technology road maps. The primary program objective is to develop exceptionally high-energy storage solutions, capable of catalyzing broad electrification of the aviation, railroad, and maritime transportation sectors.

- (a) **Aviation:** PROPEL-1K can enable regional flight up to 1000 miles (700 nautical miles [nm] with reserve) on aircraft transporting up to 100 people.
- (b) **Railroads:** PROPEL-1K can electrify all North American railroads and enable cross-country travel in the U.S. with fewer stops and reduced infrastructure required for charging or refueling.
- (c) **Maritime:** PROPEL-1K is expected to enable the electrification of all vessels that operate exclusively in U.S. territorial waters (ferries, barges, tugs, and Jones Act freight).

Note: The PROPEL-1K program targets aviation, railroad and maritime, however, it may also provide benefits for long-distance trucking.

2. BACKGROUND

Energy density has historically been the dominant attribute for energy storage of electrified passenger vehicles, with both gravimetric (Wh/kg) and volumetric (Wh/L) energy density varying in relative importance. Early battery-powered cars utilized low-energy density chemistries, such as lead acid or nickel metal hydride,⁸ although with the advent of commercial lithium-ion batteries (LiBs) in 1991, new options have emerged. LiB cells with energy densities of 100 Wh/kg and 250 Wh/L, respectively, were the obvious choice for laptop computers and other consumer devices where weight and volume are by far the most critical factors.

⁷ <https://www.eia.gov/outlooks/ieo/>

⁸ Murray, C. J. (2022). *Long Hard Road: The Lithium-Ion Battery and the Electric Car* (Chapter 6). Purdue University Press.

Ultimately, improvements to energy density, and most importantly cost,⁹ enabled LiBs to be widely adopted for electrified passenger vehicles.

Typical SoA attributes of LiB cells for EVs today include:

- 285 Wh/kg;
- 650 Wh/L;
- 1000 cycles to 80% of initial capacity;
- 30-minute charge time to 80% of full capacity; and
- \$120/kWh.

Note these parameters (i) correspond to individual cells and not to fully integrated battery packs, and (ii) assume that the full state of charge (SoC) is utilized and do not fully appreciate the difference between the beginning of life and EOL. Collectively, these factors can reduce the practical energy density to less than half of the original cell-level values.¹⁰

Although widespread electrification of passenger vehicles can be achieved with existing battery chemistries, solutions capable of enabling electrification of planes, trains, and ships remain elusive. These heavy-duty vehicles and vessels present significant challenges, not the least of which are their “workhorse” duty cycles and the decades of operational life over which they are required to perform safely and reliably. Realistically, electrification of these transportation sectors requires transformational technological advancements in energy storage that cannot be achieved via (i) incremental improvements to existing LiB chemistries, (ii) LiBs featuring silicon (Si) anodes, or (iii) all solid-state batteries containing lithium metal anodes coupled with commercial cathodes.

Considering the ambitious energy density targets defined in Section I.F, the traditional energy storage device “playbook” must be discarded. An overwhelming majority of batteries “live” in multiple-stacked boxes, are “plugged-in” to charge, and in the case of passenger EVs, are used only 5% of the time. For the remaining 95%, EVs are typically parked with a battery that is either idle or charging slowly. In sharp contrast, for the transportation sectors of interest to the PROPEL-1K program, the energy storage device will be required to (1) operate continuously over extended periods of time, (2) refuel/recharge/reset rapidly, (3) achieve exceptional longevity, including operation in harsh environments, and (4) achieve a level of safety in which thermal runaway and solvent conflagration cannot occur. An ESS that can deliver ≥ 1000 Wh/kg and ≥ 1000 Wh/L would represent a $> 4x$ improvement relative to today’s SoA LiB solutions, which is necessary if the large amounts of energy required to propel these vehicles and vessels is going to be of a practical size and weight. Specifically, this program strives to accelerate the electrification of applications that require up to 100 megawatt-hour (MWh) of stored energy to accomplish their missions.

⁹ <https://about.bnef.com/blog/behind-scenes-take-lithium-ion-battery-prices/> [Bloomberg NEF, March 5, 2019].

¹⁰ Viswanathan, V., Epstein, A.H., Chiang, Y.M. et al. The challenges and opportunities of battery-powered flight. *Nature* 601, 519–525 (2022). <https://doi.org/10.1038/s41586-021-04139-1>

There are typically seven discrete “packaging steps” for a conventional LiB ESS, as shown in Figure 2. In contrast, the innovation strategy encouraged by the PROPEL-1K program represents a diversion from traditional paradigms. PROPEL-1K starts with dismissing “package” constraints altogether and instead considers the extent to which removing the restrictions imposed by conventional materials and practices for energy storage packaging permits approaching the theoretical energy densities of a chemical or electrochemical system. As the constraints of classical energy storage thinking are reconsidered, operating temperature, fuels versus oxidizers, energy versus power, and the physical boundaries of the ESS are all subject to being redefined. As an example, there may be opportunities to combine steps or functions and even integrate the ESS into the structure of the vehicle to improve weight and volume.

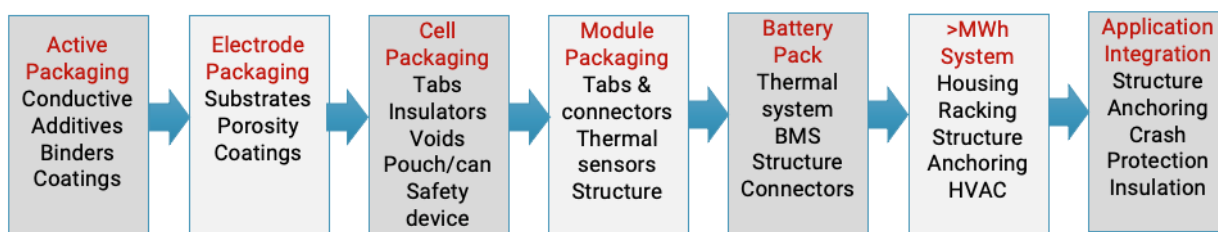


Figure 2. Typical “packaging steps” for a lithium-ion ESS (multiple-stacked boxes).

Anodes in batteries may be considered as fuels in that upon releasing energy, they are oxidized and donate electrons. Following “donation,” they can be regenerated either by electrical (i.e., charging) or mechanical (i.e., replenishing, recycling, or swapping out the “spent” oxidized anode material) methods. As indicated in Figure 3, the energy potential of metals as “fuels” may represent another intriguing technology proposition.

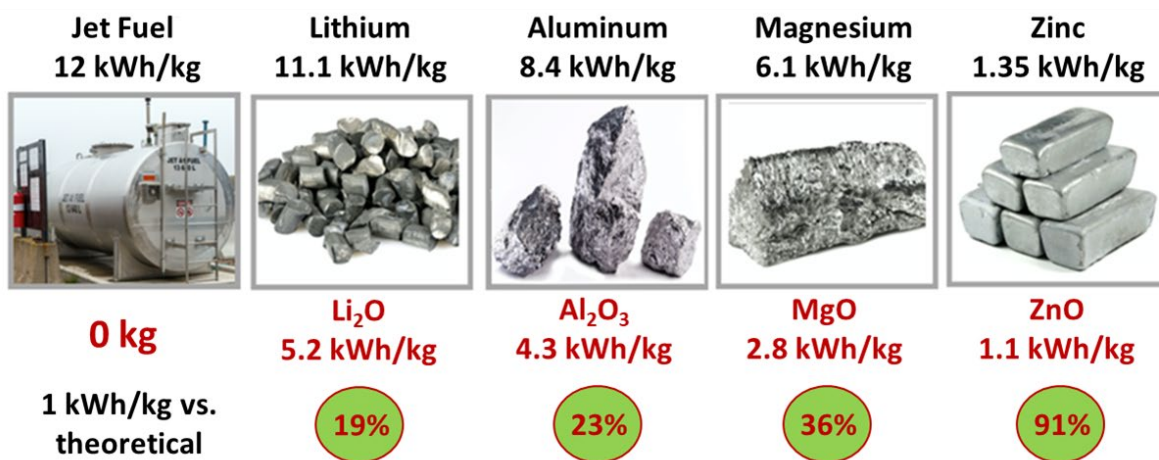


Figure 3. Theoretical energy densities of metals as fuels together with the corresponding oxides.

Notes regarding Figure 3:

Note (1): Sodium, calcium, and potassium may also have merit. Note (2): Hydrogen should not be excluded as it is also a ready “donor” of electrons. Note (3): Values in red represent the energy density based on the oxidized form that is expected to be retained on board the vehicle (jet fuel = 0).

Historically, energy storage devices have been characterized by extended development and commercialization timelines. Although the fundamental underlying mechanisms for lithium-ion were discovered in the 1970s, and a cathode to enable those primary processes was identified in 1980, the first commercial LiB product did not emerge until 11 years later (1991).¹¹

Subsequently, it took an additional 20 years for LiBs to achieve the energy and cost required to position the technology as the leading option for EVs. Assuming an energy storage solution that can deliver ≥ 1000 Wh/kg and ≥ 1000 Wh/L is possible, then development needs to be initiated now to have a chance of realizing a meaningful impact towards ARPA-E’s mission goals.

D. PROGRAM OBJECTIVES

The overarching goal of the PROPEL-1K program is to advance emission-free, high-energy density, and high-power energy storage solutions to electrify domestic aircraft, railroads, and ships. It cannot be overemphasized that traditional strategies for developing batteries and ESS are not envisaged for this program, especially since they would almost certainly fall far short of achieving the primary goals. Specific program objectives considered to be critical for accomplishing this mission include the following:

1. gravimetric energy density ≥ 1000 Wh/kg;
2. volumetric energy density ≥ 1000 Wh/L;
3. turnaround time ≤ 30 minutes;
4. discharge energy efficiency $\geq 70\%$;
5. target system size 1 MWh to 100 MWh;
6. system manufacture ≤ 100 kg CO₂/kWh; and
7. zero CO₂, NO_x, SO_x emissions during operation of vehicle, vessel, or aircraft.

The PROPEL-1K program structure acknowledges that different vehicles and vessels have distinct power requirements and cost base. Therefore, this program is divided into two discrete development tracks (Categories A and B) that are primarily differentiated by peak power capability, continuous power capability, required system voltage, and levelized cost of storage (LCOS) targets: Category A targets a greater peak power and continuous power capability with higher LCOS category for “all-electric” aircraft and Category B targets a lower peak power and continuous power capability with reduced LCOS category for railroads and ships. While high-

¹¹ Murray, C. J. (2022). *Long Hard Road: The Lithium-Ion Battery and the Electric Car* (Chapter 5). Purdue University Press.

level descriptions of Categories A and B are provided immediately below, specific technical performance and cost targets, with descriptions, are provided in Section I.F. Applicants may respond to Category A, B, or both categories within the same application.

For all commercial transportation, while higher costs may be accommodated during the test and trial of vehicles with new technology, and for niche use cases, ultimately the costs must be lower than the incumbent solutions if widespread adoption is to be achieved.

Category A

While regional flights may involve shorter run-times compared to railroads and ships, the power requirements are much higher since an aircraft must have sufficient power for both take-off and the end of a flight should an aborted landing and “go-around” be necessary. In turn, higher power may necessitate more expensive conductive additives, thicker substrates, lower impedance surfaces/interfaces, higher mass conductors and/or more precise designs, etc. For this application, higher capital expenditure (CAPEX) may be tolerated if the cost of electric propulsion maintenance is reduced compared to conventional aircraft engines.

Category B

Trains and ships have relatively lower power (C-rate) requirements compared to electric aircraft, even when considering acceleration and terrain. At the same time, these transportation sectors have a reduced cost base compared to aviation, so that, any “all-electric” solution must have a lower total cost of ownership or \$/ton-mile.

E. TECHNICAL AREAS OF INTEREST

Example technologies specifically of interest, either as standalone solutions or **in combination**, include, but may not be limited to the following:

- electrochemical systems (batteries and fuel cells);
- “swappable” batteries/energy boxes that can be rapidly and seamlessly interfaced with vehicles and/or vessels;
- mechanically rechargeable solutions (e.g., “replaceable” anodes);
- platforms that separate energy and power;
- pumpable electroactive slurries, “goops,” and metal fuels;
- high temperature chemical or electrochemical systems (e.g., up to 800° C);
- systems that utilize external catholytes (e.g., air or seawater);
- approaches that intend to make primary battery chemistries rechargeable;
- systems that are inert and inherently safe, but can be activated or deactivated by external factor(s);
- solutions that combine electrochemical function with mechanical structure;
- technologies/designs that support high-voltage systems;

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).

- systems that operate with high coulombic efficiency;
- solutions that exclude flammable solvents and/or toxic gases;
- solutions that eliminate any possibility of thermal runaway events;
- systems featuring low compression/expansion characteristics (high dimensional stability);
- compact, safe, high-energy dense packaging strategies for non-hydrocarbon fuels;
- high round trip efficiency (RTE) systems; and
- hybrid configurations (**NOT** in conjunction with hydrocarbon fuels).

F. TECHNICAL PERFORMANCE TARGETS

The primary technical and cost metrics for Categories A and B of the PROPEL-1K program are summarized in Table 1. Program expectations include the requirement that ESS proposed for development will be able to achieve all the primary performance targets.

Table 1. Primary metrics for the PROPEL-1K program (Categories A and B).

| | | Category A | Category B |
|----|--|--|-----------------------------------|
| 1 | Gravimetric Energy Density | ≥ 1000 Wh/kg | |
| 2 | Volumetric Energy Density | ≥ 1000 Wh/L | |
| 3 | Turnaround Time | ≤ 30 minutes | |
| 4 | Use/Discharge Energy Efficiency | $\geq 70\%$ | |
| 5 | System Size | ≥ 1 MWh to 100 MWh | |
| 6 | CO ₂ for System Manufacture | ≤ 100 kg CO ₂ /kWh | |
| 7 | Emissions (CO ₂ , NO _x , SO _x) | zero CO ₂ , NO _x , SO _x | |
| 8 | Peak Power Capability | ≥ 1.5 kW/kg (3 minutes) | ≥ 0.25 kW/kg (15 minutes) |
| 9 | Continuous Power Capability | ≥ 0.50 kW/kg | ≥ 0.10 kW/kg |
| 10 | Levelized Cost of Storage | $\leq \$0.30$ /kWh | $\leq \$0.20$ /kWh |
| 11 | System Voltage | ≥ 1000 V | ≥ 350 V |

Notes regarding Table 1:

1. Value reflects both net (system level) and at EOL. This is the delivered value after efficiency losses at the continuous rate (see 9).
2. Value reflects both net (system level) and at EOL. This is the delivered value after efficiency losses at the continuous power rate (see 9).
3. Refers to time required to recharge, refuel, reactivate, replenish, swap, etc.
4. Efficiency in use ($\leq 30\%$ loss to heat or other).
5. No note.
6. Applicant must provide energy source assumptions used in analysis.
7. Emissions *during* vehicle, vessel, or aircraft operation.

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8. Peak power at all SoC between 100% and 20% (Category A). Please note the purpose is to experimentally show indicative peak power capability. It is not intended to represent a specific mission or use profile.
9. At all SoC. Please note the purpose is to experimentally show indicative continuous power capability. It is not intended to represent a specific mission or use profile.
10. Additional details provided in Section I.H, LCOS Calculations and Methodology. Note for ease of consideration, hydrogen and other nonhydrocarbon fuels are considered as energy storage.
11. System designs will incorporate different series-parallel configurations. Minimizing high current draw in connectors and interconnects will be important.

Both gravimetric and volumetric energy density calculations must be submitted with all Full Applications, as they will be used by ARPA-E to track progress throughout the period of performance for awarded projects. An Excel-based PROPEL-1K Energy Density Workbook is available to complete those calculations, and applicants are strongly encouraged to utilize the template available on ARPA-E eXCHANGE (<https://arpa-e-foa.energy.gov>) to generate the required information.

Table 2 shows an example of the gravimetric energy density information that must be submitted. Applicants must submit information from fields in the “Chemistry” column from the first line through, and including, the first Target. In addition, applicants should submit information from the “1 kWh Prototype” and “Multi-MWh System” columns as they are able. Completion should be considered as a critical Go/No-go milestone in Q4 for the proposed project.

Table 2. Gravimetric energy density tracker for proposed ESS solutions. Note: Applicants are required to submit calculations for both gravimetric and volumetric energy density.

| GRAVIMETRIC ENERGY DENSITY (Wh/kg) | | | | | |
|------------------------------------|--|-----------|-----------------|------------------|--|
| # | Parameter | Chemistry | 1 kWh Prototype | Multi-MWh System | Notes/Explanation (to be completed by Applicant) |
| a | Anode Capacity (mAh/g) | | | | |
| b | Cathode Capacity (mAh/g) | | | | |
| c | Nominal Open Circuit Voltage (OCV) | | | | |
| d | Theoretical Gravimetric Energy Density (Wh/kg) | | | | |
| e | Supporting Chemistry and Non-Actives Factor | | | | |
| f | Nominal Gravimetric Energy Density (Wh/kg) | | | | |
| g | Average Operating Voltage (V) @ Continuous Rate | | | | |
| h | Target Operational Wh/kg @ Continuous Rate | 1000 | 1000 | 1000 | |
| | Calculated Operational Wh/kg @ Continuous Rate | | | | |
| i | Cell Package, Stack, Reactor Hardware Factor | N/A | | | |
| j | Target Laboratory Prototype Energy Density (Wh/kg) | N/A | 1000 | N/A | |
| | Calculated Laboratory Prototype Energy Density (Wh/kg) | N/A | | N/A | |
| k | Sub-System Hardware Factor | N/A | N/A | | |
| l | Multi-MWh System Hardware Factor | N/A | N/A | | |
| m | Application Integration Hardware Offset Factor | N/A | N/A | | |
| n | Degradation Factor (EOL versus BOL) | N/A | N/A | | |
| o | Target System-Level Energy Density (Wh/kg) | N/A | N/A | 1000 | |
| | Calculated System-Level Energy Density (Wh/kg) | N/A | N/A | | |

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Notes regarding these calculations are included within the PROPEL-1K Energy Density Workbook template on both the volumetric and gravimetric energy spreadsheets. Applicants are encouraged to explain in as much detail as possible (in Column F of the spreadsheets) the individual components and their rationale for the resulting impact(s) on both gravimetric and volumetric energy density. The purpose for this process is to understand the bridge between the theoretical energy density and projected values so that opportunities for improvement can be appropriately prioritized.

For applicants who believe it is possible to achieve the program metrics using a “non-electrochemical” approach, the required energy density calculations and information must be replaced with a justification supported by appropriate thermodynamic discussion and introduction of alternative energy parameters (thermal combustion theory and megajoules/kg, for example). This justification must be submitted as Appendix 2 to the Technical Volume (1 page maximum).

G. PROGRAM STRUCTURE AND DELIVERABLES

Based on history, the development of next-generation, high-energy storage solutions is realistically expected to take significant time; it will take even longer to simultaneously achieve optimal performance and lowest cost. Therefore, this program intends to maximize the number of potential solutions to be explored initially. The PROPEL-1K Program will consist of two separate phases. Details of Phases 1 and 2 are provided below. Full Application materials (including detailed budgets and task descriptions – see Technical Volume template) should focus primarily on PROPEL-1K Phase 1; however, the program is structured so that Phase 1 teams may be selected to continue to Phase 2. Applicants should provide a brief overview of their Phase 2 approach, schedule, and anticipated budget.

PROPEL-1K Phase 1 (SBIR/STTR Phase I and portion of SBIR/STTR Phase II) – the maximum Period of Performance (POP) for Phase 1 is 18 months.

Phase 1 includes the following deliverables:

- i) Experimentally show that $\geq 1000 \text{ Wh/kg}$ **and** $\geq 1000 \text{ Wh/L}$ at the chemistry level can be achieved where the chemistry includes the following elements:
 - a) *Batteries: additives, separators, electrolyte/diluent/solvent, substrates, binders, internal tabs, carbon, catalysts, baffles, and coatings.*
 - b) *Fuel cells/flow batteries: on-board catholyte, fuel/anolyte, membrane electrode assembly, cell endplates, gas diffusion layer, and tank hardware (pro-rated).*
 - c) *For systems that do not fit a) or b) but for which the metrics can be met, please describe the assumptions of what is included in the energy density for the chemistry versus what is not.*

Applicants must include as much detail as possible within their proposal regarding the weight and volume fractions of all active and non-active components of the chemistry. Explicitly stating all assumptions is strongly recommended. For example, for the prorated tank storage mass and volume for fuel cells and flow batteries, please ensure that the application includes an explanation of how the pro-rated contribution of these components is calculated.

The energy density calculation at this stage does not need to include cell, module, stack or system packaging, thermal management, safety containment, pumps, valves, pipes, or other balance of plant (BOP) or electronics.

In addition to confirming chemistry-level 1K performance, i.e., 1 kWh/kg and 1 kWh/L performance, reversibility/refillability/reusability, etc., must be proven through 10 consecutive cycles/reuses/refills with $\leq 10\%$ energy loss based on comparison of the 10th and 1st cycles. Also, peak power capability must be experimentally shown for 10% of the metric duty cycle (Category A = 18 seconds, Category B = 90 seconds).

Applicants should note that beyond experimentally showing reversibility, there is no requirement in the metrics to achieve cycle life targets; such considerations are driven by the LCOS goals.

- ii) Deliver an electrochemical and mechanical design for a ≥ 1 kWh unit that can be constructed to experimentally show ≥ 1000 Wh/kg and ≥ 1000 Wh/L at the packaged level. Applicants are expected to define the unit within the application, which may be a module comprising welded cells, a chemical reactor containing reactants, a fuel cell-type stack plus stored energy, a flow battery configuration, etc.
- iii) Develop a high-level system model for a ≥ 1 MWh system that includes all sub-systems (including thermal management, heating/cooling, battery management systems (BMS), safety containment or other BOP, etc.) and calculates key performance parameters as well as defines the masses and volumes of all components comprising the ≥ 1 MWh system. Modeling must also include heat rejection, thermal management, cooling/heating, etc.
- iv) Provide a “bridge” that connects the key parameters experimentally shown in i), designed in ii), and modeled in iii), which may include future technological enhancements.
- v) Identify and experimentally validate accelerated life testing (ALT) that may be implemented during technology development.
- vi) Deliver an *intermediate* technoeconomic analysis (TEA) and LCOS analysis (see Section I.H, LCOS Calculations and Methodology).

- vii) Perform a *preliminary* safety failure mode and effects analysis (FMEA) for the chemistry; correlation with established industry standards is encouraged.

PROPEL-1K Phase 2 (remainder of SBIR/STTR Phase II and SBIR/STTR Phase IIS) – the maximum POP for Phase 2 will be 18 months.

Based on each individual project's technical progress, including completion of critical Phase 1 milestones and proposals for Phase 2 funding, ARPA-E may select projects to receive Phase 2 funding to continue development, subject to the availability of appropriated funds. Phase 2 includes the following deliverables:

- i) Continue development and improvement of the chemistries proven during Phase 1 towards final project objectives, particularly those indicated for the ≥ 1 kWh unit.
- ii) Construct the ≥ 1 kWh unit per the design developed in Phase 1. The design must experimentally confirm ≥ 1000 Wh/kg and ≥ 1000 Wh/L at the packaged unit level (e.g., as a battery module, as a fuel cell/flow battery stack plus energy storage). Packaging, cell-to-cell connections, and storage tank hardware (prorated) must be included.
- iii) The ≥ 1 kWh unit is required to experimentally show reversibility/recyclability/reusability through 100 cycles/reuses/refills with $\leq 5\%$ performance loss based on a comparison of the 100th and 1st cycles. Also, peak power capability must be experimentally shown for 50% of the metric duty cycle (Category A = 90 seconds, Category B = 7.5 minutes).
- iv) System model refinement based on ≥ 1 kWh unit performance and other learnings during Phase 1 and Phase 2 of the project. In addition, simulate the system performance for one or more vehicle, vessel, or aircraft voyages/missions (to be determined and agreed upon with ARPA-E during the project as part of the technology to market activity).
- v) Develop a model in conjunction with ALT to predict the life of the system and use the numerical results to validate the LCOS prediction.
- vi) Deliver a *final* TEA and LCOS analysis (see Section I.H).
- vii) Provide a "bridge" that connects the key parameters experimentally shown in i), designed in ii), and modeled in iv).
- viii) Complete a safety FMEA for the system in collaboration with an independent, third-party organization; correlation with established industry standards is encouraged.

PROPEL-1K Phase 1 is anticipated to last 18 months and have federal funding of between \$500,000 and \$1,500,000 per award. The combined federal funding for both phases (PROPEL-

1K Phase 1 + Phase 2) should not exceed the SBIR/STTR ceiling of \$4,241,580 in federal funds. The Budget Justification Workbook submitted with the Full Application (see Section IV.C.4) should only reflect proposed PROPEL-1K Phase 1 funding.

Based on each individual project's technical success, including meeting a required Go/No-Go milestone (proposed in the Technical Volume and mutually agreed upon during project negotiations) by the conclusion of Q4 (12 months) of the POP, Phase 1 teams will be invited during Q5 of their respective projects to submit a detailed proposal of technical work, milestones, and proposed deliverables, along with a budget for the 18 months of Phase 2. ARPA-E may select projects to continue to PROPEL-1K Phase 2 (remainder of SBIR/STTR Phase II and SBIR/STTR Phase IIS), based upon this proposal and upon Phase 1 performance, subject to the availability of appropriated funds.

H. LEVELIZED COST OF STORAGE (LCOS) CALCULATIONS AND METHODOLOGY

Aviation, maritime, and railroad transportation are low margin, cost-sensitive enterprises. Hence, to achieve scale and enable transformational change, the new ESS must have a significant cost advantage over incumbent propulsion energy sources.¹²

Battery EVs enjoy lower operating costs in automotive applications due to significantly higher powertrain efficiency and lower maintenance costs. Moreover, the cycle life of current automotive batteries is long enough to avoid battery replacement over the 10- to 15-year useful life of an automobile. In contrast, transportation vessels like planes, trains, and ships have a much more demanding duty cycle. Not only are the on-board energy needs an order of magnitude higher, but these vessels are also constantly in use (> 16 hours/day) and have a longer operating life (> 20 years). These operating characteristics necessitate careful examination of the factors that affect the total cost of operation (TCO) in transportation applications.

Several peer-reviewed TEAs have been published recently comparing the TCO of electric aircraft,¹³ trains,¹⁴ and ships¹⁵ with their conventionally fueled counterparts. These studies have identified ESS installation cost, cycle life (number of replacements over the vessel's useful life), maintenance, charging infrastructure, and electricity cost as the key operational parameters affecting TCO.

¹² Steam, Diesels and Disruption, by Michael E. Iden, Classic Trains, Spring 2020
<https://www.trains.com/ctr/magazine/issues/spring-2020/>

¹³ Schäfer, A.W., Barrett, S.R.H., Doyme, K. *et al.* Technological, economic and environmental prospects of all-electric aircraft. *Nat Energy* **4**, 160–166 (2019). <https://doi.org/10.1038/s41560-018-0294-x>

¹⁴ Popovich, N.D., Rajagopal, D., Tasar, E. *et al.* Economic, environmental and grid-resilience benefits of converting diesel trains to battery-electric. *Nat Energy* **6**, 1017–1025 (2021). <https://doi.org/10.1038/s41560-021-00915-5>

¹⁵ Kersey, J., Popovich, N.D. & Phadke, A.A. Rapid battery cost declines accelerate the prospects of all-electric interregional container shipping. *Nat Energy* **7**, 664–674 (2022). <https://doi.org/10.1038/s41560-022-01065-y>

By performing TEAs of representative missions (narrow-body aircraft carrying 100 passengers, long-distance trains, and 5000 twenty-foot-equivalent unit [TEU] inter-regional container ships; each traveling 1000 nm) powered by a 1000 Wh/kg or 1000 Wh/L ESS, installation cost targets that achieved cost superiority over conventional fuels in these applications were determined.

LCOS, which compares storage technologies on a per unit energy basis, is a better metric than installation cost to characterize the total cost of an ESS, since it includes the cost to charge/refuel the storage system as well as replacement and maintenance over the vessel's useful life. LCOS offers a way to comprehensively compare the true cost of owning and operating various storage assets.¹⁶

The LCOS methodology used in this FOA is modeled on the one used by the DOE.¹⁷ It is simplified to focus only on transportation-related operational parameters (building construction costs and taxes are ignored),

$$\text{LCOS } (\$ \text{ kWh}^{-1}) = C_{\text{CAPEX}} + C_{\text{O\&M}} + C_{\text{Consumable}} + C_{\text{Infrastructure}}, \quad \text{Equation (1)}$$

Here, $C_{\text{CAPEX}} (\$ \text{ kWh}^{-1}) = \text{Annual cost of all capital expenditures related to the 1K ESS (initial installation cost + replacement cost over the useful life period)} / \text{Annual propulsion energy needed}$

$$C_{\text{CAPEX}} = \frac{\text{CRF} * \text{CAPEX}_{\text{PV}}}{\text{AH}_{\text{Annual}}} \quad \text{Equation (2)}$$

where

$$\text{CRF } (\%) = \text{Annual Capital Recovery Factor} = \frac{d}{1 - (1+d)^{-T}}, \quad \text{Equation (3)}$$

d (%) = Weighted Average Cost of Capital, WACC¹⁸, and

T (years) = Vessel useful life (20 years or more).

$\text{CAPEX}_{\text{PV}} (\$)$ = Present value of 1K ESS CAPEX over vessel useful life (T)

where

$$\text{CAPEX}_{\text{PV}} = \sum_{n=0}^T \frac{\text{CAPEX}_n}{(1+d)^n} = \text{CAPEX}_0 + \frac{\text{CAPEX}_1}{(1+d)} + \frac{\text{CAPEX}_2}{(1+d)^2} + \dots + \frac{\text{CAPEX}_T}{(1+d)^T} \quad \text{Equation (4)}$$

Note that CAPEX_0 is the initial installation cost of the 1K ESS required to meet energy requirements of the vessel and mission under consideration. It can be calculated by multiplying

¹⁶ <https://www.energy.gov/eere/analysis/2022-grid-energy-storage-technology-cost-and-performance-assessment>

¹⁷ <https://www.pnnl.gov/sites/default/files/media/file/LCOS%20Methodology.pdf>

¹⁸ <https://www.iata.org/en/iata-repository/publications/economic-reports/why-it-matters-that-the-airline-industry-stays-value-creating-for-its-investors/>. Assume 8% WACC for both Category A and Category B.

the 1K ESS installation cost (\$/kWh) noted in Table 3 by the total stored energy capacity required to meet mission propulsion requirements in the first full year of operation.

CAPEX for the year during which the 1K ESS will need to be replaced based on its maximum life (e.g., number of cycles/refuels before EOL) needs to be increased accordingly. Appropriate assumptions about the learning rate (decrease in 1K ESS cost over time) should be listed. Inflation can be assumed to be 2% per year over the useful life period T.

If additional 1K ESS are required to meet the turnaround time target of ≤ 30 minutes (e.g., if fully replenished 1K ESS will be swapped in under 30 minutes), the cost of holding and charging additional inventory will need to be included.

A tabular listing of $CAPEX_n$ where $n = 0$ to T should be provided along with all key assumptions related to 1K ESS inventory.

AH_{Annual} (kWh) = Annual propulsion energy required (specific to the transportation mode, mission, and vessel being analyzed for LCOS).

Note that AH_{Annual} is the output energy needed for propulsion, not energy stored in the ESS.

$Co\&M$ (\$ kWh⁻¹) = Fixed annual 1K ESS operating and maintenance (O&M) cost / Annual propulsion energy needed. **Equation (5)**

In cases where reliable O&M cost estimates are not available, analysis showing the expected cost range should be provided.

$C_{\text{Consumable}}$ (\$ kWh⁻¹) = Annual cost of consumables (e.g., electricity, electrolytes, anode/cathode materials, etc.) over the vessel useful life / Annual propulsion energy needed.¹⁹

$C_{\text{Infrastructure}}$ (\$ kWh⁻¹) = Levelized cost of infrastructure required to achieve the turnaround time target by replenishment, recharging, refueling, reactivating, swapping, etc.²⁰

A range of appropriate capacity utilization factors may be used to calculate the *preliminary* levelized infrastructure cost for non-electricity applications.

¹⁹ This could be a direct electricity cost or a fuel cost that requires electricity in its manufacture. In all cases and for consistency, an electricity cost of \$0.03/kWh can be assumed (<https://www.energy.gov/sites/default/files/2022-09/2022%20Grid%20Energy%20Storage%20Technology%20Cost%20and%20Performance%20Assessment.pdf>). Hydrogen production cost can be assumed to be \$1/kg (<https://www.energy.gov/sites/default/files/2021-09/h2-shot-summit-plenary-doe-overview.pdf>)

²⁰ For calculating heavy-duty electric infrastructure levelized cost, Argonne National Lab's HEVISAM tool can be used (<https://hdsam.es.anl.gov/index.php?content=hevisam>). For hydrogen delivery infrastructure cost analysis, ANL's HDSAM can be used (<https://hdsam.es.anl.gov/index.php?content=hdsam>). If another replenishment methodology is proposed for PROPEL-1K, a preliminary estimate for the infrastructure cost should be made. A range of appropriate capacity utilization factors may be used.

An example of LCOS analysis for a heavy-duty transportation mission is described below. The graphic output is representative of the analysis expected from applicants.

LCOS of \$0.30/kWh for a 115-passenger regional electric aircraft flying 700 nautical miles, up to three missions a day, is equivalent to 70% TCO of a similar aircraft fueled by \$5/gallon sustainable aviation fuel. Figure 4 provides a breakdown of LCOS among its constituents, with baseline assumptions indicated at the bottom of the figure.

The LCOS target is \$0.30/kWh for Category A (primarily focusing on aviation). Category B (focusing on trains and ships) has lower power requirements, and since trains and ships have a lower cost base, **\$0.20/kWh is the LCOS target for Category B.**

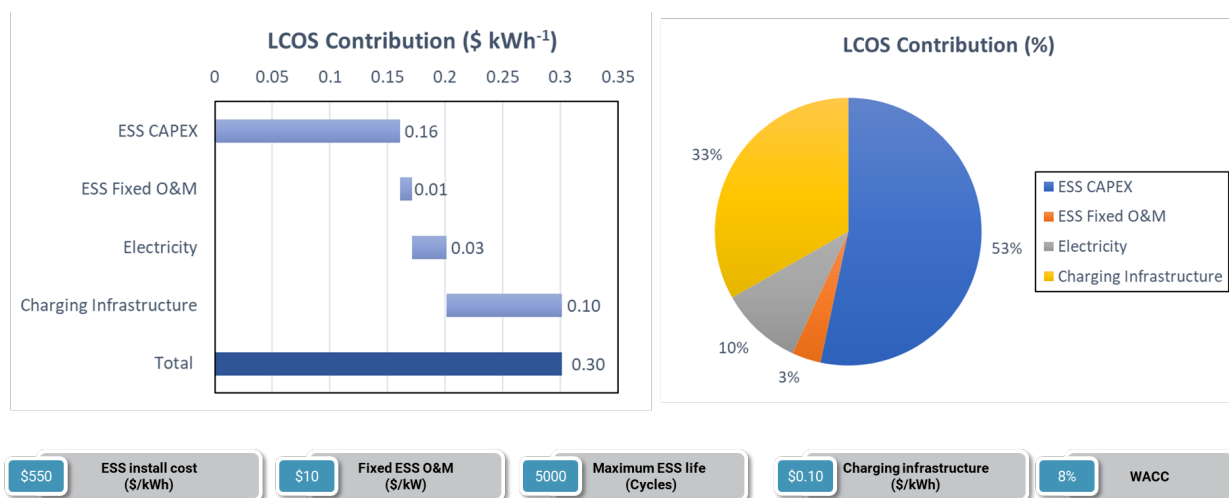


Figure 4. Relative magnitude of the different components of LCOS for the aviation example.

As a comparison, LCOS estimates of current electrochemical storage technologies range from \$0.18 per kWh to \$0.48 per kWh depending on the power level as well as the duration of storage.²¹ Application specific energy reserves can be neglected in the preliminary LCOS analysis. Depth of discharge (DoD) can be assumed to be 100% for calculating mission energy requirements.

This program does not mandate a 1K ESS installation cost or maximum life target. Appropriate trade-offs between 1K ESS initial CAPEX, replacement frequency, and O&M costs will need to be made to achieve the category LCOS target.

Applicants must submit the applicable information and calculations from Table 3 below to estimate LCOS; references and rationale must be provided for each input value. This information will be submitted as Appendix 1 to the Technical Volume (maximum 1 page). A pie

²¹ <https://www.pnnl.gov/lcos-estimates>

chart showing the breakdown of LCOS among its components should also be provided in the Technology-to-Market section of the Technical Volume (see Figure 4).

Table 3. Table for LCOS calculations.

| | Category A | Category B |
|---|---------------------|----------------------|
| Transportation application | Aviation | Railroad or Maritime |
| WACC, d (%) | 8 | 8 |
| Vessel useful life, T (> 20 years) | Input | Input |
| Capital Recovery Factor (CRF) | Calculation (Eq. 3) | Calculation (Eq. 3) |
| 1K ESS installation cost (\$/kWh) | Input | Input |
| 1K ESS maximum life (e.g., # of cycles/refuels) | Input | Input |
| CAPEX _{PV} (\$) | Calculation (Eq. 4) | Calculation (Eq. 4) |
| Provide a tabular listing of CAPEX _n where n = 0 to T. Identify 1K ESS replacement years and replacement cost (\$/kWh) clearly. | | |
| AH _{Annual} (kWh) | Input | Input |
| C _{CAPEX} (\$ kWh ⁻¹) | Calculation (Eq. 2) | Calculation (Eq. 2) |
| Fixed O&M _{Annual} (\$) | Input | Input |
| C _{O&M} (\$ kWh ⁻¹) | Calculation (Eq. 5) | Calculation (Eq. 5) |
| C _{Consumable} (\$ kWh ⁻¹) | Input | Input |
| C _{Infrastructure} (\$ kWh ⁻¹) | Input | Input |
| LCOS (\$/kWh) ²² | Calculation (Eq. 1) | Calculation (Eq. 1) |
| LCOS (\$/kWh) Target | ≤0.30 | ≤0.20 |

It should be noted that at this early stage, the purpose of LCOS calculations is to show a solid understanding of the key parameters affecting 1K-ESS LCOS in the intended application. Any assumptions made to estimate LCOS should be listed clearly.

²² A range of LCOS can be provided based on variability in key input parameters.

II. AWARD INFORMATION

A. AWARD OVERVIEW

ARPA-E expects to make approximately \$30 million available for new awards, subject to the availability of appropriated funds. ARPA-E anticipates making approximately 10-15 PROPEL-1K Phase 1 awards under FOAs DE-FOA-0003162 and DE-FOA-0003163. ARPA-E may, at its discretion, issue one, multiple, or no awards.

Individual awards may vary between \$500,000 and \$1.5 million in Federal share for Phase 1 of the PROPEL-1K program, and they may not exceed the SBIR/STTR limit of \$4,241,580 million in Federal share for combined Phase 1 and Phase 2 of the program. These PROPEL-1K Phases are distinct from SBIR/STTR phases.

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

ARPA-E plans to fully fund negotiated budgets at the time of award.

Applicants must apply for a Combined Phase I/II Award or a Combined Phase I/II/IIS Award. Combined Phase I/II and I/II/IIS Awards are intended to develop transformational technologies with disruptive commercial potential. Such commercial potential may be evidenced by (1) the likelihood of follow-on funding by private or non-SBIR/STTR sources if the project is successful, or (2) the Small Business Concern's record of successfully commercializing technologies developed under prior SBIR/STTR awards. Phase IIS awards are a "sequential" (i.e., additional) Phase II award, intended to allow the continued development of promising energy technologies. Combined Phase I/II/IIS awards may be funded up to \$4,241,580. Funding amounts will be consistent with the Phase I and Phase II limits posted on the SBA's website.²³

ARPA-E reserves the right to select all or part of a proposed project (i.e., only Phase I, or only Phase I and Phase II). In the event that ARPA-E selects Phase I only or Phase I/II only, then the maximum award amount for a Phase I award is \$295,924 and the maximum amount for a Phase I/II award is \$2,268,752.

The period of performance for PROPEL-1K Phase 1 funding agreements may not exceed 18 months, and the combined Phase 1 and Phase 2 period of performance may not exceed 36 months. ARPA-E expects to issue funding agreements in April 2024, or as negotiated.

²³ For current SBIR Phase I and Phase II funding amounts, see <https://www.sbir.gov/about/about-sbir>. For current STTR Phase I and Phase II funding amounts, see <https://www.sbir.gov/about/about-sttr>. Phase IIS funding amounts are equal to Phase II funding amounts for both SBIR and STTR awards.

B. RENEWAL AWARDS

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

C. ARPA-E FUNDING AGREEMENTS

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

Congress directed ARPA-E to "establish and monitor project milestones, initiate research projects quickly, and just as quickly terminate or restructure projects if such milestones are not achieved."²⁴ Accordingly, ARPA-E has substantial involvement in the direction of every Cooperative Agreement, as described in Section II.D below.

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.

Phase I will be made as a fixed-amount award. Phase II and Phase IIS of Combined Phase I/II/IIS awards will be made on a cost-reimbursement basis.

ARPA-E encourages Prime Recipients to review the Model Cooperative Agreement, which is available at <https://arpa-e.energy.gov/technologies/project-guidance/pre-award-guidance/funding-agreements>.

D. STATEMENT OF SUBSTANTIAL INVOLVEMENT

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

- Project Teams must adhere to ARPA-E's agency-specific and programmatic requirements.

²⁴ U.S. Congress, Conference Report to accompany the 21st Century Competitiveness Act of 2007, H. Rpt. 110-289 at 171-172 (Aug. 1, 2007).

- ARPA-E may intervene at any time in the conduct or performance of work under an award.
- ARPA-E does not limit its involvement to the administrative requirements of an award. Instead, ARPA-E has substantial involvement in the direction and redirection of the technical aspects of the project as a whole.
- ARPA-E may, at its sole discretion, modify or terminate projects that fail to achieve predetermined Go/No Go decision points or technical milestones and deliverables.
- During award negotiations, ARPA-E Program Directors and Prime Recipients mutually establish an aggressive schedule of quantitative milestones and deliverables that must be met every quarter. In addition, ARPA-E will negotiate and establish “Go/No-Go” milestones for each project. If the Prime Recipient fails to achieve any of the “Go/No-Go” milestones or technical milestones and deliverables as determined by the ARPA-E Contracting Officer, ARPA-E may – at its discretion - renegotiate the statement of project objectives or schedule of technical milestones and deliverables for the project. In the alternative, ARPA-E may suspend or terminate the award in accordance with 2 C.F.R. §§ 200.339 – 200.343.
- ARPA-E may provide guidance and/or assistance to the Prime Recipient to accelerate the commercialization of ARPA-E-funded technologies. Guidance and assistance provided by ARPA-E may include coordination with other Government agencies and nonprofits²⁵ to provide mentoring and networking opportunities for Prime Recipients. ARPA-E may also organize and sponsor events to educate Prime Recipients about key barriers to the commercialization of their ARPA-E-funded technologies. In addition, ARPA-E may establish collaborations with private and public entities to provide continued support for the development and commercialization of ARPA-E-funded technologies.

²⁵ The term “nonprofit organization” or “nonprofit” is defined in Section IX.

III. ELIGIBILITY INFORMATION

A. ELIGIBLE APPLICANTS

1. SBIR ELIGIBILITY

SBA rules and guidelines govern eligibility to apply to this FOA. For information on program eligibility, please refer to the SBIR/STTR website, available at <https://www.sbir.gov>, and to the “Eligibility” section for SBIR/STTR programs at <https://www.sbir.gov/about>.

A Small Business Concern²⁶ may apply as a Standalone Applicant²⁷ or as the lead organization for a Project Team.²⁸ If applying as the lead organization, the Small Business Concern must perform at least 66.7% of the work in Phase I and at least 50% of the work in Phase II and Phase IIS, as measured by the Total Project Cost.²⁹

For information on eligibility as a Small Business Concern, please refer to SBA’s website (<https://www.sba.gov/content/am-i-small-business-concern>).

2. STTR ELIGIBILITY

SBA rules and guidelines govern eligibility to apply to this FOA. For information on program eligibility, please refer the SBIR/STTR website, available at <https://www.sbir.gov>, and to the “Eligibility” section for SBIR/STTR programs at <https://www.sbir.gov/about>.

Only a Small Business Concern may apply as the lead organization for a Project Team. The Small Business Concern must perform at least 40% of the work in Phase I, Phase II, and/or Phase IIS, as measured by the Total Project Cost. A single Research Institution must perform at least 30% of the work in Phase I, Phase II, and/or Phase IIS, as measured by the Total Project

²⁶ A Small Business Concern is a for-profit entity that: (1) maintains a place of business located in the United States; (2) operates primarily within the United States or makes a significant contribution to the United States economy through payment of taxes or use of American products, materials or labor; (3) is an individual proprietorship, partnership, corporation, limited liability company, joint venture, association, trust, or cooperative; and (4) meets the size eligibility requirements set forth in 13 C.F.R. § 121.702. Where the entity is formed as a joint venture, there can be no more than 49% participation by foreign business entities in the joint venture. Small Business Concerns that are majority-owned by multiple venture capital operating companies, hedge funds, or private equity firms are eligible to apply to this FOA.

²⁷ A “Standalone Applicant” is an Applicant that applies for funding on its own, not as part of a Project Team.

²⁸ 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 any of the research and development work under an ARPA-E funding agreement, whether or not costs of performing the research and development work are being reimbursed under any agreement.

²⁹ 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, FFRDCs, and GOCOs.

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).

Cost. Please refer to Section III.B.1 of the FOA for guidance on Research Institutions' participation in STTR projects.

For information on eligibility as a Small Business Concern, please refer to SBA's website (<https://www.sba.gov/content/am-i-small-business-concern>).

3. JOINT SBIR AND STTR ELIGIBILITY

An Applicant that meets both the SBIR and STTR eligibility criteria above may request both SBIR and STTR funding if:

- The Small Business Concern is partnered with a Research Institution;
- The Small Business Concern performs at least 66.7% of the work in Phase I and at least 50% of the work in Phase II and/or Phase IIS (as applicable), as measured by the Total Project Cost;
- The partnering Research Institution performs 30-33.3% of the work in Phase I and 30-50% of the work in Phase II and/or Phase IIS (as applicable), as measured by the Total Project Cost; and
- The Principal Investigator (PI) is employed by the Small Business Concern. If the PI is employed by the Research Institution, submissions will be considered only under the STTR program.

B. ELIGIBLE SUBRECIPIENTS

1. RESEARCH INSTITUTIONS

A Research Institution³⁰ may apply only as a member of a Project Team (i.e., as a Subrecipient to a Small Business Concern). In STTR projects, a single Research Institution must perform at least 30%, but no more than 60%, of the work under the award in Phase I, Phase II, and/or Phase IIS (as applicable), as measured by the Total Project Cost.

2. OTHER PROJECT TEAM MEMBERS

The following entities are eligible to apply for SBIR/STTR funding as a member of a Project Team (i.e., as a Subrecipient to a Small Business Concern):

- For-profit entities, including Small Business Concerns

³⁰ Research Institutions include FFRDCs, nonprofit educational institutions, and other nonprofit research organizations owned and operated exclusively for scientific purposes. Eligible Research Institutions must maintain a place of business in the United States, operate primarily in the United States, or make a significant contribution to the U.S. economy through the payment of taxes or use of American products, materials, or labor.

- Nonprofits other than Research Institutions³¹
- Government-Owned, Government Operated laboratories (GOGOs)
- State, local, and tribal government entities
- Foreign entities³²

In SBIR projects, Project Team members other than the lead organization, including but not limited to Research Institutions, may collectively perform no more than 33.3% of the work under the award in Phase I and no more than 50% of the work under the award in Phase II and/or Phase IIS. This includes efforts performed by Research Institutions.

In STTR projects, Project Team members (other than the lead organization and the partnering Research Institution) may collectively perform no more than 30% of work under the award in Phase I, Phase II, and/or Phase IIS.

C. ELIGIBLE PRINCIPAL INVESTIGATORS

I. SBIR

For the duration of the award, the PI for the proposed project (or, if multiple PIs, at least one PI) must be employed by, and perform more than 50% of his or her work for, the Prime Recipient. The Contracting Officer may waive this requirement or approve the substitution of the PI after consultation with the ARPA-E SBIR/STTR Program Director.

For projects with multiple PIs, at least one PI must meet the primary employment requirement. That PI will serve as the contact PI for the Project Team.

2. STTR

For the duration of the award, the PI for the proposed project (or, if multiple PIs, at least one PI) must be employed by, and perform more than 50% his or her work for, the Prime Recipient or the partnering Research Institution. The Contracting Officer may waive this requirement or approve the substitution of the PI after consultation with the ARPA-E SBIR/STTR Program Director.

For projects with multiple PIs, at least one PI must meet the primary employment requirement. That PI will serve as the contact PI for the Project Team.

³¹Nonprofit 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 Subrecipient.

³² All work by foreign entities must be performed by subsidiaries or affiliates incorporated in the United States (see Section IV.G.6 of the FOA). However, the Applicant may request a waiver of this requirement in the Business Assurances & Disclosures Form submitted with the Full Application.

D. ELIGIBILITY OF PRIOR SBIR AND STTR Awardees: SBA Benchmarks on Progress Towards Commercialization

Applicants awarded multiple prior SBIR or STTR awards must meet DOE's benchmark requirements for progress towards commercialization before ARPA-E may issue a new Phase I award. For purposes of this requirement, Applicants are assessed using their prior Phase I and Phase II SBIR and STTR awards across all SBIR agencies. If an awardee fails to meet either of the benchmarks, that awardee is not eligible for an SBIR or STTR Phase I award and any Phase II award for a period of one year from the time of the determination.

ARPA-E applies two benchmark rates addressing an Applicant's progress towards commercialization: (1) the DOE Phase II Transition Rate Benchmark and (2) the SBA Commercialization Rate Benchmark:

- The DOE Phase II Transition Rate Benchmark sets the minimum required number of Phase II awards the Applicant must have received for a given number of Phase I awards received during the specified period. **This Transition Rate Benchmark applies only to Phase I Applicants that have received more than 20 Phase I awards during the last five (5) year period, excluding the most recently completed fiscal year.** DOE's Phase II Transition Rate Benchmark requires that 25% of all Phase I awards received over the past five years transition to Phase II awards.

The SBIR/STTR Phase II transition rates and commercialization rates are calculated using the data in the SBA's TechNet database. For the purpose of these benchmark requirements, awardee firms are assessed once a year, on June 1st, using their prior SBIR and STTR awards across all agencies. SBA makes this tabulation of awardee transition rates and commercialization rates available to all federal agencies. ARPA-E uses this tabulation to determine which companies do not meet the DOE benchmark rates and are, therefore, ineligible to receive new Phase I awards.

- The Commercialization Rate Benchmark sets the minimum Phase III³³ commercialization results that an Applicant must have achieved from work it performed under prior Phase II awards (i.e., this measures an Applicant's progress from Phase II or Phase IIS to Phase III awards). **This benchmark requirement applies only to Applicants that have received more than 15 Phase II awards during the last 10 fiscal years, excluding the two most recently completed fiscal years.**

³³ Phase III refers to work that derives from, extends or completes an effort made under prior SBIR/STTR funding agreements, but is funded by sources other than the SBIR/STTR Program. Phase III work is typically oriented towards commercialization of SBIR/STTR research or technology. For more information please refer to the Small Business Administration's "Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) Program Policy Directive" at https://www.sbir.gov/sites/default/files/SBIR-STTR_Policy_Directive_2019.pdf.

The current Commercialization Benchmark requirement, agreed upon and established by all 11 SBIR agencies, is that the Applicants must have received, to date, an average of at least \$100,000 of sales and/or investments per Phase II award received, or have received a number of patents resulting from the relevant SBIR/STTR work equal to or greater than 15% of the number of Phase II awards received during the period.

- On June 1 of each year, SBIR/STTR awardees registered on SBIR.gov are assessed to determine if they meet the Phase II Transition Rate Benchmark requirement. (At this time, SBA is not identifying companies that fail to meet the Commercialization Rate Benchmark requirement). Companies that fail to meet the Phase II Transition Rate Benchmark as of June 1 of a given year will not be eligible to apply to an SBIR/STTR FOA for the following year. For example, if SBA determined on June 1, 2017 that a small business failed to meet the Phase II Transition Rate Benchmark requirement, that small business would not be eligible to apply to an ARPA-E SBIR/STTR FOA from June 1, 2017 to May 31, 2018.

E. COST SHARING

Cost sharing is not required for this FOA.

F. OTHER

1. COMPLIANT CRITERIA

Full Applications are deemed compliant if:

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

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

Replies to Reviewer Comments are deemed compliant if:

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

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

2. RESPONSIVENESS CRITERIA

ARPA-E performs a preliminary technical review of Full Applications.

The following types of submissions may be deemed nonresponsive and may not be reviewed or considered:

- Submissions that fall outside the technical parameters specified in this FOA.
- Submissions that have been submitted in response to currently issued ARPA-E FOAs.
- Submissions that are not scientifically distinct from applications submitted in response to currently issued ARPA-E FOAs.
- Submissions for basic research aimed solely at discovery and/or fundamental knowledge generation.
- Submissions for large-scale demonstration projects of existing technologies.
- Submissions for proposed technologies that represent incremental improvements to existing technologies.
- Submissions for proposed technologies that are not based on sound scientific principles (e.g., violates a law of thermodynamics).
- Submissions for proposed technologies that are not transformational, as described in Section I.A of the FOA.
- Submissions for proposed technologies that do not have the potential to become disruptive in nature, as described in Section I.A of the FOA. Technologies must be scalable such that they could be disruptive with sufficient technical progress.
- Submissions that are not distinct in scientific approach or objective from activities currently supported by or actively under consideration for funding by any other office within Department of Energy.
- Submissions that are not distinct in scientific approach or objective from activities currently supported by or actively under consideration for funding by other government agencies or the private sector.

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).

- 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.
- Submissions that do not propose a Combined Phase I/II/IIS Award, as described in Section II.A of the FOA.

3. SUBMISSIONS SPECIFICALLY NOT OF INTEREST

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

- Submissions that propose incremental improvements to SoA LiB.
- Submissions limited to computational approaches and that exclude physical experimentation/testing as a primary component of the technology development plan.
- Combustion-based proposals that produce CO₂, NO_x, or SO_x emissions during operation and/or cannot achieve the “in-use” 70% efficiency target.

4. LIMITATION ON NUMBER OF SUBMISSIONS

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

Small business Applicants that qualify as a “Small Business Concern” may apply to only one of the two ARPA-E PROPEL-1K FOAs: DE-FOA-0003163 (PROPEL 1-K SBIR/STTR), or DE-FOA-0003162 (PROPEL-1K). Small businesses that qualify as “Small Business Concerns” are strongly encouraged to apply under the former (SBIR/STTR FOA). To determine eligibility as a “Small Business Concern” under DE-FOA-0003163, please review the eligibility requirements in Sections III.A – III.D above.

IV. APPLICATION AND SUBMISSION INFORMATION

A. APPLICATION PROCESS OVERVIEW

1. REGISTRATION IN SBA COMPANY REGISTRY

The first step in applying to this FOA is registering in the U.S. Small Business Administration (SBA) Company Registry (<http://sbir.gov/registration>). Upon completing registration, Applicants will receive a unique small business Control ID and Registration Certificate in Adobe PDF format, which may be used at any participating SBIR and STTR agencies. Applicants that have previously registered in the SBA Company Registry need not register again.

Applicants must submit their Registration Certificate in ARPA-E eXCHANGE (<https://arpa-e-foa.energy.gov>) as part of their Full Application (see Section IV.C.7 of the FOA).

2. REGISTRATION IN ARPA-E eXCHANGE

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

3. FULL APPLICATIONS

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

ARPA-E performs a preliminary review of Full Applications to determine whether they are compliant and responsive, as described in Section III.F 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.

4. REPLY TO REVIEWER COMMENTS

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

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).

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

5. PRE-SELECTION CLARIFICATIONS AND “DOWN-SELECT” PROCESS

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

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

6. SELECTION FOR AWARD NEGOTIATIONS

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

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

B. APPLICATION FORMS

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

response to the Business Assurances & Disclosures Form is available on ARPA-E eXCHANGE.

C. CONTENT AND FORM OF FULL APPLICATIONS

Full Applications must conform to the following formatting requirements:

- Each document must be submitted in the file format prescribed below.
- The Full Application must be written in English.
- All pages must be formatted to fit on 8-1/2 by 11-inch paper with margins not less than one inch on every side. Single space all text and use Times New Roman typeface, a black font color, and a font size of 12 point or larger (except in figures and tables).
- The ARPA-E assigned Control Number, the Lead Organization Name, and the Principal Investigator's Last Name must be prominently displayed on the upper right corner of the header of every page. Page numbers must be included in the footer of every page.

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

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

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

Full Applications must conform to the content requirements described below.

| Component | Required Format | Description and Information |
|-------------------------|-----------------|---|
| Technical Volume | PDF | The technical volume is the centerpiece of the Full Application. Applicants must provide a detailed description of the proposed R&D project and Project Team. |
| Energy Density Workbook | XLS | (Optional, encouraged) The Energy Density Workbook template includes spreadsheets to help applicants complete both Gravimetric and Volumetric energy density calculations. Applicants are encouraged to submit both calculations with their Full Application using the provided Energy Density Workbook template. (Exception: Applicants who are aiming to use a 'non-electrochemical' approach.) |
| SF-424 | PDF | Application for Federal Assistance. Applicants are responsible for ensuring that the proposed costs listed in eXCHANGE match those listed on forms SF-424 and SF-424A. Inconsistent submissions may impact ARPA-E's final award determination. |
| Budget Justification | XLS | Budget Information – Non-Construction Programs |

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

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| Workbook/SF-424A | | |
| Summary for Public Release | PDF | Short summary of the proposed R&D project. Intended for public release. |
| Summary Slide | PPT | A four-panel project slide summarizing different aspects of the proposed R&D project. |
| SBA Company Registration Certificate | PDF | Registration Certificate generated upon completion of registration in the SBA Company Registry (http://sbir.gov/registration). |
| Certification for Applicants that are (a) Majority-Owned by Multiple Venture Capital Operating Companies, Hedge Funds, or Private Equity Firms and/or (b) joint ventures minority-owned by a foreign entity (if applicable) | PDF | Requires SBIR Applicants that are majority-owned by multiple venture capital operating companies, hedge funds, or private equity firms or that are joint ventures minority-owned by a foreign entity to self-identify, provide certain information, and verify registration as such in the SBA Company Registry (http://sbir.gov/registration). |
| Business Assurances & Disclosures Form | PDF | Applicants should provide comprehensive responses to the questions on this form. Requires the Applicant to acknowledge eligibility with SBIR/STTR program requirements, 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 an Applicant Team Member is an FFRDC/DOE Lab, that entity must provide written authorization from the cognizant Federal agency and, if a DOE/NNSA FFRDC/DOE Lab, a Field Work Proposal. This form allows the Applicant to request a waiver or modification of the Performance of Work in the United States requirement. This form requires the Applicant to submit a Disclosure of Foreign Relationships. A sample response to the Business Assurances & Disclosures Form is also available on ARPA-E eXCHANGE. |

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.

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).

If Applicants exceed the maximum page lengths specified for each section, or add any additional sections not requested, ARPA-E may review only the authorized number of pages and disregard any additional pages or sections, or ARPA-E may determine that the submission as a whole is noncompliant per Section III.F of the FOA.

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, all relevant technical information should be included in the body of the Technical Volume.

2. SECOND COMPONENT: ENERGY DENSITY WORKBOOK

Both gravimetric and volumetric energy density calculations should be submitted with all Full Applications, as they will be used by ARPA-E to track progress throughout the period of performance for awarded projects. An Excel-based PROPEL-1K Energy Density Workbook is available to complete those calculations, and applicants are strongly encouraged to utilize the template available on ARPA-E eXCHANGE (<https://arpa-e-foa.energy.gov>) to generate the required information.

The Energy Density Workbook template includes spreadsheets for both gravimetric and volumetric energy density calculations; Applicants should utilize both tabs of this Excel-based document. Applicants must submit information from fields in the “Chemistry” column from parameter ‘a’ through to, and including, parameter ‘h’. In addition, applicants should submit information from the “1 kWh Prototype” and “Multi-MWh System” columns as they are able. Notes regarding these calculations are included within the Energy Density Workbook template on both the volumetric and gravimetric energy spreadsheets. Applicants are encouraged to explain in as much detail as possible (in Column F of the spreadsheets) the individual components and their impact(s) on both gravimetric and volumetric energy density.

For applicants who believe it is possible to achieve the program metrics using a “non-electrochemical” approach, the Energy Density Workbook template can be replaced with a justification supported by appropriate thermodynamic discussion. This justification will be Appendix 2 to the Technical Volume (First Component).

3. THIRD 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 must complete all required fields in accordance with the instructions. Applicants may identify and include in Block 14 the entities, their addresses, and corresponding census tract numbers for any project activities that will occur within any designated Qualified Opportunity Zone (QOZ). To locate Qualified

Opportunity Zones go to: <https://www.cdfifund.gov/opportunity-zones>.

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.

4. FOURTH COMPONENT: BUDGET JUSTIFICATION WORKBOOK/SF-424A

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

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

performed, the purpose/need for the effort, and a sufficient basis for the estimated costs.

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

- Applicants may request funds under the appropriate object class category tabs as long as the item and amount requested are necessary to perform the proposed work, meet all the criteria for allowability under the applicable Federal cost principles, and are not prohibited by the funding restrictions described herein.
- If Patent costs are requested, they must be included in the Applicant's proposed budget (see Section IV.F.3 of the FOA for more information on Patent Costs).
- Unless a waiver is granted by ARPA-E, each Project Team must spend at least 5% of the Federal funding (i.e., the portion of the award that does not include the recipient's cost share) on Technology Transfer & Outreach (TT&O) activities to promote and further the development and eventual 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>.

5. FIFTH 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 | <p>Briefly describe the proposed effort, summarize its objective(s) and technical approach, describe its ability to achieve the "Program Objectives" (see Section I.D of the FOA), and indicate its potential impact on ARPA-E statutory goals (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.</p> <p>INSTRUCTIONS:</p> <p>(1) The Summary for Public Release <u>shall not exceed 250 words and one paragraph</u>.</p> <p>(2) The Summary for Public Release <u>shall consist only of text</u>—no graphics, figures, or tables.</p> |
|------------------|-----------------------------------|--|

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

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| | | (3) For applications selected for award negotiations, the Summary may be used as the basis for a public announcement by ARPA-E; therefore, <u>this Cover Page and Summary should not contain confidential or proprietary information</u> . See Section VIII.I of the FOA for additional information on marking confidential information. |
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6. SIXTH COMPONENT: SUMMARY SLIDE

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

- A Technology Summary;
 - Bullet points that describe novel aspects of the proposed technology and technology approach;
- A description of the technology's impact;
 - Quantitative description (through text or graphic) of the impact the proposed project will provide to the market and ARPA-E statutory goals;
- 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.

7. SEVENTH COMPONENT: SBA REGISTRATION CERTIFICATE

Applicants are required to provide a copy of the SBA Registration Certificate generated in the SBA Company Registry (<http://sbir.gov/registration>) in Adobe PDF format (see Section IV.A.1 of the FOA). Applicants that have previously registered in the SBA Company Registry may submit a copy their existing Registration Certificate.

8. EIGHTH COMPONENT: CERTIFICATION FOR APPLICANTS THAT ARE (A) MAJORITY-OWNED BY MULTIPLE VENTURE CAPITAL OPERATING COMPANIES, HEDGE FUNDS, AND PRIVATE EQUITY FIRMS AND/OR (B) JOINT VENTURES MINORITY-OWNED BY A FOREIGN ENTITY

Only those Applicants that are (a) majority-owned by multiple venture capital operating companies, hedge funds, or private equity firms and/or (b) joint ventures minority-owned by a foreign entity are required to complete the Certification for Applicants Majority-Owned by Multiple Venture Capital Operating Companies, Hedge Funds, and Private Equity Funds and Joint Venture Applicants Minority-Owned by Foreign Business Entities (VCOC/FJV Certification). The certification must be submitted in Adobe PDF format. This form is available on ARPA-E eXCHANGE at <https://arpa-e-foa.energy.gov>.

In the VCOC/FJV Certification, the Applicant is required to self-identify as an entity that falls into one of those categories, provide certain information, verify its ownership status, and verify that it has registered in the SBA Company Registry (<http://sbir.gov/registration>) as such an entity.

Applicants that are neither (a) majority-owned by multiple venture capital operating companies, hedge funds, or private equity firms nor (b) joint ventures minority-owned by a foreign entity are not required to complete the VCOC/FJV Certification.

9. NINTH 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:

- Acknowledge that it has reviewed SBA's eligibility requirements for the SBIR and STTR programs and that it anticipates that it will be able to certify eligibility to participate in ARPA-E's SBIR/STTR program at the time of award;
- Disclose conditions bearing on responsibility, such as criminal convictions and Federal tax liability;
- Disclose conflicts of interest within the Project Team and provide the Applicant's up-to-date, written, and enforced conflict of interest policy in accordance with DOE Interim COI Policy guidance at <https://www.energy.gov/management/financial-assistance-letter-no-fal-2022-02>;
- If a FFRDC/DOE Lab is a member of the Project Team, submit written authorization from the cognizant Federal agency;
- If a DOE/NNSA FFRDC/DOE Lab is a subrecipient, submit a Field Work Proposal; and
- Submit a Disclosure of Foreign Relationships.

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).

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.”³⁴ 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.

The Applicant may use the Business Assurances & Disclosures Form to:

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

D. CONTENT AND FORM OF REPLIES TO REVIEWER COMMENTS

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

Replies to Reviewer Comments must conform to the following requirements:

- The Reply to Reviewer Comments must be submitted in Adobe PDF format.
- The Reply to Reviewer Comments must be written in English.
- All pages must be formatted to fit on 8-1/2 by 11-inch paper with margins not less than one inch on every side. Use Times New Roman typeface, a black font color, and a font size of 12 points or larger (except in figures and tables).
- The Control Number must be prominently displayed on the upper right corner of the header of every page. Page numbers must be included in the footer of every page.

ARPA-E may not review or consider noncompliant Replies to Reviewer Comments (see Section III.F.1 of the FOA). ARPA-E will review and consider each compliant and responsive Full Application, even if no Reply is submitted or if the Reply is found to be noncompliant.

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

³⁴ America COMPETES Act, Pub. L. No. 110-69, § 5012 (2007), as amended (codified at 42 U.S.C. § 16538).

additional pages. ARPA-E may review only the first three pages and disregard any additional pages, or ARPA-E may determine that the submission as a whole is noncompliant.

| SECTION | PAGE LIMIT | DESCRIPTION |
|---------|-----------------|--|
| Text | 2 pages maximum | <ul style="list-style-type: none">Applicants may respond to one or more reviewer comments or supplement their Full Application. |
| Images | 1 page maximum | <ul style="list-style-type: none">Applicants may provide graphs, charts, or other data to respond to reviewer comments or supplement their Full Application. |

E. INTERGOVERNMENTAL REVIEW

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

F. FUNDING RESTRICTIONS

1. ALLOWABLE COSTS

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

2. PRE-AWARD COSTS

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

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

3. PATENT COSTS

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

The Prime Recipient may request a waiver of the \$30,000 cap. Note that, patent costs are considered to be Technology Transfer & Outreach (TT&O) costs (see Section IV.F.8 of the FOA below) and should be requested as such.

4. CONSTRUCTION

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

5. FOREIGN TRAVEL

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

6. PERFORMANCE OF WORK IN THE UNITED STATES

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

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

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

7. PURCHASE OF NEW EQUIPMENT

All equipment purchased under ARPA-E funding agreements must be made or manufactured in the United States, to the maximum extent practicable. This requirement does not apply to used or leased equipment. The Prime Recipients are required to notify the ARPA-E Contracting Officer reasonably in advance of purchasing any equipment that is not made or manufactured in the United States with a total acquisition cost of \$250,000 or more. Purchases of foreign equipment with a total acquisition cost of \$1,000,000 or more require the approval of the Head of Contracting Activity (HCA). 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 eventual 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.D.3 of the FOA.

9. LOBBYING

Prime Recipients and Subrecipients may not use any Federal funds, directly or indirectly, to influence or attempt to influence, directly or indirectly, congressional action on any legislative or appropriation matters pending before Congress, other than to communicate to Members of Congress as described in 18 U.S.C. § 1913. This restriction is in addition to those prescribed elsewhere in statute and regulation.

Prime Recipients and Subrecipients are required to complete and submit SF-LLL, "Disclosure of Lobbying Activities"

(<https://www.gsa.gov/forms-library/disclosure-lobbying-activities>) 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 Grants and Cooperative Agreements. 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.

12. PROHIBITION ON CERTAIN TELECOMMUNICATIONS AND VIDEO SURVEILLANCE SERVICES OR EQUIPMENT

Per 2 C.F.R. § 200.216, recipients and subrecipients are prohibited from obligating or expending project funds to: (1) procure or obtain; (2) extend or renew a contract to procure or obtain; or (3) enter into a contract (or extend or renew a contract) to procure or obtain equipment, services, or systems that uses covered telecommunications equipment or services as a substantial or essential component of any system, or as critical technology as part of any system. As described in Public Law 115-232, section 889, covered telecommunications equipment is telecommunications equipment produced by Huawei Technologies Company or ZTE Corporation (or any subsidiary or affiliate of such entities). Refer to 2 C.F.R. § 200.216 for possible additional prohibitions and limitations.

13. BUY AMERICA REQUIREMENT FOR PUBLIC INFRASTRUCTURE PROJECTS

Projects funded through this FOA that are for, or contain, construction, alteration, maintenance, or repair of public infrastructure in the United States undertaken by applicable recipient types, require that:

- All iron, steel, and manufactured products used in the infrastructure project are produced in the United States; and
- All construction materials used in the infrastructure project are manufactured in the United States.

However, ARPA-E does not anticipate soliciting for or selecting projects that propose project tasks that are for, or contain, construction, alteration, maintenance, or repair of public infrastructure. If a project selected for award negotiations includes project tasks that may be subject to the Buy America Requirement, those project tasks will be removed from the project before any award is issued – i.e., no federal funding or Recipient cost share will be available for covered project tasks.

This “Buy America” requirement does not apply to an award where the Prime Recipient is a for-profit entity.

14. REQUIREMENT FOR FINANCIAL PERSONNEL

ARPA-E requires Small Business or Nonprofit applicants to identify a finance/budget professional (employee or contracted support) with an understanding of Federal contracting and/or financial assistance and cost accounting (including indirect costs, invoicing, and financial management systems) that will support the team in complying with all applicable requirements.

G. OTHER SUBMISSION REQUIREMENTS

1. USE OF ARPA-E eXCHANGE

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

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

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).

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

Applicants are responsible for meeting each submission deadline in ARPA-E eXCHANGE.

Applicants are strongly encouraged to submit their applications at least 48 hours in advance of the submission deadline. Under normal conditions (i.e., at least 48 hours in advance of the submission deadline), Applicants should allow at least 1 hour to submit a Full Application. In addition, Applicants should allow at least 15 minutes to submit a Reply to Reviewer Comments. Once the application is submitted in ARPA-E eXCHANGE, Applicants may revise or update their application until the expiration of the applicable deadline.

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

ARPA-E may not review or consider incomplete applications and applications received after the deadline stated in the FOA. Such applications may be deemed noncompliant (see Section III.F.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.F of the FOA). ARPA-E also performs a preliminary review of Replies to Reviewer Comments to determine whether they are compliant.

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

1. CRITERIA FOR FULL APPLICATIONS

Full Applications are evaluated based on the following criteria:

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

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

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

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

- Management of risk, to include identifying major technical R&D risks and feasible, effective mitigation strategies.

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

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

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

- Plausibility of plan to manage people and resources;
- Allocation of appropriate levels of effort and resources to proposed tasks;
- Reasonableness of the proposed project schedule, including major milestones; and
- Reasonableness of the proposed budget to accomplish the proposed project.

Submissions will not be evaluated against each other since they are not submitted in accordance with a common work statement.

The above criteria will be weighted as follows:

| | |
|---|-----|
| Impact of the Proposed Technology | 30% |
| Overall Scientific and Technical Merit | 30% |
| Qualifications, Experience, and Capabilities of the Proposed Project Team | 30% |
| Soundness of Management Plan | 10% |

2. CRITERIA FOR REPLIES TO REVIEWER COMMENTS

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

B. REVIEW AND SELECTION PROCESS

1. PROGRAM POLICY FACTORS

In addition to the above criteria, ARPA-E may consider the following program policy factors in determining which Full Applications to select for award negotiations:

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- I. **ARPA-E Portfolio Balance.** Project balances ARPA-E portfolio in one or more of the following areas:
 - a. Diversity of technical personnel in the proposed Project Team;
 - b. Technological diversity;
 - c. Organizational diversity;
 - d. Geographic diversity;
 - e. Technical or commercialization risk; or
 - f. Stage of technology development.
- II. **Relevance to ARPA-E Mission Advancement.** Project contributes to one or more of ARPA-E's key statutory goals:
 - a. Reduction of U.S. dependence on foreign energy sources;
 - b. Stimulation of U.S. manufacturing and/or software development
 - 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 Project Impact Relative to Project Cost.**
- VI. **Qualified Opportunity Zone (QOZ).** Whether the entity is located in an urban and economically distressed area including a Qualified Opportunity Zone (QOZ) or the proposed project will occur in a QOZ or otherwise advance the goals of QOZ. The goals include spurring economic development and job creation in distressed communities throughout the United States. For a list or map of QOZs go to:
<https://www.cdfifund.gov/opportunity-zones>.

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

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their knowledge and understanding of the relevant field and application, their experience and skills, and their ability to provide constructive feedback on applications.

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

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

3. ARPA-E SUPPORT CONTRACTORS

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

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

C. ANTICIPATED ANNOUNCEMENT AND AWARD DATES

ARPA-E expects to announce selections for negotiations in approximately January 2024 and to execute funding agreements in approximately April 2024.

VI. AWARD ADMINISTRATION INFORMATION

A. AWARD NOTICES

1. REJECTED SUBMISSIONS

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

2. FULL APPLICATION NOTIFICATIONS

ARPA-E promptly notifies Applicants of its determination. ARPA-E sends a notification letter by email to the technical and administrative points of contact designated by the Applicant in ARPA-E eXCHANGE. The notification letter may inform the Applicant that its Full Application was selected for award negotiations, or not selected. Alternatively, ARPA-E may notify one or more Applicants that a final selection determination on particular Full Applications will be made at a later date, subject to the availability of funds and other factors.

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

a. SUCCESSFUL APPLICANTS

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

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

b. POSTPONED SELECTION DETERMINATIONS

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

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

C. UNSUCCESSFUL APPLICANTS

By not selecting a Full Application, ARPA-E intends to convey its lack of programmatic interest in the proposed project. Such assessments do not necessarily reflect judgments on the merits of the proposed project. ARPA-E hopes that unsuccessful Applicants will submit innovative ideas and concepts for future FOAs.

B. ADMINISTRATIVE AND NATIONAL POLICY REQUIREMENTS

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

- If a subaward is made to a DOE/NNSA National Laboratory, all Disputes and Claims will be resolved in accordance with the terms and conditions of the DOE/NNSA National Laboratory's management and operating (M&O) contract, as applicable, in consultation between DOE and the prime awardee.
- If a subaward is made to another Federal agency or its FFRDC contractor, all Disputes and Claims will be resolved in accordance with the terms and conditions of the interagency agreement in consultation between DOE and the prime awardee.

1. UNIQUE ENTITY IDENTIFIER- AND SAM, FSRS, AND FEDCONNECT REGISTRATIONS

Prime Recipients must register with the System for Award Management (SAM) at www.sam.gov/SAM prior to submitting an application, at which time the system will assign (if newly registered) a Unique Entity Identifier (UEI).

Prime Recipients must:

- Maintain an active SAM registration with current information, including information on a its immediate and highest-level owner and subsidiaries, as well as on all predecessors that have been awarded a Federal contract or financial assistance award within the last three years, if applicable, at all times during which it has an active Federal award or an application or plan under consideration by a Federal awarding agency;
- Remain registered in the SAM database after the initial registration;
- Update its information in the SAM database as soon as it changes;

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- Review its information in the SAM database on an annual basis from the date of initial registration or subsequent updates to ensure it is current, accurate and complete; and
- Not make a subaward to any entity unless the entity has provided its UEI.

Subrecipients are not required to register in SAM but must obtain a UEI.

Prime Recipients and Subrecipients should commence this process as soon as possible in order to expedite the execution of a funding agreement. Registering with SAM and obtaining the UEI 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/>.³⁵ 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. Prime Recipients are required to keep the FSRS data current throughout the duration of the project.

ARPA-E may not execute a funding agreement with the Prime Recipient until it has obtained a UEI and completed its SAM and FSRS registrations.

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. Refer to Attachment 6 of ARPA-E's Model Cooperative Agreement (<https://arpa-e.energy.gov/technologies/project-guidance/pre-award-guidance/funding-agreements>) for information on the National Policy Assurances.

3. 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).

³⁵ The Federal Funding Accountability and Transparency Act, P.L. 109-282, 31 U.S.C. 6101 note.

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/technologies/project-guidance/pre-award-guidance/required-forms-and-templates>. Each Prime Recipient must wait to complete the Environmental Impact Questionnaire (EIQ) until after ARPA-E has notified them that Attachment 3 Statement of Program Objectives is in final form. The completed EIQ is then due back to ARPA-E within 14 calendar days.

4. TECHNOLOGY-TO-MARKET PLAN

During award negotiations, Prime Recipients are required to negotiate and submit an initial Technology-to-Market Plan for Phase II and Phase IIS with 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 any 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. Prime Recipients are not required to negotiate a Technology-to-Market Plan for Phase I only awards.

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

5. 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/technologies/project-guidance/post-award-guidance/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. At that time ARPA-E may negotiate with the Prime Recipient a mutually agreeable list of data that may be released to the public and not be treated as SBIR/STTR data. 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.

6. U.S. COMPETITIVENESS

A primary objective of DOE's multi-billion-dollar research, development and demonstration investments – including ARPA-E awards - is advancement of new energy technologies, manufacturing capabilities, and supply chains for and by U.S. industry and labor. Therefore, in exchange for receiving taxpayer dollars to support an applicant's project, the applicant must agree to the following U.S. Competitiveness Provision as part of an award under this FOA.

U.S. Competitiveness

The Contractor (Prime Recipient in ARPA-E awards) agrees that any products embodying any subject invention or produced through the use of any subject invention will be manufactured substantially in the United States unless the Contractor can show to the satisfaction of DOE that it is not commercially feasible. In the event DOE agrees to foreign manufacture, there will be a requirement that the Government's support of the technology be recognized in some appropriate manner, e.g., alternative binding commitments to provide an overall net benefit to the U.S. economy. The Contractor agrees that it will not license, assign or otherwise transfer any subject invention to any entity, at any tier, unless that entity agrees to these same requirements. Should the Contractor or other such entity receiving rights in the invention(s): (1) undergo a change in ownership amounting to a controlling interest, or (2) sell, assign, or otherwise transfer title or exclusive rights in the invention(s), then the assignment, license, or other transfer of rights in the subject invention(s) is/are suspended until approved in writing by DOE. The Contractor and any successor assignee will convey to DOE, upon written request from DOE, title to any subject invention, upon a breach of this paragraph. The Contractor will include this paragraph in all subawards/contracts, regardless of tier, for experimental, developmental or research work.

A subject invention is any invention of the contractor conceived or first actually reduced to practice in the performance of work under an award. An invention is any invention or discovery which is or may be patentable. The contractor includes any awardee, recipient, sub-awardee, or sub-recipient.

As noted in the U.S. Competitiveness Provision, at any time in which an entity cannot meet the requirements of the U.S. Competitiveness Provision, the entity may request a modification or waiver of the U.S. Competitiveness Provision. For example, the entity

may propose modifying the language of the U.S. Competitiveness Provision in order to change the scope of the requirements or to provide more specifics on the application of the requirements for a particular technology. As another example, the entity may request that the U.S. Competitiveness Provision be waived in lieu of a net benefits statement or U.S. manufacturing plan. The statement or plan would contain specific and enforceable commitments that would be beneficial to the U.S. economy and competitiveness. Commitments could include manufacturing specific products in the U.S., making a specific investment in a new or existing U.S. manufacturing facility, keeping certain activities based in the U.S. or supporting a certain number of jobs in the U.S. related to the technology. If DOE, in its sole discretion, determines that the proposed modification or waiver promotes commercialization and provides substantial U.S. economic benefits, DOE may grant the request and, if granted, modify the award terms and conditions for the requesting entity accordingly.

The U.S. Competitiveness Provision is implemented by DOE pursuant to a Determination of Exceptional Circumstances (DEC) under the Bayh-Dole Act and DOE Patent Waivers. See Section VIII.A, "Title to Subject Inventions", of this FOA for more information on the DEC and DOE Patent Waiver.

7. 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.

8. 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 §200.206(b)(2). ARPA-E may require special award terms and conditions depending upon results of the risk analysis.

ARPA-E will not make an award if ARPA-E has determined that:

- The entity submitting the proposal or application:

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- o has an owner or covered individual that is party to a malign foreign talent recruitment program;
 - o has a business entity, parent company, or subsidiary located in the People's Republic of China or another foreign country of concern; or
 - o has an owner or covered individual that has a foreign affiliation with a research institution located in the People's Republic of China or another foreign country of concern; and
- The relationships and commitments described above:
 - o interfere with the capacity for activities supported by the Federal agency to be carried out;
 - o create duplication with activities supported by the Federal agency;
 - o present concerns about conflicts of interest;
 - o were not appropriately disclosed to the Federal agency;
 - o violate Federal law or terms and conditions of the Federal agency; or
 - o pose a risk to national security.

9. RECIPIENT INTEGRITY AND PERFORMANCE MATTERS

Prior to making a Federal award, 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. 200.206).

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.

10. 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 the 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.

11. INTERIM CONFLICT OF INTEREST POLICY FOR FINANCIAL ASSISTANCE

The DOE interim Conflict of Interest Policy for Financial Assistance (COI Policy) can be found at <https://www.energy.gov/management/financial-assistance-letter-no-fal-2022-02>. This policy is applicable to all non-Federal entities applying for, or that receive, DOE funding by means of a financial assistance award (e.g., a grant, cooperative agreement, or technology investment agreement or similar other transaction agreement) and, through the implementation of this policy by the entity, to each Investigator who is planning to participate in, or is participating in, the project funded wholly or in part under the DOE financial assistance award. DOE’s interim COI Policy establishes standards that provide a reasonable expectation that the design, conduct, and reporting of projects funded wholly or in part under DOE financial assistance awards will be free from bias resulting from financial conflicts of interest or organizational conflicts of interest. The applicant is subject to the requirements of the interim COI Policy and

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within each application for financial assistance, the applicant must certify that it is, or will be by the time of receiving any financial assistance award, compliant with all requirements in the interim COI Policy. For applicants to any ARPA-E Funding Opportunity Announcement, this certification, disclosure of any managed or unmanaged conflicts of interest, and a copy of (or link to) the applicant's own conflict of interest policy must be included with the information provided in the Business Assurances & Disclosures Form. The applicant must also flow down the requirements of the interim COI Policy to any subrecipient non-Federal entities.

12. COMMERCIALIZATION PLAN AND SOFTWARE REPORTING

If your project is selected and it targets the development of software, you may be required to prepare a Commercialization Plan for the targeted software and agree to special provisions that require the reporting of the targeted software and its utilization. This special approach to projects that target software mirrors the requirements for reporting that attach to new inventions made in performance of an award.

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/technologies/project-guidance/pre-award-guidance/funding-agreements>).

VII. AGENCY CONTACTS

A. COMMUNICATIONS WITH ARPA-E

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

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

- ARPA-E will post responses on a weekly basis to any questions that are received that have not already been addressed at the link above. ARPA-E may re-phrase questions or consolidate similar questions for administrative purposes.
- ARPA-E will cease to accept questions approximately 10 business days in advance of each submission deadline. Responses to questions received before the cutoff will be posted no later than three business days in advance of the submission deadline. ARPA-E may re-phrase questions or consolidate similar questions for administrative purposes.
- Responses are published in a document specific to this FOA under “CURRENT FUNDING OPPORTUNITIES – FAQs” on ARPA-E’s website (<http://arpa-e.energy.gov/faq>).

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

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

During the “quiet period,” only the Contracting Officer may authorize communications between ARPA-E personnel and Applicants. The Contracting Officer may communicate with Applicants as necessary and appropriate. As described in Section IV.A of the FOA, the Contracting Officer may arrange pre-selection meetings and/or site visits during the “quiet period.”

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).

B. DEBRIEFINGS

ARPA-E does not offer or provide debriefings. ARPA-E provides Applicants with reviewer comments on Full Applications before the submission deadline for Replies to Reviewer Comments.

VIII. OTHER INFORMATION

A. TITLE TO SUBJECT INVENTIONS

Ownership of subject inventions is governed pursuant to the authorities listed below:

- Domestic Small Businesses, Educational Institutions, and Nonprofits: Under the Bayh-Dole Act (35 U.S.C. § 200 et seq.), domestic small businesses, educational institutions, and nonprofits may elect to retain title to their subject inventions;
- All other parties: The federal Non-Nuclear Energy Act of 1974, 42 U.S.C. 5908, provides that the government obtains title to new subject inventions unless a waiver is granted (see below):
 - Class Patent Waiver for Domestic Large Businesses: DOE has issued a class patent waiver that applies to this 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 to the U.S. Competitiveness Provision in accordance with Section VI.B.6. of this FOA.
 - Advance and Identified Waivers: For applicants that do not fall under the class patent waiver or the Bayh-Dole Act, those applicants may request a patent waiver that will cover subject inventions that may be made under the award, in advance of or within 30 days after the effective date of the award. Even if an advance waiver is not requested or the request is denied, the recipient will have a continuing right under the award to request a waiver for identified inventions, i.e., individual subject inventions that are disclosed to DOE within the time frames set forth in the award's intellectual property terms and conditions. Any patent waiver that may be granted is subject to certain terms and conditions in 10 CFR 784.
- DEC: On June 07, 2021, DOE approved a DETERMINATION OF EXCEPTIONAL CIRCUMSTANCES (DEC) UNDER THE BAYH-DOLE ACT TO FURTHER PROMOTE DOMESTIC MANUFACTURE OF DOE SCIENCE AND ENERGY TECHNOLOGIES. In accordance with this DEC, all awards, including sub-awards, under this FOA made to a Bayh-Dole entity (domestic small businesses and nonprofit organizations) shall include the U.S. Competitiveness Provision in accordance with Section VI.B.6 of this FOA. A copy of the DEC may be found on the DoE website. Pursuant to 37 CFR § 401.4, any Bayh-Dole entity affected by this DEC has the right to appeal it by providing written notice to DOE within 30 working days from the time it receives a copy of the determination.

B. GOVERNMENT RIGHTS IN SUBJECT INVENTIONS

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

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).

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: Pursuant to special statutory authority for SBIR/STTR awards, data generated under ARPA-E SBIR/STTR awards may be protected from public disclosure for twenty years from the date of award in accordance with provisions that will be set forth in the award. In addition, invention disclosures may be protected from public disclosure for a reasonable time in order to allow for filing a patent application.

D. PROTECTED PERSONALLY IDENTIFIABLE INFORMATION

Applicants may not include any Protected Personally Identifiable Information (Protected PII) in their submissions to ARPA-E. Protected PII is defined as data that, if compromised, could cause harm to an individual such as identity theft. Listed below are examples of Protected PII that Applicants must not include in their submissions.

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

E. FOAs AND FOA MODIFICATIONS

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

F. OBLIGATION OF PUBLIC FUNDS

The Contracting Officer is the only individual who can make awards on behalf of ARPA-E or

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obligate ARPA-E to the expenditure of public funds. A commitment or obligation by any individual other than the Contracting Officer, either explicit or implied, is invalid.

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

G. REQUIREMENT FOR FULL AND COMPLETE DISCLOSURE

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

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

H. RETENTION OF SUBMISSIONS

ARPA-E expects to retain copies of all Full Applications, Replies to Reviewer Comments, and other submissions. No submissions will be returned. By applying to ARPA-E for funding, Applicants consent to ARPA-E's retention of their submissions.

I. MARKING OF CONFIDENTIAL INFORMATION

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

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

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

Notice of Restriction on Disclosure and Use of Data:

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

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

J. ADDITIONAL NOTICES

- This FOA is intended for informational purposes and reflects current planning. If there is any inconsistency between the information contained herein and the terms of any resulting SBIR or STTR funding agreement, the terms of the funding agreement are controlling.
- Before award of an SBIR or STTR funding agreement, ARPA-E may request the selectee to submit certain organizational, management, personnel, and financial information to assure responsibility of the Prime Recipient. In addition, selectees will be required to make certain legal commitments at the time of execution of funding agreements resulting from this FOA. ARPA-E encourages Prime Recipients to review the Model Cooperative Agreement for SBIR/STTR Awards, which is available at <https://arpa-e.energy.gov/?q=site-page/funding-agreements>.
- Actual or suspected fraud, waste, or abuse may be reported to the DOE Office of Inspector General (OIG) at 1-800-541-1625.

K. EXPORT CONTROL INFORMATION

Do not include information subject to export controls in any submissions, including Full Applications and Replies to Reviewer Comments – whether marked as subject to US export control laws/regulations or otherwise. Such information may not be accepted by ARPA-E and may result in a determination that the application is non-compliant, and therefore not eligible for selection. This prohibition includes any submission containing a general, non-determinative statement such as "The information on this page [or pages _ to_] may be subject to US export control laws/regulations", or similar. Under the terms of their award, awardees shall be responsible for compliance with all export control laws/regulations.

L. 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.

M. PAYMENT OF FEE OR PROFIT

ARPA-E will pay a fee or profit to Prime Recipients in an amount not to exceed 7% of total project cost under any agreement resulting from this FOA, subject to negotiations. Any fee or profit paid by Prime Recipients to their sub-recipients (but not commercial suppliers, vendors, or contractors) must be paid from fee or profit paid to Prime Recipients by ARPA-E. Any fee or profit must be included in the budget submitted with Prime Recipients' Full Applications and will be payable to Prime Recipients upon: (i) completion of all work required by the agreement, (ii) submission and acceptance of all for-profit audit reports and resolution of all findings (if any) identified in the reports, (iii) submission and acceptance by the Government of all closeout documentation required by Attachment 4 to the agreement (refer to ARPA-E's Model Cooperative Agreement found at <https://arpa-e.energy.gov/?q=site-page/funding-agreements>), and (iv) submission of an acceptable invoice.

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 Preliminary Application, Full Application, Reply to Reviewer Comments, and Small Business Grant Application (if applicable).

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

Cost Sharing: Is the portion of project costs 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.

Covered Individual: an individual who contributes in a substantive, meaningful way to the scientific development or execution of an R&D project proposed to be carried out with an award from ARPA-E. This includes, but is not limited to, the PI, Co-PI, Key Personnel, and technical staff (e.g., postdoctoral fellows/researchers and graduate students). ARPA-E may further designate covered individuals during award negotiations or the period of performance.

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.

Foreign Affiliation: a funded or unfunded academic, professional, or institutional appointment or position with a foreign government or government-owned entity, whether full-time, part-time, or voluntary (including adjunct, visiting, or honorary).

Foreign Countries of Concern: the People's Republic of China, the Democratic People's Republic of Korea, the Russian Federation, the Islamic Republic of Iran, Burma, Eritrea, Pakistan, Saudi Arabia, Tajikistan, and Turkmenistan.

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

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

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).

Malign Foreign Talent Recruitment Program: the meaning given such term in section 10638 of the Research and Development, Competition, and Innovation Act (division B of Public Law 117–167) or 42 USC 19237, as of October 20, 2022.

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

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

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

PI: Principal Investigator.

Project Team: A Project Team consists of the Prime Recipient, Subrecipients, and others performing or otherwise supporting work under an ARPA-E funding agreement.

SBA: U.S. Small Business Administration.

SBIR: Small Business Innovation Research Program.

Small Business: Small businesses are domestically incorporated entities that meet the criteria established by the U.S. Small Business Administration’s (SBA) “Table of Small Business Size Standards Matched to North American Industry Classification System Codes” (NAICS) (<http://www.sba.gov/content/small-business-size-standards>).

Small Business Concern: A for-profit entity that: (1) maintains a place of business located in the United States; (2) operates primarily within the United States or makes a significant contribution to the United States economy through payment of taxes or use of American products, materials or labor; (3) is an individual proprietorship, partnership, corporation, limited liability company, joint venture, association, trust, or cooperative; and (4) meets the size eligibility requirements set forth in 13 C.F.R. § 121.702. Where the entity is formed as a joint venture, there can be no more than 49% participation by foreign business entities in the joint venture. Such joint ventures must submit the VCOC/FJV Certification (the seventh component of the Full Application).

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

STTR: Small Business Technology Transfer Program.

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

Subrecipient: An entity (not an individual) that receives a subaward from the Prime Recipient to carry out part of the ARPA-E award.

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

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

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