FINANCIAL ASSISTANCE
FUNDING OPPORTUNITY ANNOUNCEMENT

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

GRID OVERHAUL WITH PROACTIVE, HIGH-SPEED UNDERGROUNDING FOR RELIABILITY, RESILIENCE, AND SECURITY SBIR/STTR (GOPHURRS SBIR/STTR)

Announcement Type: Initial Announcement
Funding Opportunity No. DE-FOA-0003048
CFDA Number 81.135

Funding Opportunity Announcement (FOA) Issue Date:	March 30, 2023
First Deadline for Questions to ARPA-E-CO@hq.doe.gov:	5 PM ET, April 28, 2023
Submission Deadline for Concept Papers:	9:30 AM ET, May 9, 2023
Second Deadline for Questions to ARPA-E-CO@hq.doe.gov:	5 PM ET, TBD
Submission Deadline for Full Applications:	9:30 AM ET, TBD
Submission Deadline for Replies to Reviewer Comments:	5 PM ET, TBD
Expected Date for Selection Notifications:	October 2023
Total Amount to Be Awarded	Approximately $40 million, subject to the availability of appropriated funds to be shared between FOAs DE-FOA-0003047 and DE-FOA-0003048.
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.H.1 of the FOA.
- Applicants are responsible for meeting each 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 Concept Papers, Full Applications, and Replies to Reviewer Comments, see Sections IV.C, IV.D, and IV.E of the FOA.

SUBMISSION	COMPONENTS	OPTIONAL/ MANDATORY	FOA SECTION	DEADLINE
Concept Paper	• Each Applicant must submit a Concept Paper in Adobe PDF format by the stated deadline. The following sections of the Concept Paper must not exceed 4 pages in length including graphics, figures, and/or tables, and must include the following: ○ Concept Summary ○ Innovation and Impact ○ Proposed Work ○ Team Organization and Capabilities • The Concept Paper shall also include responses to Question-and-Answer Tables specific to each applicable technical category addressed (more detail available in Section I.F Technical Performance Targets), each not to exceed 1 page. ○ Concept Papers addressing 2 technical categories (the maximum permitted) are limited to no more than 6 total pages ○ Concept Papers addressing only 1 technical category are limited to no more than 5 total pages	Mandatory	IV.C	9:30 AM ET, May 9, 2023
Full Application	[TO BE INSERTED BY FOA MODIFICATION IN JUNE 2023]	Mandatory	IV.D	9:30 AM ET, TBD
Reply to Reviewer Comments	[TO BE INSERTED BY FOA MODIFICATION IN JUNE 2023]	Optional	IV.E	5 PM ET, TBD

I. FUNDING OPPORTUNITY DESCRIPTION

A. AGENCY OVERVIEW

The Advanced Research Projects Agency – Energy (ARPA-E), an organization within the Department of Energy (DOE), is chartered by Congress in the America COMPETES Act of 2007 (P.L. 110-69), as amended by the America COMPETES Reauthorization Act of 2010 (P.L. 111-358), 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. By contrast, ARPA-E supports transformative research that has the potential to create fundamentally new learning curves. ARPA-E technology projects typically start with cost/performance estimates well above the level of an incumbent technology. Given the high risk inherent in these projects, many will fail to progress, but some may succeed in generating a new learning curve with a projected cost/performance metric that is significantly better than that of the incumbent technology.

ARPA-E funds technology with the potential to be disruptive in the marketplace. The mere creation of a new learning curve does not ensure market penetration. Rather, the ultimate value of a technology is determined by the marketplace, and impactful technologies ultimately become disruptive – that is, they are widely adopted and displace existing technologies from the marketplace or create entirely new markets. ARPA-E understands that definitive proof of market disruption takes time, particularly for energy technologies. Therefore, ARPA-E funds the development of technologies that, if technically successful, have 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

[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.

disadvantaged and women-owned Small Business Concerns, and (5) improve the return on 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. EXECUTIVE SUMMARY

GOPHURRS (**G**rid **O**verhaul with **P**roactive, **H**igh-Speed **U**ndergrounding for **R**eliability, **R**esilience, and **S**ecurity) intends to fund a portfolio of new technologies based on bold and unconventional ideas that will transform the construction of underground medium voltage (MV, 5 – 46 kV) power distribution grids (e.g., primary feeders and laterals) in urban and suburban areas and reduce the cost of undergrounding electric power grids by at least 50% in order to improve the overall reliability, resilience, and security of power infrastructure in the United States.

SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index) are two commonly used reliability metrics. In the United States today, SAIDI and SAIFI range approximately 5-8 hours and 1.5 times per customer, respectively, which is responsible for an economic cost to U.S. electricity consumers of $79 billion/year.[5] Undergrounding powerlines is a proven way of improving the system reliability for both transmission and distribution grids as indicated in stark differences in SAIDI and SAIFI of overhead systems and underground systems (Figure 1).[6] Despite the reliability benefits, the cost of burying distribution powerlines is significant, up to five to ten times that of overhead distribution lines,[7] making it the major barrier to making such grid investment decisions. Furthermore, today's undergrounding processes pose safety concerns, such as damage to other

[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] "Cost of Power Interruptions to Electricity Consumers in the United States (U.S.)" LBNL-58164 (2006) (https://www.osti.gov/biblio/908489)

[6] Out of Sight, Out of Mind – An Updated Study on the Undergrounding of Overhead Powerlines, Edison Electricity Institute, 2012 (https://woodpoles.org/portals/2/documents/OutofSightOutofMind2012.pdf)

[7] "Power outages often spur questions around burying powerlines" U.S. Energy Information Administration (https://www.eia.gov/todayinenergy/detail.php?id=7250)

buried utilities during construction, occupational safety and health hazards associated with tasks performed in a manhole, and lengthy surface disruptions and traffic detours affecting the safety of surrounding communities, making undergrounding a difficult project to undertake.

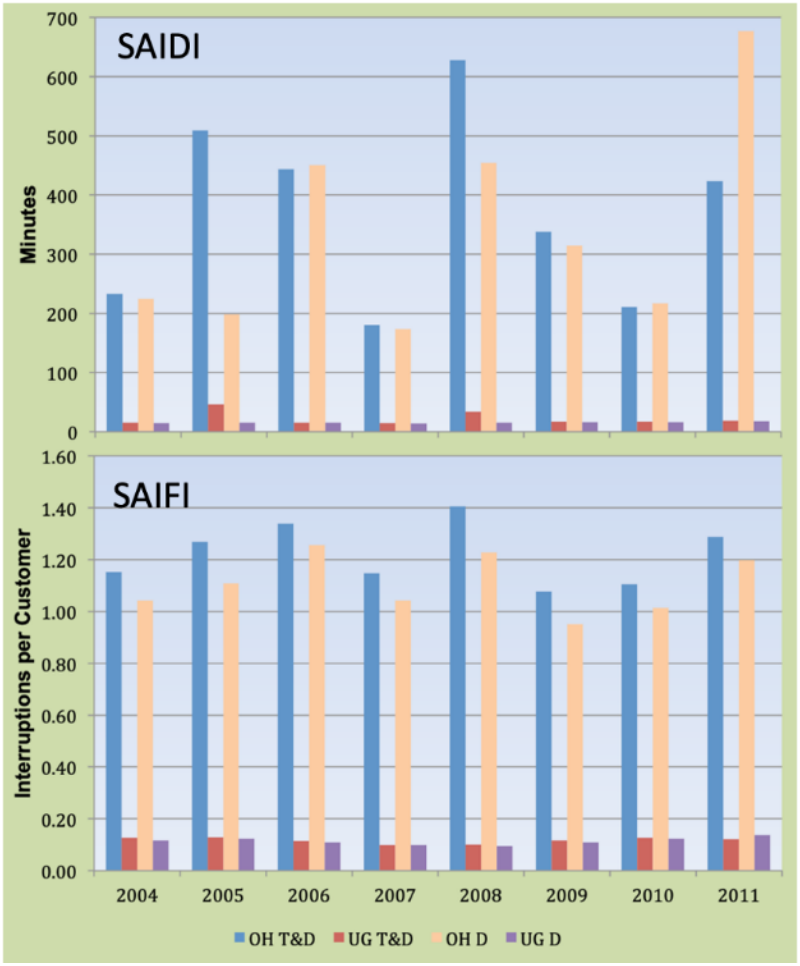

Figure 1. SAIDI (System Average Interruption Duration Index) and SAIFI (System Average Interruption Frequency Index) comparisons for overhead (OH) and underground (UG) transmission (T) and distribution (D) power infrastructure in the United States[6].

The GOPHURRS program aims to reduce the time and cost required to underground by a factor of at least two when compared to traditional trenching-based methods.[5,8,9] More specifically, GOPHURRS technologies will shift the paradigm of undergrounding from digging to drilling in order to leave the surface nearly untouched. In order to achieve this goal, GOPHURRS focuses on developing transformative technologies capable of achieving autonomous/trenchless utility installation, such as automated and rapid subsurface drilling along the terrain and concurrent

[8] "Overhead vs. Underground Residential Distribution Circuits. Which One Is 'Better'?" November 13, 2017 (https://electrical-engineering-portal.com/overhead-vs-underground)

[9] "Resilient Power Grids: Strategically Undergrounding Powerlines Workshop", Office of Electricity, US Department of Energy, March 22, 2022 (https://www.energy.gov/oe/resilient-power-grids-strategically-undergrounding-powerlines)

conduit installation, while also avoiding hidden underground obstacles (e.g., existing infrastructure, geologic anomalies) with advanced look-ahead sensors (Figure 2). In addition, GOPHURRS aims to reduce the life cycle cost of an underground power system by developing reliable cable joint designs and installation systems, as cable joints are typically the first to fail during operation. The GOPHURRS program could reduce costs, increase speed, and improve the reliability and safety of undergrounding operations and the surrounding communities by developing such technologies focused on automation, damage prevention, and error elimination.

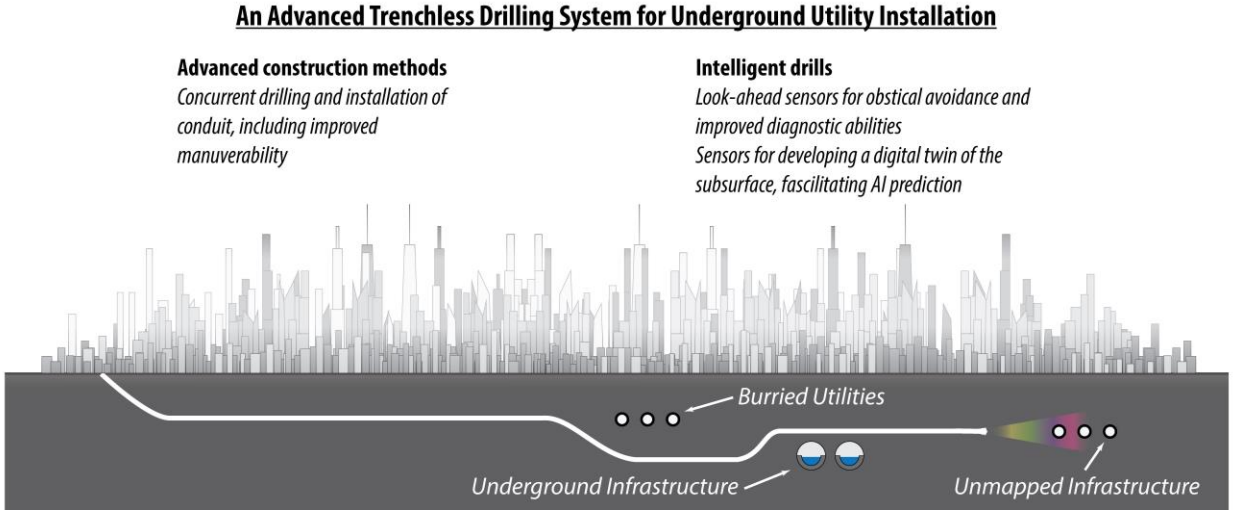

Figure 2. A conceptual schematic of a hypothetical autonomous drill for underground installation of distribution powerlines in urban/suburban settings. The main technological subsystems include maneuverable drills with concurrent installation of conduits to navigate this complex environment and advanced geophysical sensors (i.e. look-ahead sensors and surveys for AI predictive digital twins of the subsurface) providing information of the drill head's surrounding environment and situational intelligence in real time.

Specific technology categories include: (1) high-speed construction tools with maneuverability to install underground conduits with minimal disruption to the surface, where the installed conduits are suitable for pulling medium voltage (5 – 46 kV) power cables;[10] (2) sensors that characterize near-surface geology, underground obstacles, and existing underground infrastructure in order to assist underground construction operations at the required speed and to minimize risk of utility strikes and cross-borings; and (3) automated cable splice installation systems as well as novel splice designs to ensure error-free and safe installation of cable joints.

GOPHURRS technologies should enable underground construction with minimal surface disruption and automation to the greatest extent possible (with the ultimate goal of autonomous drilling, concurrent construction of conduits, ducts, vaults), and be equipped with enhanced situational intelligence (e.g., real-time detection of other buried utilities and obstacles, steerable drilling tools to avoid damages). GOPHURRS technologies should be able to

[10] "IEEE Recommended Practice for Cable Installation in Generating Stations and Industrial Facilities", IEEE Standard 1185 (2019) (https://ieeexplore.ieee.org/document/9093259)

create > 5” inner diameter (I.D.) conduits suitable for pulling medium voltage power cables at depths of up to 6 feet in the time it takes conventional tools to create just boreholes. It is essential for these technologies to have a small rig footprint, to develop high-speed mobilization/demobilization capabilities with low power requirements, and to have low noise and minimal hazardous wastes. Sensor technologies should be able to provide real-time look-ahead underground intelligence to supplement the development of construction tools. GOPHURRS technologies for cable joint design and installation will dramatically reduce errors during cable joint installation by automating the process and by inspecting during and after the installation.

GOPHURRS technologies will improve the reliability, resilience, and security of power infrastructure in the United States (contributing to SAIDI < 30 minutes by 2050) by promoting proactive, high-speed, and cost-effective undergrounding through the adoption of transformative new undergrounding technologies, advanced underground obstacle sensors, and error-free installation of cable joints. This program also aims to help accelerate grid expansion and position the United States as a global leader in the delivery of clean, affordable, equitable, and climate-resilient electricity. If successfully developed, the technologies envisioned would also improve the speed of underground construction of other types of infrastructure through automation, as well as the safety of the operators and surrounding communities. The development of GOPHURRS technologies is an urgent matter due to the need for increased undergrounding to improve reliability and resilience in the face of growing severe weather-related threats resulting from climate change.

2. BACKGROUND

The Reliability of Electric Power Distribution

Due to outdated infrastructure, the reliability, resilience, and security of the grid system in the United States are lower than in many other developed countries.[11] Furthermore, the frequently used reliability indices[12] such as SAIDI and SAIFI have recently been getting worse, as the frequency and intensity of extreme weather events is increasing, exacerbated by climate change (Figure 3).[13,14]

[11] "Benchmarking of Reliability: North American and European Experience", J. McDaniel, W. Friedl, H. Caswell, 23rd International Conference on Electricity Distribution (2015) (http://cired.net/publications/cired2015/papers/CIRED2015_0182_final.pdf)

[12] "IEEE 1366 Reliability Indices", (https://site.ieee.org/boston-pes/files/2019/03/IEEE-1366-Reliability-Indices-2-2019.pdf)

[13] "Billion-Dollar Weather and Climate Disasters", NOAA (https://www.ncdc.noaa.gov/billions/)

[14] "U.S. electricity customers averaged seven hours of power interruptions in 2021", U.S. Energy Information Administration (https://www.eia.gov/todayinenergy/detail.php?id=54639)

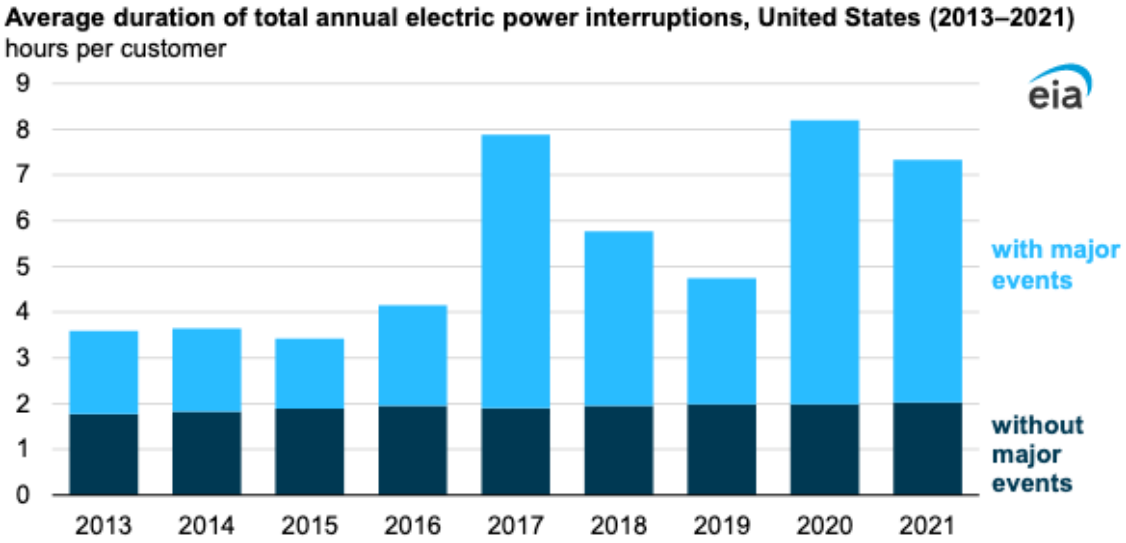

Figure 3. Average U.S. SAIDI (System Average Interruption Duration Index) for electricity has been steadily increasing over the past decade due to aging infrastructure and an increasing number of frequent and severe weather events. Source: U.S. Energy Information Administration, Annual Electric Power Industry Report.[14]

To enable a transition to a decarbonized energy system, the United States must upgrade and expand its grid infrastructure to accommodate the adoption of renewable power generation technologies, an increase in distributed energy resources (DERs), and the use of electric vehicles.[15,16] Among many grid upgrade approaches, undergrounding provides reliability, resilience, and security; yet, it is expensive and time-consuming to deploy.[5,7,8,9,17,18] Existing undergrounding technologies are slow, expensive, unsafe for workers, and disruptive to surfaces and environments which can lead to low societal acceptance. Therefore, the GOPHURRS program aims to develop faster, safer, more cost-effective underground power grid installation technologies.

The recent increase in the frequency and severity of extreme weather events is exacerbating weather-related power outages across the United States.[7,13,14] The electric power distribution system in the United States has over 5.5 million line-miles and over 180 million power poles that can be damaged by weather or tree-related incidents.[19] Weather-related damages to these powerlines and poles account for 62% of all power outages in the country.[5,7] Grid dependability

[15] "Net-Zero America: Potential Pathways, Infrastructure, and Impacts, Final Report Summary" October 29, 2021 (https://netzeroamerica.princeton.edu/img/Princeton%20NZA%20FINAL%20REPORT%20SUMMARY%20(29Oct2021).pdf)
[16] "Building the Underground Distribution Grid of the Future to Support Clean Energy Goals", T&D World, October 28, 2022 (https://www.tdworld.com/intelligent-undergrounding/article/21251771/building-the-underground-distribution-grid-of-the-future-to-support-clean-energy-goals)
[17] "Distribution Grid Resiliency: Prioritization of Options", 2015 Report, Electric Power Research Institute (https://www.epri.com/research/products/000000003002006668)
[18] "Distribution Grid Resiliency: Undergrounding", 2015 Report, Electric Power Research Institute (https://www.epri.com/research/products/000000003002006782)
[19] US data derived from EIA 2021 report (https://www.eia.gov/todayinenergy/detail.php?id=50316)

is also a climate and energy justice concern because low-income and disadvantaged populations experience more frequent and longer outages.[20,21,22]

Undergrounding powerlines is a proven method to improve grid reliability, as illustrated in Figure 4.[5,6,8,9,11,18,20,21,22] Overhead circuits typically fail about 90 times/100 mi/year, whereas underground circuits fail less than 10 times/100 mi/year.[8] However, it is more difficult to locate faults and provide necessary maintenance and repair on underground powerlines than on overhead powerlines.

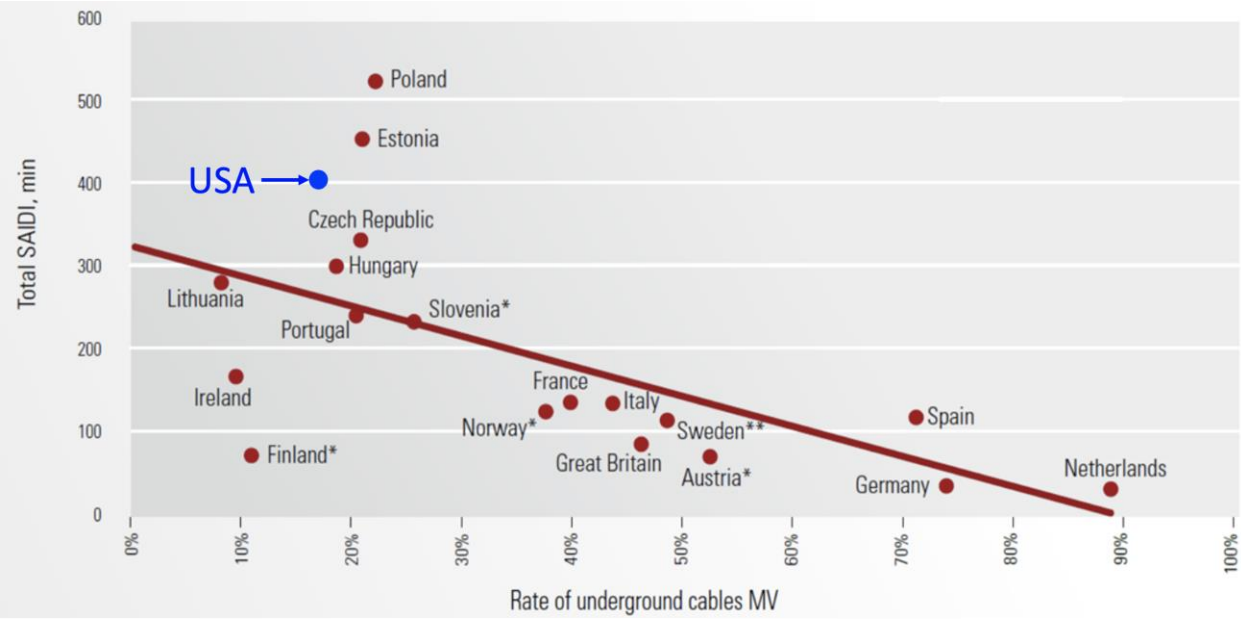

Figure 4. Statistical correlation between the percentage of underground cables in MV networks and "total SAIDI" (unplanned SAIDI including exceptional events plus planned SAIDI) averaged over 3 years. (2008 – 2010 or 2007 – 2009 data). The 9-year average SAIDI (2013 – 2021) for the U.S. (5.4 hours) is extracted from the EIA report. The 3-year average SAIDI (2019-2021) for the U.S. is 6.7 hours.[5,8,19] According to 2007 data, only 0.74% and 18% of total lines were undergrounded in the U.S. for transmission and distribution, respectively.

[20] "Equitable community resilience: The case of Winter Storm Uri in Texas", A. Nejat, L. Solitare, E. Pettitt, H. Mohsenian-Rad, International Journal of Disaster Risk Reduction, Volume 77, July 2022, 103070

[21] "Frozen out: Minorities suffered four times more power outages in Texas blackouts", April 14, 2021 (https://www.umass.edu/news/article/frozen-out-minorities-suffered-four-times)

[22] "Racial and ethnic minorities are more vulnerable to wildfires", November 6, 2018 (https://theconversation.com/racial-and-ethnic-minorities-are-more-vulnerable-to-wildfires-106290)

The Cost of Undergrounding

Despite numerous studies showing that underground power grids improve reliability and resilience, the upfront cost is frequently cited as the primary barrier to making such investment decisions. The cost structure varies depending on the project (Figure 5), but the general consensus is that civil work[23] is the major cost driver — accounting for about 75-90% of the total cost of undergrounding (Figure 6). This is especially true in urban and suburban areas where undergrounding powerlines can be up to 10 times more expensive than overhead powerlines due to high civil work costs.[24,25,26]

[23] Civil work includes excavation and backfilling, repaving, restoring landscapes, to install elements such as conduits, duct banks, access shafts, connection boxes, jointing chambers, pads, etc.

[24] "Feasibility study for undergrounding electric distribution lines in Massachusetts", Massachusetts Department of Energy Resources, December 2014 (https://www.mass.gov/doc/feasibility-study-for-undergrounding-electric-distribution-lines-in-massachusetts/download)

[25] "Study of the Feasibility and Reliability of Undergrounding Electric Distribution Lines in the District of Columbia", July 2010; (https://www.pgecurrents.com/2017/10/31/facts-about-undergrounding-electric-lines/)

[26] The cost structure information is based on ARPA-E's discussions with various utility companies and EPC (Engineering, Procurement, and Construction) firms.

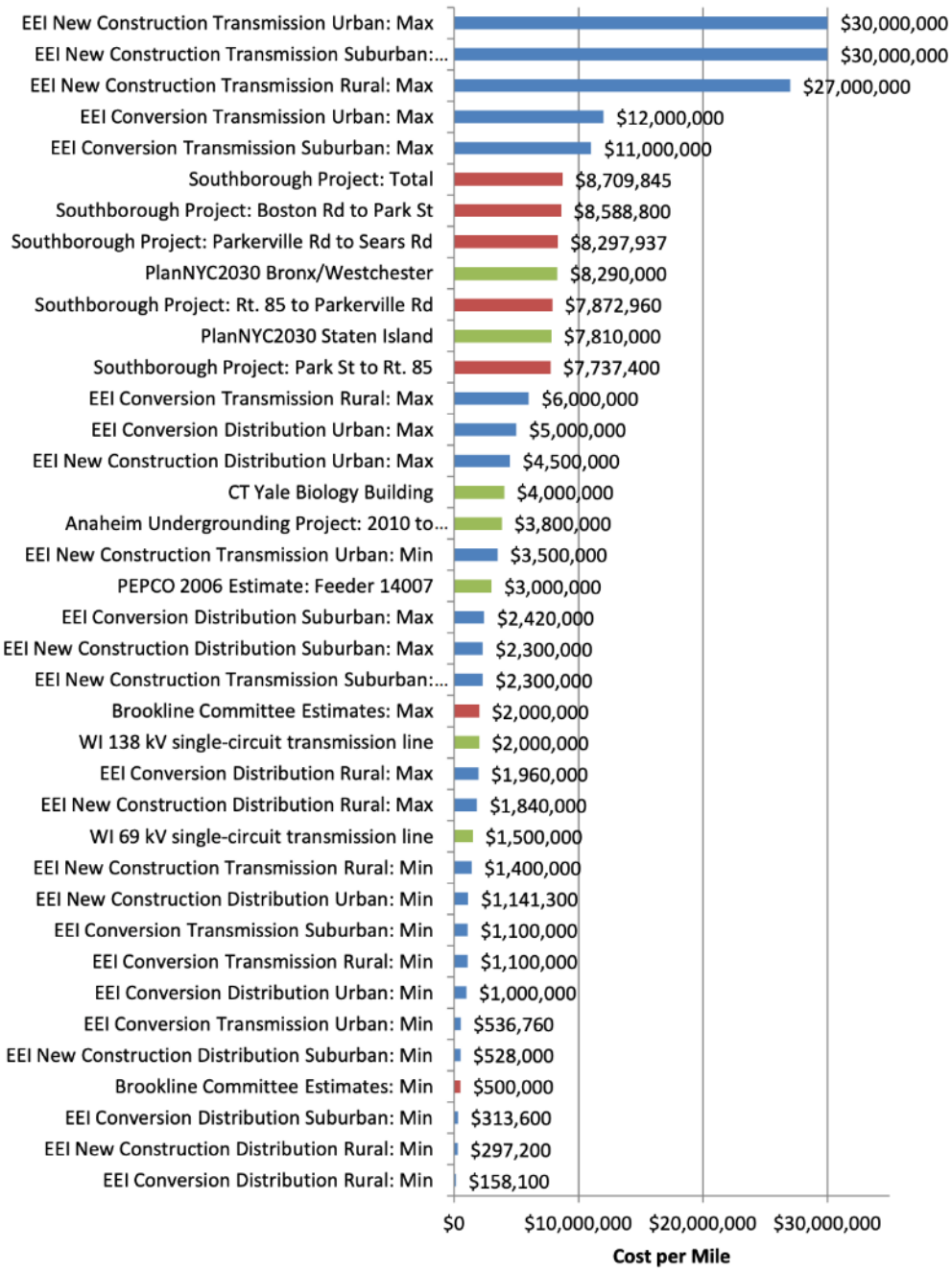

Figure 5. Cost estimates per mile of underground powerlines from various reports. These estimates have not been altered for inflation, with most estimates from the 2012 EEI study but also including estimates from the 2010 D.C. report and the 2013 PlanNYC study. They represent both averages for states and specific projects.[24,25]

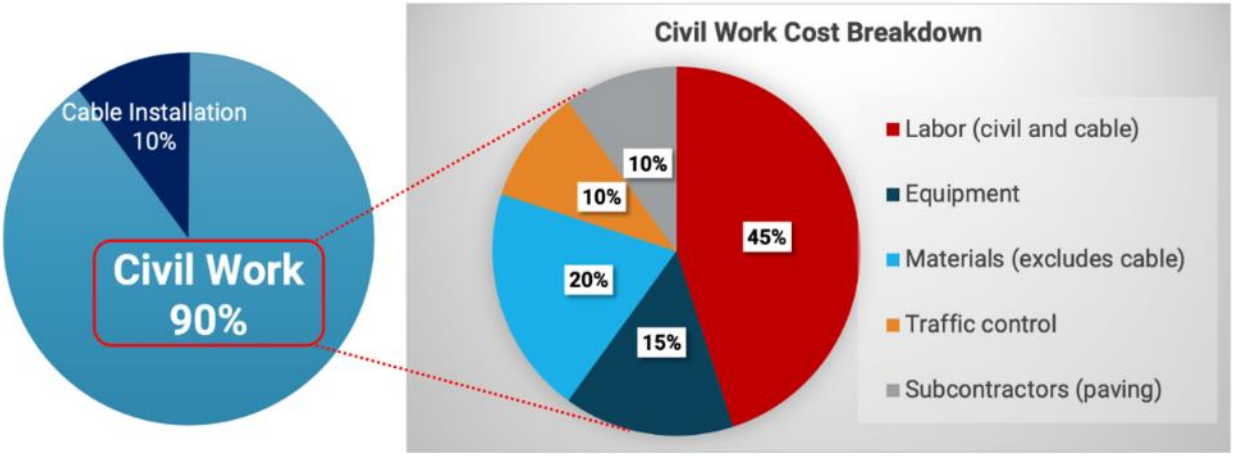

Figure 6. An example cost breakdown of an urban undergrounding project sourced from Underground Construction Co., Inc., a Quanta Services company.

To show a proposed project's pathway to meeting ARPA-E's cost reduction goal of at least 50%, each Applicant for categories 1 and 2 is required to submit a preliminary economic model in their Full Application. A sample model is available on eXCHANGE as a starting point. The sample model is available for review during the Concept Paper phase, but will not be required until the Full Application phase. Whether applicants use the sample model as-is or modify it for specific project requirements, each applicant must show a minimum 50% cost reduction pathway in an Excel format. The Applicant should calculate and compare the baseline cost of current construction methods (under certain construction conditions, such as urban or suburban, new or replacement line, and geological conditions, as specified by the application) with the costs achievable by utilizing the new technology being proposed.

The ultimate commercial success of new GOPHURRS technologies would be widespread adoption by utilities and their service contractors to achieve significant cost savings, which will require coordination and collaboration with a wide range of stakeholders. As "natural monopolies",[27] electric distribution utilities make network investment decisions through a highly regulated process. Investor-owned utilities (IOUs), which serve 71% of U.S. electricity customers,[28] must submit new capital investment plans, which could include network undergrounding projects, for approval to state utility regulators, typically referred to as "public utility commissions" or "PUCs", although the term varies by state. This is known as the "rate case process" because any new investments made by IOUs would have an impact on the rates that customers pay on their utility bills. PUCs evaluate utility proposals for their impact on cost, reliability, safety, and, increasingly on their environmental sustainability and public equity, and strive to strike a balance across all of these important factors. Upon PUC approval – which typically comes only after extensive documentation by and negotiation with the utilities, as well as public testimony by consumer advocates, environmental groups, and other interested third-party stakeholders – utilities typically execute turn-key contracts with service companies for

[27] "Emergence of Electrical Utilities in America", Smithsonian National Museum of American History (https://americanhistory.si.edu/powering/past/h1main.htm)

[28] Municipality-owned utilities and electric cooperative utilities serve the remaining 16% and 13%, respectively.

complex construction projects such as undergrounding. The service companies acquire the necessary capital equipment (e.g., excavators); procure necessary materials such as conduits, ducts, prefabricated vaults, conductors, cable joining materials, etc.; and often subcontract services such as mapping existing buried utilities (today, typically through a process known as "potholing" to daylight buried utilities[29]), repaving roads, and restoring landscapes. Critically, new technology adoption requires buy-in across all of these stakeholders. A utility must be confident that the new technology will create underground power systems that meet the criteria under which a PUC approved the investment; a service company must be confident that the technology will enable it to bid and deliver successfully; and original equipment manufacturers (OEMs) and subcontractors must be confident that the effort and investment required to commercialize a new technology are commensurate with the ultimate market opportunity. Figure 7 illustrates a value chain map depicting these relationships. Consequently, Applicants for this FOA will need to describe their plans for bringing their technologies to market as integrated turn-key products or service offerings, either through partnership or other commercialization strategies. To facilitate this coordination, ARPA-E has provided a Teaming List Announcement (TLA)[30] and, as a starting point, strongly encourages Applicants to engage industry partners in the development and validation of the preliminary economic model. It should be noted that having a utility partner as an advisor or a project partner is strongly encouraged but not required for a project team to be considered for this ARPA-E award.

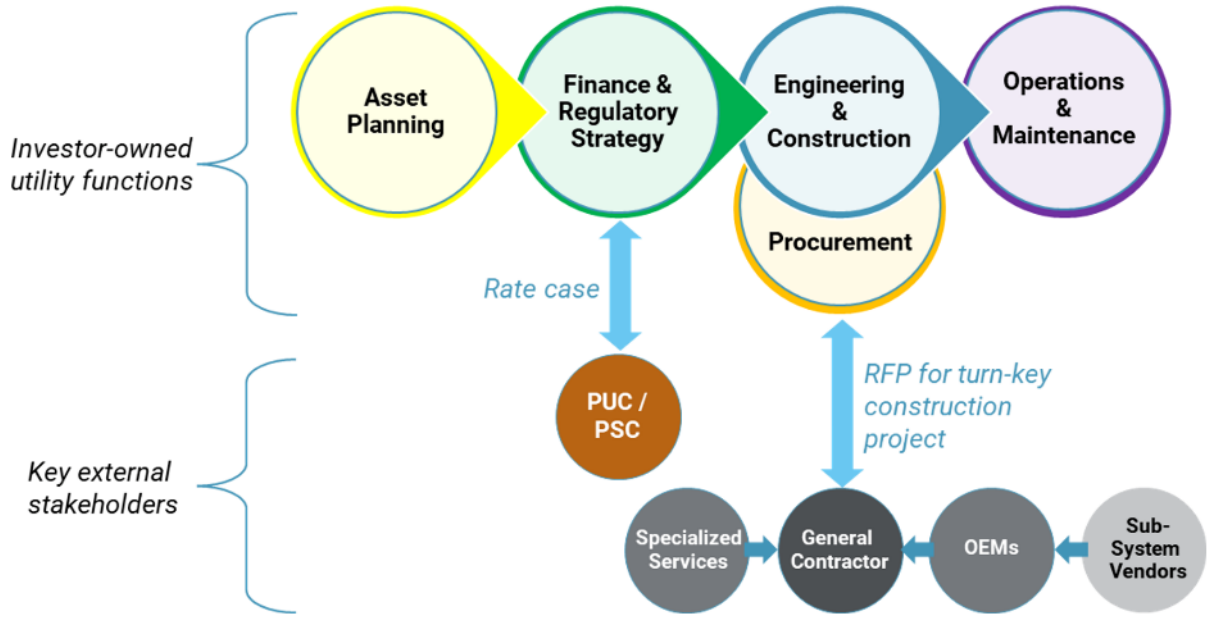

Figure 7. IOU (Investor-Owned Utility) capital investment value chain.

[29] "Potholing", TrenchlessPedia, August 20, 2020, (https://www.trenchlesspedia.com/definition/2523/potholing)
[30] ARPA-E Funding List, DOE (https://arpa-e-foa.energy.gov/Default.aspx#FoaIda6318a75-2811-42f3-abd9-d5032a9e675f)

Underground Construction

Due to the high labor, material, and equipment costs to underground powerlines, undergrounding projects are currently up to ten times more expensive than overhead powerline installations, particularly in urban and suburban areas.[7] Currently, open-trenching is the most commonly used method for underground powerline installation.[31] Open-trenching is a multistep construction workflow broadly described as digging a trench, laying the conduits and powerline, and backfilling the trench within a depth range between the frost line (5 - 100") to ~30 feet below the surface.

Unlike open-trenching, trenchless methods (e.g., horizontal directional drilling, tunnel boring, auger boring) (Figure 8) can also be used for powerline installation when trenching is impractical, such as crossing a body of water, highways, or railroads. Trenchless construction introduces several benefits, such as minimal surface disruptions to traffic, reduced need to demolish and rebuild urban infrastructure, and less safety concerns for the local community. Despite these benefits, the cost of trenchless installation is nearly double compared to open-trenching.[32] The increased cost of trenchless installation is attributed to: (1) specialized equipment costs ranging from $300/ft to $18,000/ft,[33,34] (2) frequent cross-borings and collisions with existing utilities, and (3) a cost-ineffective multistep construction workflow. Trenchless construction methods would greatly benefit from advanced construction tools for trenchless installation of powerlines that possesses the ability to drill continuously in all geologic media with high steerability, rapid penetration rates, variable bore diameters, and the ability to install conduits concurrently to increase construction efficiency.[35]

The oil and gas industry has successfully developed multi-capable tools that perform advanced drilling and subsurface surveying to maximize cost effectiveness. However, creating a versatile construction tool to simplify the trenchless construction workflow for undergrounding of powerlines in urban/suburban environments has unique technical challenges. Trenchless installation of powerlines (summarized in Figure 9) commonly requires digging a pilot hole, pre-reaming, installing a conduit, and finally pulling a cable. These processes are not accounted for in the oil and gas industry. Additional technical challenges are inherent to operating in near surface environments, such as interference associated with a proximity to active urban/suburban environments (e.g., traffic and noise), complex forces associated with predominately horizontal drilling, changes in surface terrain, and the presence of other underground infrastructure. Many of these challenges require high-resolution sensing to detect existing infrastructure and high-steerability to navigate this highly dynamic environment.

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[31] "Undergrounding", WoodPoles.org (https://woodpoles.org/Issues/Undergrounding)
[32] "Trenchless Sewer Repair: To Trench or Not to Trench? ", TrenchlessPedia, August, 4, 2021, (https://www.trenchlesspedia.com/the-true-cost-of-trenchless-vs-open-trench-sewer-repair/2/3657)
[33] "TBM Tunnel Assumptions and Cost Estimating Output", Very Large Hadron Collider, (https://www.vlhc.org/cna/hmm_appendix.pdf)
[34] "Analysis of Parameters Affecting Costs of Horizontal Directional Drilling Projects in the United States for Municipal Infrastructure", Emmania Claudyne Vilfrant, MS. Thesis, Arizona State University, December 2010 (https://keep.lib.asu.edu/_flysystem/fedora/c7/29240/Vilfrant_asu_0010N_10038.pdf)
[35] "Undergrounding Workshop", ARPA-E, 2022 (https://arpa-e.energy.gov/events/undergrounding-workshop)

Consequently, the task of trenchless installation of powerlines in urban/suburban environments is complicated and unique, preventing direct adoption of oil and gas drilling technology.

Method	Horizontal Directional Drilling	Microtunneling	Auger Boring	Compaction Boring	Pipe Ramming
Cost	21.83 $/ft/inch	$18,144/ft	$600/ft		
Steerable	Yes	Yes	Yes	No	No
ROP (ft/hr)	10 – 600	2 – 7	350		3 – 65

Figure 8. Summary of existing drilling tools with their average cost, steerability, and rate of penetration (ROP).

Trenching and open-trench installation commonly installs conduits, such as polyvinylchloride (PVC), metal, fiberglass, and high-density polyethylene (HDPE) conduits.[36] These conduits are typically pulled through boreholes after pre-reaming. Because conduits are not installed until several steps into the traditional construction process (Figure 9), inefficiencies are introduced, resulting in higher costs associated with longer work times. Conduits must also meet strict performance specifications. For example, conduits must operate within an allowable temperature range, be electrically insulating, be water-resistant, be corrosion-resistant, have an optimal degree of structural integrity, be abrasion resistant, provide low internal friction to facilitate pulling cables, and ideally have high thermal conductivity (market available common plastic pipe products have low thermal conductivity ranging from 0.15 to 0.6 W/m·K).

The GOPHURRS program seeks to support the development of technologies that simplify this process by adopting a streamlined drilling and conduit construction such as simultaneous operation (Figure 9) or automated drilling and installation of conduits that reduces the inefficiencies associated with the state-of-the-art (SOA) of horizontal drilling and conduit installation. In order to accomplish this goal, the resulting construction methods must be developed with the consideration of meeting regulations and best practices for drilling and construction safety, in addition to any existing safety regulations. For cable splicing, enough underground space must be secured, which is often achieved by installing concrete vaults with manhole access in urban areas. The number of vaults constructed per line mile varies with customer density and is another key driver of the overall construction cost. Therefore, reducing the number of vaults per mile is an opportunity to reduce the overall cost of undergrounding.

[36] "Trenchless Installation of Conduits Beneath Roadways", Tom Iseley, Sanjiv B. Gokhale, National Cooperative Highway Research Program, Synthesis of Highway Practice 242, National Academy Press (1997), (https://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_syn_242.pdf)

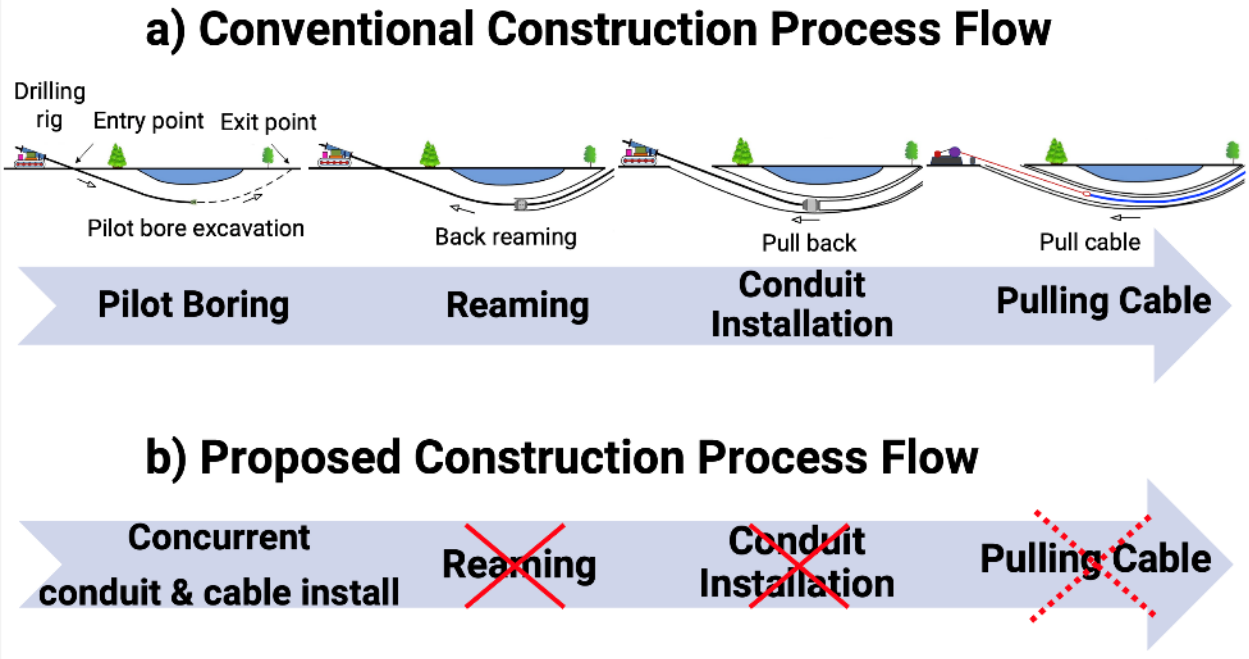

Figure 9. Schematic illustrations comparing (a) conventional multistep construction workflow for a trenchless installation of an underground conduit and (b) a more cost-effective concurrent borehole and conduit installation with potential concurrent installation of cables altogether.

Underground Utility/Obstacles Detection and Avoidance

Underground utility damages (utility strikes, cross-bores) cost the United States approximately $30 billion in 2019 alone and represent a major drag on national economies.[37] Such damages incur additional road closures for repairs, downtime for business and homes, environmental damage, and requirement of emergency resources leading to major cost overruns and delays in underground projects.[37,38] Current approaches to mitigate underground utility damages, such as subsurface surveying, are employed pre-installation or concurrently with the installation of powerlines by trenching or trenchless methods. A primary requirement for either approach is proper subsurface characterization to avoid cross-boring or delays caused by geologic obstacles, which can result in substantial additional costs.[39] Current subsurface surveying requires multiple methods (e.g., ground penetrating radar (GPR), seismic sensors, electromagnetic sensors) to correctly identify subsurface geologic media, materials, and object size. Additionally, no single method possesses the spatial resolution, fast scan capabilities, and

[37] "Excavation-Related Damages to Utilities Cost the U.S. Approximately $30 Billion in 2019", by Common Ground Alliance, The American Surveyor, October, 15, 2020 (https://amerisurv.com/2020/10/15/excavation-related-damages-to-utilities-cost-the-u-s-approximately-30-billion-in-2019/)

[38] "Causes, impacts, and costs of strikes on buried utility assets", Metje, N. et al., Proceedings of the Institution of Civil Engineers – Municipal Engineer, vol. 168(3), September 2015 (https://doi.org/10.1680/jmuen.14.00035)

[39] "Damage Information Reporting Tool (DIRT)", Common Ground Alliance, 2021 Analysis & Recommendations, vol. 18 (https://commongroundalliance.com/Portals/0/DIRT%20Report%202021%20-%20FINAL1.pdf?ver=2022-11-30-165941-267)

background canceling ability to identify a wide range of subsurface geologic media and obstacles while drilling.[40]

Real-time look-ahead sensors: As a solution to the uncertainty of surface-based surveys, look-ahead sensors are potentially a transformative advancement for undergrounding distribution lines. This approach is intended to give a drill the capability to measure in front of its intended pathway in order to detect objects before contact is made. This capability has the potential to significantly reduce the cost of undergrounding distribution powerlines by reducing, and potentially eliminating outright, costly utility strikes and cross-bores. Such an advancement in the utility undergrounding space could increase the speed by which underground utilities can be installed, further driving down the cost. This capability is also a necessary technological component for advanced drilling and automation, providing drills with situational awareness and environmental characterization in real time during operation.

While there have been several attempts at look-ahead sensors from the oil and gas industry,[41,42] there are only a few systems designed for utility detection and operation within the near surface environment.[43,44] Figure 10 gives an overview of existing technologies (surface surveys and real time look-ahead sensors) that may be adapted to provide more capable look-ahead sensors for undergrounding utility operations.

[40] "Mapping the underworld – state-of-the-art-review", Metje, N. et al., Tunnelling and Underground Space Technology, vol. 22 (5-6), November 2007 (https://doi.org/10.1016/j.tust.2007.04.002)
[41] "IriSphere, Look-ahead-while-drilling", Schlumberger (https://www.slb.com/drilling/surface-and-downhole-logging/logging-while-drilling-services/irisphere-look-ahead-while-drilling-service)
[42] "Seismic Guided Drilling - Optimize well placement in real time", Schlumberger (https://www.slb.com/reservoir-characterization/seismic/seismic-drilling-solutions/seismic-guided-drilling)
[43] Orfeus Project (https://orfeus.org/)
[44] RodRadar, Inc. (http://www.rodradar.com)

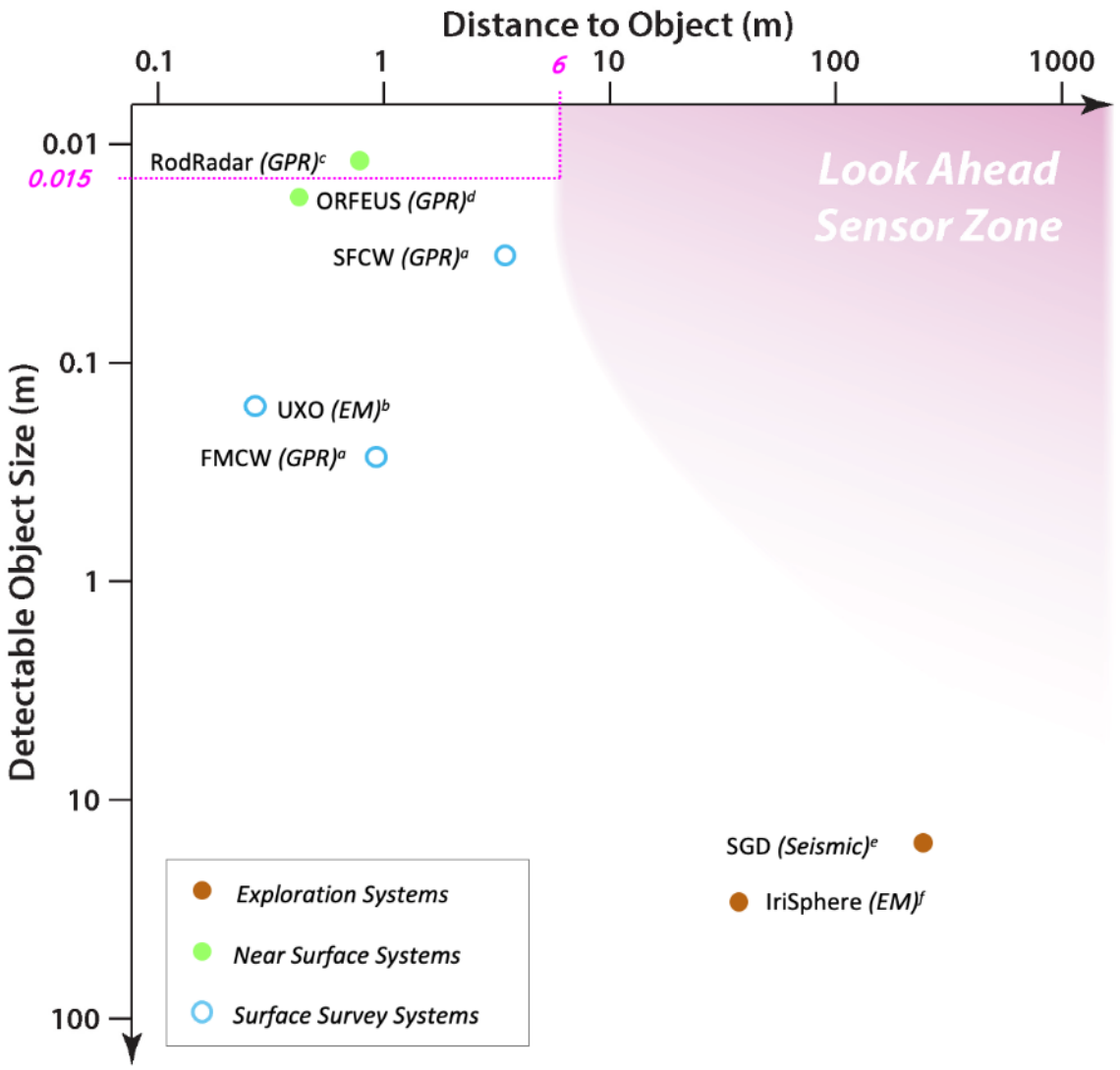

Figure 10. State-of-the-art (SOA) for surface and look-head sensor systems used in drilling and subsurface object detection. Current near-surface look-ahead systems fall short of identified performance goals, while exploration systems are designed with very different focuses (i.e., geologic characterization and deeper operation). There are many surface-based geophysical methods that are not currently utilized as look-ahead sensors (see Program Category 2.1) in the near surface environment. Abbreviations: GPR – ground penetrating radar, EM – electromagnetic, UXO – unexploded ordinance, FMCW – frequency modulated continuous wave, SFCW – single frequency continuous wave, SGD – seismic guided drilling, ORFEUS – optimized radar for every utility in the street.[45]

[45] a. "Mapping the underworld – state-of-the-art-review", Metje, N. et al., Tunnelling and Underground Space Technology, vol. 22 (5-6), November 2007 (https://doi.org/10.1016/j.tust.2007.04.002), b. "A review of ground penetrating radar application in civil engineering: a 30-year journey from locating and testing to imaging and diagnosis", Lai et al., NDT&E International, vol. 96, June 2018 (https://doi.org/10.1016/j.ndteint.2017.04.002), c. RodRadar, Inc. (http://www.rodradar.com), d. Orfeus Project (https://orfeus.org/), e. "Seismic Guided Drilling - Optimize well placement in real time", Schlumberger (https://www.slb.com/reservoir-characterization/seismic/seismic-drilling-solutions/seismic-guided-drilling), f. "IriSphere, Look-ahead-while-drilling", Schlumberger (https://www.slb.com/drilling/surface-and-downhole-logging/logging-while-drilling-services/irisphere-look-ahead-while-drilling-service)

Utility surveying in advance: Another necessary approach is the advancement of surface-based utility surveys prior to construction to provide more reliable subsurface maps. Surface-based surveys in advance for utility mapping largely constitute the SOA for detecting underground utilities. While a significant amount of research is being conducted to advance surface-based surveys, there are limited returns in terms of utility detection. Much of this research is centered on cart-based methods for mapping existing utilities.[46]

While already being employed for utility detection in the field, a transformational advancement in this space is still necessary to better inform subsurface drilling operations. By dramatically decreasing the survey time and cost, the overall cost of undergrounding operations will be reduced. GOPHURRS is looking for cutting-edge technologies for utility surveying in advance, such as the use of novel sensors, sensor fusion, and advanced artificial intelligence (AI) approaches.

Error-free Cable Splicing

Even though medium voltage underground cables and splices are manufactured in cutting-edge facilities with strict quality control, splice assembly in the field is still done entirely by hand by cable splicing crews, often in hazardous conditions. Such practices result in high levels of error that are not immediately detected but become the failure point early in the life cycle of the cable system. Premature failures at joints, such as splices and terminations, within the first 12 months after commissioning a high voltage power line system account for up to 15% of total lifecycle system failures.[47] Joints (splice and connector) and terminations collectively account for 75% of failures in medium voltage underground power systems, with cables accounting for the remaining failures.[48] Human error and poor workmanship were identified as the main causes of this premature failure of a medium voltage system at the joint, accounting for a total of 66% of the failure.[48] Therefore, error-free joint installation during installation can significantly lower operating costs associated with repair and replacement while also increasing the reliability of the power system.

GOHPURRS aims to eliminate human errors by developing an automatic, light weight, and compact splicing machine that a splicing operator can operate safely in the field. A new splice design may also need to be developed and tested in order to allow for machine-enabled splicing.

[46] "Utility specifications, Nondestructive Location and Marking of Underground Utilities", Subsurface Investigation Methodology, (https://www.simspec.org/utility-specifications)

[47] "A Holistic Approach to Risk-Based Maintenance Scheduling for HV Cables", IEEE Access, vol. 7, pp. 118975-118985 (2019), (https://ieeexplore.ieee.org/document/8807195)

[48] "Review of Medium-Voltage Asset Failure Investigations", PowerTest Conference (2018), (https://eatechnology.com/media/n3amoyyq/review-of-mv-asset-failure.pdf)

D. PROGRAM OBJECTIVES

The GOPHURRS program aims to achieve the following technical objectives in undergrounding in order to reduce the overall construction cost by at least 50%:

- **Build with speed and efficiency**: automate and concurrently drill and install conduits to avoid long disruptions on the surface and to reduce non-productive time.
- **Build with underground intelligence**: nondestructively 'day-light' all buried utilities and other obstacles to avoid utility strikes and cross-bores and to put an end to the practice of building blindly.
- **Eliminate human errors**: automate the job site operations and procedures of component installations that are prone to human errors.

GOPHURRS prioritizes overcoming the upfront cost barriers to the adoption of undergrounding. Technical approaches concerning the system operation, health monitoring, maintenance, and repair of underground power systems are beyond the scope of GOPHURRS.

E. TECHNICAL CATEGORIES OF INTEREST

The overarching program goal is at least a 50% total cost reduction of underground power installation over the current methods by automation, damage prevention, and elimination of human error during installation to enable rapid grid expansion while also ensuring reliability, resilience, and security. To achieve this, three key technical categories and their goals are defined as follows:

Category 1: Transformative construction tools that facilitate the widespread adoption of trenchless construction as a means for undergrounding distribution powerlines in urban and suburban environments. These new construction tools must operate in construction zones defined by shallow depths, near-surface activities (e.g., traffic and pedestrians), lateral drill paths, heterogeneous geology, and the presence of other underground infrastructure. Proposed technologies should have the capability of simplifying the trenchless construction workflow to create a borehole and install a conduit which is suitable for cable installation in order to increase overall construction efficiency and speed.

Category 2: Underground Intelligence

Category 2.1: Look-ahead sensors that provide information of the region in front of the drill head in real-time during operation. Examples of relevant information are location of legacy utilities, the presence of voids, soil conditions, as well as the location of other non-utility buried objects (e.g., boulders, foundations). These sensors should have the capabilities of informing drill operation in real-time to limit or eliminate utility strikes or cross-bores. These sensors can be designed separately from Category 1 technologies but should be capable of integration with both new and legacy systems broadly.

Category 2.2: Transformative surface-based geophysical surveys, data analysis approaches, and technologies that allow for faster, more accurate, and more economical subsurface mapping of legacy utilities. Surveys from these methods should result in comprehensive geographic information systems (GIS), based on advanced modeling approaches (such as AI and machine learning (ML) approaches) to provide solutions for future autonomous underground construction systems.

Category 3: Error-free Cable Splicing

Category 3.1: An automated splicing machine that can install medium voltage underground cable splices with high speed, reproducibility, and accuracy in order to further improve the reliability of the splice by reducing human errors and improving safety of the splicing operation. The machine must be ruggedized and operable in various manholes and climate conditions, meet the necessary SWaP (size, weight, and power) requirements specified in the metrics, be able to monitor and record the splicing process to detect and correct any errors, and must conduct post-installation inspection to provide the operators with pass/fail information.

Category 3.2: A transformative new splice for medium voltage underground cables designed for fast, error-free, reproducible machine-operable splicing and higher pulling tension. Advanced splices may utilize new materials (e.g., water-resistant, high dielectric breakdown strength, highly adhesive, electrically insulating and high thermal conductivity) or novel designs.

All teams are **required to prove the feasibility** of their technologies based on an in-house test and validation proposed by each Applicant (to be approved by ARPA-E) for a potential field test after a successful completion of their project. Potential field tests include running a 500' drilling and surveying field test (for Categories 1 and 2), carrying out an in-field cable splicing operation (Category 3.1), or testing the splice performance (Category 3.2). Subject to approval and budget allocations, ARPA-E may selectively support successful projects to run such field tests.

Applicants are encouraged to form multi-disciplinary teams of experts, including but not limited to civil engineers, mechanical engineers, electrical engineers, physicists, sensor developers, geophysicists, data scientists, robotics researchers, industrial engineers, chemists, materials engineers, EPC (Engineering, Procurement, and Construction) companies, cable manufacturers, equipment developers/OEM companies, and utility companies.

1. CATEGORY 1 — AUTONOMOUS DRILLING/CASING TOOLS

The United States' energy transition towards broader electrification across all sectors of the economy has brought rising concerns about the reliability of overhead lines and the threat of public safety from downed powerlines due to extreme weather conditions. In order to provide electricity more safely and reliably, more utilities seek to proactively and strategically convert critical parts of overhead distribution lines to underground networks. However, the conventional methods for undergrounding utilities impede rapid adoption due to high cost and construction inefficiencies. The current construction workflow requires multiple steps for

undergrounding utilities and can be broadly characterized as proposing a bore plan, drilling a pilot bore, pre-reaming with a trailing rod, reaming pullback with conduit, and finally pulling utility cable. Due to the increasing threat of severe weather events accelerated by climate change and associated power outages, there is a pressing need to innovate the process of undergrounding power utilities. Consequently, the objective of Category 1 is to develop cost-reducing construction tools with the ability to underground medium voltage power cables within >5" I.D. conduit at depths of up to 6 feet safely, reduce surface disruptions, and increase the speed of trenchless installation by reducing inefficiencies (Figure 9). Category 1 Applicants may possess expertise in (i) drilling tools and operations (e.g., experience in drilling for infrastructure installation, oil and gas, mining, geothermal exploration), (ii) robotics and remote operations, (iii) underground civil construction and engineering, and (iv) materials, coatings, liners for power conduit construction proficiencies.

Applicants may propose any system that meets the following criteria:

- Conduits should meet state-of-the-art specifications for crush ratings, withstand the tension from pulling cable,[8] and tolerate up to 10× tighter turning radius than that of conventional tools (1000 ft).
- Drilling may operate autonomously following a predesigned drilling path or follow optimum subsurface drilling conditions from concurrent subsurface characterization.
- Buried power lines must be protected by the conduit as the first line of protection from mechanical damage as well as groundwater ingress.
- Conduits should be able to sustain geological stresses and hazards (e.g., earthquakes, subsidence, fluctuating water table).
- Drilling should be able to operate within near-surface heterogeneous conditions (e.g., conglomerated geologic media composed of soils, pebbles, and cobbles; variable water tables; biological hazards such as tree roots).
- Drilling should be able to change depth during creation of a borehole (e.g., follow terrain, avoid geologic hazards or obstacles).
- Conduits and vaults may be constructed *in situ* or constructed *ex situ* and subsequently undergrounded.

2. CATEGORY 2 — LOOK-AHEAD SENSING AND UTILITY SURVEYING IN ADVANCE

Current geophysical surveying of buried utilities is often unreliable due to wide variations in geological conditions, limitations of individual methods, long survey times, and delays due to unexpected events such as utility strikes and cross-bores. The location of existing subsurface infrastructure is often unknown, leading to significant delays and cost overruns for undergrounding operations. Undergrounding of distribution powerlines whether by conventional trenching or using trenchless methods requires accurate information of subsurface conditions, including soil conditions and locations of legacy infrastructure. Developing automated underground construction systems for infrastructure installation will require enhanced underground intelligence, including situational awareness and a comprehensive model of the site of operation. A fully 'autonomous' system will likely not be

achieved during the GOPHURRS program. However, real-time underground sensing and better utility mapping are essential steps toward realizing a fully autonomous system in the future. Category 2 seeks to produce geophysical subsystems that improve the sensory aspects of undergrounding operations, including situational awareness of the drill/tool (Category 2.1) and mapping of legacy infrastructure and underground modeling of the job site in advance (Category 2.2). Strong preference will be given to transformative solutions for both Category 2.1 and Category 2.2. Incremental advances to existing technologies are not of interest to ARPA-E for Category 2 technologies. As Category 2.1 addresses significantly more technological whitespace than Category 2.2, Category 2.1 applications are strongly encouraged.

Category 2.1 Real-Time Look-Ahead Sensors

Real-time sensing is necessary for the safest and accident-free operation of an autonomous construction system even in the presence of *a priori* underground information obtained through a survey in advance. For trenchless systems, such as horizontal directional drilling (HDD) and other trenchless methods near the surface (<6 m depth), look-ahead sensors are necessary to facilitate drill automation and obstacle avoidance. Look-ahead sensors are currently used in the oil and gas industry for resource exploration and characterization. We expect Category 2.1 teams to adapt methods and systems, either existing look-ahead systems or surface-based geophysical methods, in order to guide and assist near-surface drilling/underground construction system operation. These sensors should provide real time measurements and feedback to an operator or autonomous system. The GOPHURRS look-ahead sensors may be located close to the drill head, on the surface, above the surface, or in a combination of multiple locations as long as they can provide cost-effective, adequate, and real-time look-ahead information.

Applicants may propose any system that meets the following criteria:

- Drill or in-ground systems that provide information from the area directly in front of the drill, **OR** systems with components internal to the drill/underground construction system accompanied by surface equipment (either stationary or mobile), **OR** systems with accompanying measurements from aerial vehicles, **OR** systems with additional in-ground components not associated with the main drill/underground construction system.
- Underground look-ahead sensor systems must collect data in real-time, at a rate appropriate for drill/vehicle operation.
- Data may be collected continuously during drill/vehicle operation, or intermittently during a pause in operation.
- Operation of the drill/vehicle and sensor system must facilitate target installation speeds as defined in Category 1.
- Provide data that can be integrated into large databases associated with subsurface mapping of underground structures such as utilities.
- Inform an operator or autonomous control system with actionable information or recommendations from the datasets associated with collected measurements (i.e., final interpretable datasets rather than raw datasets).

Category 2.2 Utility Surveying in Advance

For an ideally automated drill/construction system, accurate maps of the subsurface are needed in advance. These maps are necessary for both limiting collisions and cross-bores with legacy infrastructure, but also important for optimizing a drill path based on geological (e.g., water table, petrology, soil conditions, etc.) information. We seek to produce a highly accurate digital twin of the subsurface prior to undergrounding work that can be quickly produced, less disruptive, and at low cost. Accomplishing this goal requires reliable, accurate, and fast mapping of subsurface utilities of all kinds in all conditions.

Current subsurface infrastructure surveys, however, are slow and susceptible to uncertainty, limiting the confidence utility operators have in the resulting datasets. These uncertainties may be caused by varying sensitivity to different material types, limits in the skin depth of investigation, limits to the minimum detectable size, effects caused by varying geology and hydrology (e.g., water content and soil texture variations), and masking of vertically positioned targets. To overcome these challenges, we seek proposals that focus on advanced/disruptive methods to improve the speed and efficiency of surface surveys for utility measurements.

Applicants may propose any system that meets the following criteria:

- Surface mapping methods that can reduce the cost of geophysical utility surveys, justified through a preliminary economic model.
- Surface mapping methods that provide a transformational increase in the speed and coverage area of utility surface surveys over current state-of-the-art systems.
- Systems that produce datasets capable of being integrated into a database of a variety of subsurface information, to be used to produce a digital twin of the subsurface.
- Systems that utilize a geophysical sensor, or a combination of sensors, that are capable of overcoming uncertainty related to variations in hydrology, geology, variation in utility materials (i.e., metal, polymer, clay, concrete), and varying size of utilities.

3. CATEGORY 3 — AUTOMATED JOINT INSTALLATIONS AND ADVANCED SPLICES

Cable accessories account for over 70% of operational faults in power systems.[49] Many of these faults, particularly at joints and interconnection points in medium voltage underground power systems, are primarily attributable to workmanship error.[50] In addition to being error prone, installation of joints in underground manholes require considerable safety measures that can add time and complexity, and even with these extra precautions there is always some safety risk for personnel.[51] The splicing process for these medium voltage cables often requires several steps including but not limited to removing insulating and semiconducting layers, managing

[49] "Insulation Properties and Interface Defect Simulation of Distribution Network Cable Accessories Under Moisture Condition", G. Li et al., IEEE Transactions on Dielectrics and Electrical Insulation, vol. 29, no. 2, pp. 403-411, April 2022, doi: 10.1109/TDEI.2022.3157902.

[50] "Partial Discharge Tests for Medium-Voltage Power Cable Systems", NETAWORLD JOURNAL, (https://netaworldjournal.org/partial-discharge-tests-for-medium-voltage-power-cable-systems/)

[51] U.S. Department of Labor Occupational Safety and Health Administration Standard No. 1926.965 – Underground electrical installations, (https://www.osha.gov/laws-regs/regulations/standardnumber/1926/1926.965)

metallic ground shields, crimping or connecting conductors, applying silicone grease, and installing a splice body and splice jacket.[52] Category 3 seeks to develop an automated joint installation machine that performs error-free splicing operations with high accuracy and repeatability in order to eliminate human errors in the installation process. Category 3 also seeks new designs of cable splices that are either suitable for machine-operated splicing or provide improved reliability.

Category 3.1 Automated Joint Installation

In present day practice, all medium-voltage underground cable splicing is done by hand by a skilled professional. Accidental introduction of defects or workmanship mistakes during this manual process can allow for air voids, water, or other contaminants to become embedded in the splice or result in knicks in the insulation, semiconducting layers, or conductors. All of these errors can lead to additional contaminant ingress or uneven electric field distributions and eventual failure well before the joints reach their normal service life.[53] GOPHURRS seeks to develop technology that will greatly increase the repeatability of the splicing operation, eliminate errors, and increase the reliability of underground electrical systems.

Systems should include relevant on-site non-destructive testing and/or inspection to ensure the integrity of the joint and may additionally include advanced or novel visual inspections methods such as images coupled with AI-based interpretation, ultrasonic phased arrays, computerized tomography scans and x-rays or other advanced sensing methods.[54,55,56]

Applicants may propose any system that meets the following criteria:

- Applicants may choose a medium voltage cable type and a splice to develop an automated splice installation system for homogeneous one-way to one-way (splicing a single-phase cable of same type) joint. Recommended cable specifications: 1) Al or Cu conductor size (2 American wire gauge [AWG] to 1500 kcmil), conductor diameter (0.25” to 1.3”), cable diameter (0.9” to 2.5”), cable weight (440 lbs/1000 ft to 3200 lbs/1000 ft), cable bend radius (12” to 30”).
- Cable splicing machine capable of end-to-end splicing for ethylene propylene rubber (EPR), cross-linked polyethylene (XLPE) or other solid-state insulation (e.g., tree retardant cross-linked polyethylene (TR-XLPE), EAM (ethylene alkene copolymer filled),

[52] T. M. Shoemaker and J. E. Mack, The Lineman’s and Cableman’s Handbook, Thirteenth Edition. McGraw-Hill Education, 2017. [Online]. Available: https://books.google.com/books?id=wzxhvgAACAAJ

[53] "Cable Accessory Failure Analysis", F. Dean Williams, NEETRAC ICC Education Session, Fall 2010, (https://www.neetrac.gatech.edu/publications/ICC_Fall_2010_ICC_education_session.pdf)

[54] "Ultrasonic phased array detection of internal defects in composite insulators", C. Yuan, C. Xie, L. Li, F. Zhang and S. M. Gubanski, IEEE Transactions on Dielectrics and Electrical Insulation, vol. 23, no. 1, pp. 525-531, February 2016, doi: 10.1109/TDEI.2015.005225.

[55] "A Terahertz 3-D Imaging Method for Complex Internal Structure of Object", S. Wang, H. Mei, J. Liu, D. Chen and L. Wang, IEEE Transactions on Instrumentation and Measurement, vol. 71, pp. 1-10, 2022, Art no. 4503310, doi: 10.1109/TIM.2022.3169540.

[56] "Automating High-Precision X-Ray and Neutron Imaging Applications With Robotics", J. A. Hashem, M. Pryor, S. Landsberger, J. Hunter and D. R. Janecky, IEEE Transactions on Automation Science and Engineering, vol. 15, no. 2, pp. 663-674, April 2018, doi: 10.1109/TASE.2017.2675709.

polypropylene (PP) single-phase cable types typical for new underground primary distribution installations. PILC (paper-insulated lead-covered) cables are outside of the scope of GOPHURRS program.

- Methods that do not require personnel in the manhole during the operation of an automated splicing machine.
- Systems should be capable of automatically checking each step of the automated splicing process through advanced visual inspections coupled with AI/ML interpretation, and/or other relevant methods.

Category 3.2 Advanced Splices

Splice kits can take many forms and many advances have been made to improve components used in the splicing process over the years such as cold shrink to eliminate heat guns and shearing bolts to improve torquing consistency.[57] Advances in understanding the environmental stresses that can bring about joint failure such as the effect of moisture, temperature, and pressures on different insulating materials[42,58] may inform material or splice kit development. GOPHURRS seeks to fund the development of advanced medium voltage splice designs that will make the installation process less prone to error, faster, or improve the insulating capabilities or conductor connections and could also be designed to support a more automated installation process as described in Category 3.1. For medium voltage underground cables, splicing personnel must manage the proper connection or terminations of neutrals (ground shields) and methods should be considered to improve this process or incorporate it into the splicing kit.

Applicants may propose any system that meets the following criteria:

- Materials or designs which reduce the electrical stress and/or help with field grading at the joint.
- Splice kit that supports a less error prone or more automated installation process.
- Splice designs that can withstand at least 2x higher pulling tension than conventional splices.

F. TECHNICAL PERFORMANCE TARGETS

Submissions to GOPHURRS may address either a single program category or subcategory (e.g., Category 1, Category 2.1, Category 2.2, Category 3.1, or Category 3.2 as a subsystem) or more than one category or subcategory in a combined and integrated system. **Applicants submitting to Categories 1 or 2 may not address Category 3 in the same application and vice versa. Instead, Applicants must submit separate applications (one or two application(s) for Category 1 and/or 2, and a separate application for Category 3) if they wish to address all technical categories of the GOPHURRS program.**

[57] "Cable Accessory Technologies & Developments to Watch", INMR, Cables & Accessories, January 20, 2023, (https://www.inmr.com/cable-accessory-technologies-developments-to-watch/)

[58] "Dielectric Loss of EPDM Insulation Subjected to Thermal Stress and Pressure", Z. Lei et al., IEEE Access, vol. 10, pp. 129139-129148, 2022, doi: 10.1109/ACCESS.2022.3228249.

Category 1 or 2 Applicants are encouraged to address both categories in order to create an integrated system. Category 1 or 2 Applicants who address only one of the program categories as a subsystem or partial solution are encouraged to seek complementary subsystem developers as partners for integration at a later stage of the project. Applicants should discuss in their proposal how they will integrate technological subsystems.

Applicants addressing the following combinations of categories **must submit** the following material (no more than 1 page per question-and-answer table):

- Applications solely addressing Category 1, 2.1, 2.2, 3.1, or 3.2 – a single Concept Paper (up to 4 pages); the corresponding question-and-answer table (Table 1, 2, 3, 4, or 5, respectively).
- Applicants addressing Category 1 and 2.1 – a single Concept Paper (up to 4 pages); question-and-answer Tables 1 and 2.
- Applicants addressing Category 1 and 2.2 – a single Concept Paper (up to 4 pages); question-and-answer Tables 1 and 3.
- Applicants addressing Category 3.1 and 3.2 – a single Concept Paper (up to 4 pages); question-and-answer Tables 4 and 5.

The question-and-answer tables for categories 1, 2.1, 2.2, 3.1, and 3.2 (Tables 1-5) are provided in this FOA in Section I.G. The information in response to the question-and-answer tables does not count towards the 4-page limit on the Concept Paper, but any text beyond 4 pages for the Concept Paper or 1 page per table response will exceed the respective page limits and be redacted in the review process.

For the Concept Paper submission, the Category 1 and 2 Applicants are required to describe a pathway to a potential cost reduction at least 50% in overall project costs using their proposed new technologies compared to conventional underground construction methods. A The sample preliminary economic model available with this FOA on eXCHANGE can be used as guidance. A complete preliminary economic model is required only in the Full Application.

1. CATEGORY 1 — AUTONOMOUS DRILLING/CASING TOOLS:

Category 1 – Performance Targets

Required:

- Develop a technology-based pathway to 50% reduction of cost to underground by examples but not limited to: reducing NPT (non-productive time) via reduced steps, automation, and the capability to avoid obstacles if information is provided.
- Create borehole and install casing/conduit (minimum 5" I.D.) in the same amount of time conventional trenchless tools complete the borehole only for a range of different subsurface conditions.[59]

[59] Average HDD rates (Maxi Rigs - Horizontal Directional Drilling - Rig Worker)

- Install conduits of minimum 5" I.D. to accommodate three insulated underground MV cables (e.g., individual cable has a 500-750 kcmil conductor and typically rated for 15 kV) in a single borehole.
- Installed flexible conduit must have deflection limits set by both ASTM (7.5%) and AWWA (5%) due to dead and live loads as conventional conduit systems.[60]
- >95% tolerance to follow a pre-designed drill-path under normal conditions.
- Meet minimum required local safety standards and codes (e.g., NFPA 70E).[61]

Desired:

- Drill multiple boreholes in parallel.
- Conduit is resistant to geologic hazards (e.g., earthquakes, subsidence, fluctuating water table, etc.).
- Enable *in situ* construction of an underground structure necessary for joint installation (e.g., underground vault via additive/subtractive method).
- Be compatible (e.g., conduits) with current practice of cable installation (i.e., maximum pulling tension specified in IEEE 1185 standards).[62]
- Operate for various terrains (i.e. drill tools must be able to follow the terrain in a desired situation).
- Operate in various climate zones with fast mobilization/demobilization.
- Minimize or eliminate generated waste/spoil (e.g., compaction of soil to create boreholes in a desired situation, re-using removed soil for other purposes such as creating the casing or conduit out of removed spoil *in situ*).
- Maximize the power-to-footprint ratio to reduce weight and size of the rig to allow for easier transport (fast mobilization and demobilization), minimal impact on traffic flow, existing landscapes, and the general public working in urban areas.[63]
- Use low carbon power source (e.g., electric).
- Implement methods to more easily locate the powerlines once undergrounded (e.g., tracer wire).
- Operate in all geological conditions (e.g., hard rock, soft rock, within water tables, etc.).
- Drill, install conduit, and pull cable concurrently.
- Change drill depths easily (e.g., up and down movement as needed rather than a smooth U-shape vertical path of a conventional HDD).
- Autonomous drilling ability to follow a pre-designed path or adjust to most efficient drill path determined by look-ahead sensors.

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[60] "Deflection Testing of Buried PVC Pipe" (PI-TB-007-US-EN-0119.2_Deflection-Testing-Buried-PVC-Pipe.pdf (westlakepipe.com))

[61] "NFPA 70E Standard for Electrical Safety in the Workplace" (https://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards/detail?code=70E)

[62] "1185-2019 - IEEE Recommended Practice for Cable Installation in Generating Stations and Industrial Facilities" (https://ieeexplore.ieee.org/abstract/document/4459221)

[63] "HDD Rigs: More Power In A Small Footprint", Underground Infrastructure, March 2015, vol. 70, no. 3 (https://undergroundinfrastructure.com/magazine/2015/march-2015-vol-70-no-3/features/hdd-rigs-more-power-in-a-small-footprint)

- Drill through common natural obstacles such as tree roots.

Table 1: Category 1 Question(s) Table (must be included in the application as a separate one-page document)

Question(s)	Applicant's Technology	State of the Art (provide references)
Q1. What is the minimum distance in feet required for your proposed technology to make a lateral 90-degree turn in the subsurface (please specify the soil types) while creating a borehole suitable for a 5" I.D. conduit?		
Q2. What is the minimum achievable bending radius of the proposed conduit in feet? (5" I.D. conduit)		
Q3. What is the minimum distance in feet required for your proposed technology to make a vertical 90-degree turn (i.e., change depth) in the subsurface (please specify the soil types) while creating a borehole suitable for a 5" I.D. conduit?		
Q4. What is the target speed of construction (install 5" I.D. conduit) for subsurface conditions characterized as: • Silt, sand, clay in ft/hr • Gravel in ft/hr • Soft Rock in ft/hr Hard Rock in ft/hr		
Q5. How will the conduit be installed?		
Q6. Is the proposed 5" ID conduit compliant for current standard properties such as thermal, electrical, waterproof, fire resistance, and others?		
Q7. What is the expected range of tension in lbf (pound-force) required to pull a cable (15 kV rating) in your conduit?		
Q8. What is the expected deflection in percent of the proposed conduit (5" I.D.) in the temperature range of 50 to 120 ºF under normal dead and live loads?		

2. CATEGORY 2 — LOOK-AHEAD SENSING AND UTILITY MAPPING IN ADVANCE:

Category 2.1 – Performance Targets

Required:

- Sensors must be capable of detecting the presence of underground infrastructure made of concrete, metal, and plastic (i.e., pipes, conduits, etc., as small as 1.5”), other obstacles hazardous to construction (i.e., boulders, foundations, etc.), and/or geotechnical conditions within the path of installation (in front) at a distance of ≥ 10 feet.
- System must operate during trenchless installation operation, and interface with drilling/installation equipment.
- Measurements must consist of real-time data collection, analysis, and visualization/communication to the operator/equipment.
- System should be operable in all soil systems.

Desired:

- Sensors should be capable of detecting the presence of underground infrastructure (i.e., pipes, conduits, etc., as small as 1.5” diameter linear objects), other obstacles hazardous to construction (i.e., boulders, foundations, etc.), and/or geotechnical conditions within the path of installation (in front) at a distance of ≥ 20 feet.
- Look ahead sensor systems can be single method, or multiple method systems (e.g., ground penetrating radar (GPR), GPR + electrical resistivity tomography (ERT)).
- Sensor systems can consist of onboard systems, surface systems, or hybrid onboard/surface systems.
- Sensor system refresh rate, or the time needed for measurement, analysis, and visualization/communication with the operator/equipment, should allow ≥ 6 measurements within the time of initial detection and hypothetical contact with an anomaly based on rates defined in Category 1.
- Data should be capable of being exported and integrated into existing GIS (Geographic Information Systems).

Table 2: Category 2.1 Question(s) Table (must be included in the application as a separate one-page document)

Question(s)	Applicant's Technology	State of the Art (provide references)
Q1. What is the sensitivity distance of the proposed technology? (In feet)		
Q2. What is the spatial accuracy of the proposed technology? (In feet)		
Q3. What is the smallest diameter of a detectable conduit of the proposed technology? (In inches)		
Q4. What is the expected measurement frequency (refresh rate) of the proposed technology? (In s^{-1})		
Q5. What is the detection confidence of the proposed technology? (In %)		

Category 2.2 – Performance Targets

Required:

- Cost reduction must be ≥ 50% per unit volume of earth surveyed over SOA.[41]
- Speed of survey must be increased by ≥ 200 % per unit volume of earth surveyed over SOA.[41]
- Accuracy of prediction must be ≥ 95% confidence of detection.
- Survey penetration depth must be repeatable over all geologic conditions (e.g., consolidated/unconsolidated, varying water content, varying clay content).
- Datasets must be compatible with large scale database/mapping initiatives.

Desired:

- Speed of survey should be increased by ≥400% per unit volume of earth surveyed over SOA.[41]

Table 3: Category 2.2 Question(s) Table (must be included in the application as a separate one-page document)

Question(s)	Applicant's Technology	State of the Art (provide references)
Q1. What is the sensitivity distance of the proposed technology? (In feet)		
Q2. What is the spatial accuracy of the proposed technology? (In feet)		
Q3. What is the smallest diameter of a detectable conduit the proposed technology at the sensitivity distance answered in Q1? (In inches)		
Q4. How long will a survey utilizing the proposed technology take? (In either days/hours/minutes)		
Q5. What is the detection confidence of the proposed technology? (In %)		

Category 3.1 – Performance Targets

Required:

- The system must meet the minimum level of SWaP requirements. Size: fit down a 24" diameter manhole; Weight: a single splicing operator must be able to carry it down through the manhole; Power: must be powered on-site either from an above ground power source or a battery system.
- Once set up properly by an operator, the machine should not require human intervention during the normal operations for splicing and post-splice testing or inspection.
- Must complete a splicing job at the speed equivalent to human-operated splicing job.
- The system must be ruggedized to operate in a typical manhole environment across different seasons.
- Must be able to prepare a cable that is not perfectly round (off-centered layers by up to 5%, deformed cables up to 5% of original dimensions).
- Advanced anomaly detection methods including but not limited to visual analysis of the procedure interpreted by an artificial intelligence to detect items such as any unevenness in the perimeter of each cut, ragged edges, knicks in the layers, air or contaminant ingress, or help in locating the splice body at the exact center between the two cable ends. Applicants are encouraged to look up the installation instructions for their selected cable types and splice bodies.

- Completed splices should comply with relevant standards as applicable such as IEEE Standard 400™-2012,[64] IEEE Standard 404™-2012[65] or IEEE Standard 48™-2020.[66]

Desired:

- Minimal personnel downhole time to provide any setup or testing.
- A system that can splice more than one type of cable or use more than one type of splice kit with simple adjustments.
- A system that can splice three-way to three-way cables (full 3-phase AC cables).
- A system that can perform a transition splice (i.e., from one type of cable to another type of cable).
- The speed of completing a splicing job is faster than what an average skilled operator can do.
- Battery powered system that allows for a continuous operation for greater than 8 hours (may use multiple batteries and swapping them).
- Every operation for the automated process addressed including but not limited to access in and out of hole, maneuvering, retaining cable, various cuts and material removal and material applications, cleaning operations, and testing.
- Novel technologies that improve some portion of the automated process such as AI-enabled visual inspections with advanced imaging or novel ways to remove or apply material.
- Automated correction of detected defects.

[64] "IEEE Guide for Field Testing and Evaluation of the Insulation of Shielded Power Cable Systems Rated 5 kV and Above," IEEE Standard 400-2012 (Revision of IEEE Standard 400-2001) , vol., no., pp.1-54, 5 June 2012, doi: 10.1109/IEEESTD.2012.6213052.

[65] "IEEE Standard for Extruded and Laminated Dielectric Shielded Cable Joints Rated 2.5 kV to 500 kV," IEEE Standard 404-2012 (Revision of IEEE Standard 404-2006) , vol., no., pp.1-46, 18 June 2012, doi: 10.1109/IEEESTD.2012.6220225.

[66] "IEEE Standard for Test Procedures and Requirements for Alternating-Current Cable Terminations Used on Shielded Cables Having Laminated Insulation Rated 2.5 kV through 765 kV or Extruded Insulation Rated 2.5 kV through 500 kV," IEEE Standard 48-2020 (Revision of IEEE Standard 48-2009) , vol., no., pp.1-49, 12 Oct. 2020, doi: 10.1109/IEEESTD.2020.9222616.

Table 4: Category 3.1 Question(s) Table (must be included in the application as a separate one-page document)

Question(s)	Applicant's Technology	State of the Art (provide references)
Q1. What type of cable will be your focus? Include insulation and conductor materials, shield types and ranges for diameters, stranding, voltage and current ratings, etc.		
Q2. What are the minimum dimensions of the space in which your machine will operate? (In ft x ft x ft)		
Q3. What is the length and the thickness of the completed splice? (In inches)		
Q4. How long will it take to install the splice? (In minutes)		
Q5. What percentage of the time will the operators be exposed to potentially hazardous environment (e.g., manholes) during the splicing operation? (In minutes)		
Q6. What is the smallest detectible defect (splits, pinholes, inclusions) via any automated inspection or testing during installation? (In inches)		
Q7. How much does it cost to replace a splice? (In US dollars)		
Q8. What level of accuracy is expected for any defect detection?		

Category 3.2 – Performance Targets

Required:

- Must not require new customized tools to install unless the tool is considered part of the machine described in Category 3.1.
- Materials or hardware must be easily installed in a manhole.
- Completed splices incorporating any new technology should be able to comply with relevant standards as applicable such as IEEE Standard 400™-2012, IEEE Standard 404™-2012 or IEEE Standard 48™-2020.

Desired:

- Materials or designs that make defects or electric field distortions less likely and/or more detectable.
- Withstand pulling tensions 2× greater than what SOA splices can.

Table 5: Category 3.2 Question(s) Table (must be included in the application as a separate one-page document)

Question(s)	Applicant's Technology	State of the Art (provide references)
Q1. What type of cable will be your focus? Include insulation and conductor materials, shield types and ranges for diameters, stranding, voltage and current ratings, etc.		
Q2. How long will it take to install the splice? (In minutes)		
Q3. What is the length and thickness of the completed splice? (In inches)		
Q4. If proposing new material(s) as part of splice, provide relevant metrics such as thermal conductivity (W/mK), dielectric constants, installed dielectric strength (kV/mm), conductivity (S/m), etc.		
Q5. How much does it cost to replace a splice? (In US dollars)		
Q6. How much pulling tension can the splice withstand (in MPa tensile strength)?		

G. PROGRAM STRUCTURE AND DELIVERABLES

GOPHURRS program consists of a group of projects lasting up to 36-month that are offered in a single contracting phase.

Awards will include specific Go/No-Go milestones approximately after 12 and 24 months from the beginning of the project to evaluate the overall progress made in de-risking during the first and second periods. The second Go/No-Go milestones must present an assessment based on ARPA-E approved, Applicant's proposed, in-house testing methods for the feasibility of newly developed technologies. The outcome of this milestone will focus on an engineered field testing/validation course during the last remaining project term (approximately 9th to 12th quarters).

All in-house testing protocols and metrics should be explicitly stated in the final application which will be subject to ARPA-E's approval during final pre-award negotiation stage.

The GOPHURRS program intends to drive the development of technology that would succeed in an engineered field test site, not merely in in-house lab testing and validation. ARPA-E may seek the development of test sites that could be used to test GOPHURRS-funded technologies across all categories in the future, but no details are available at this time. Applicants may be required

to submit a plan for a field test during the last stage of the project as a final deliverable, after they have successfully validated the feasibility of their technology to move forward to a field test.

Table 6: Required Program Milestones (must be included in Full Application Technical Volume)

Milestone(s)	Quarter
M1. Define target (quantifiable) technical metrics and obtain ARPA-E approval	Pre-Award Negotiation
M2. Define testing protocol (benchtop and field) and obtain ARPA-E approval	Pre-Award Negotiation
M3. Complete preliminary benchtop development of proposed technology and submit results for evaluation	Q7 - Q9
M4. Complete final benchtop development of proposed technology and submit results for evaluation	Q9 - Q11
M5. Complete a plan for a field testing*	Q10-Q12

**Required upon approval by ARPA-E for the proof of feasibility (M5).*

II. AWARD INFORMATION

A. AWARD OVERVIEW

ARPA-E expects to make approximately $40 million available for new awards, subject to the availability of appropriated funds. ARPA-E anticipates making approximately 10-14 awards under FOAs DE-FOA-0003047 and DE-FOA-0003048. ARPA-E may, at its discretion, issue one, multiple, or no awards.

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.[67]

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 funding agreements may not exceed 36 months for a Combined Phase I/II/IIS Award. ARPA-E expects to issue funding agreements in January 2024, or as negotiated.

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

[67] 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.

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."[68] Accordingly, ARPA-E has substantial involvement in the direction of every Cooperative Agreement, as described in Section II.C 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.

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

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

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

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

similar terms and conditions as ARPA-E's Model Cooperative Agreement (https://arpa-e.energy.gov/technologies/project-guidance/pre-award-guidance/funding-agreements).

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

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.
- 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 nonprofits[69] 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.

[69] 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 Concern[70] may apply as a Standalone Applicant[71] or as the lead organization for a Project Team.[72] 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.[73]

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

[70] 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.

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

[72] 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.

[73] 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.

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 Institution[74] 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

[74] 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 Institutions[75]
- Government-Owned, Government Operated laboratories (GOGOs)
- State, local, and tribal government entities
- Foreign entities[76]

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

1. 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.

[75]Nonprofit organizations described in section 501(c)(4) of the Internal Revenue Code of 1986 that engaged in lobbying activities after December 31, 1995 are not eligible to apply for funding as a Subrecipient.
[76] 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 III[77] 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.**

[77] 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 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

Concept Papers are deemed compliant if:

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

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

Full Applications are deemed compliant if:

- The Applicant submitted a compliant and responsive Concept Paper;

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

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

Replies to Reviewer Comments are deemed compliant if:

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

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

2. RESPONSIVENESS CRITERIA

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

- Submissions that fall outside the technical parameters specified in this FOA.
- Submissions that have been submitted in response to currently issued ARPA-E FOAs.
- Submissions that are not scientifically distinct from applications submitted in response to currently issued ARPA-E FOAs.
- Submissions for basic research aimed solely at discovery and/or fundamental knowledge generation.
- Submissions for large-scale demonstration projects of existing technologies.
- Submissions for proposed technologies that represent incremental improvements to existing technologies.

- Submissions for proposed technologies that are not based on sound scientific principles (e.g., violates a law of thermodynamics).
- Submissions for proposed technologies that are not transformational, as described in Section I.A of the FOA.
- Submissions for proposed technologies that do not have the potential to become disruptive in nature, as described in Section I.A of the FOA. Technologies must be scalable such that they could be disruptive with sufficient technical progress.
- Submissions that are not distinct in scientific approach or objective from activities currently supported by or actively under consideration for funding by any other office within Department of Energy.
- Submissions that are not distinct in scientific approach or objective from activities currently supported by or actively under consideration for funding by other government agencies or the private sector.
- Submissions that do not propose a R&D plan that allows ARPA-E to evaluate the submission under the applicable merit review criteria provided in Section V.A of the FOA.
- Submissions that do not propose a Combined Phase I/II/IIS Award, as described in Section II.A of the FOA.
- Submissions that propose using funding for construction, alteration, maintenance, or repair of public infrastructure in the United States.

3. SUBMISSIONS SPECIFICALLY NOT OF INTEREST

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

- Incremental solutions (e.g., commercially available GPR either pulled or cart based, manual surveys using surface arrays such as ERT or seismic).
- Above ground conduits (i.e., a conduit placed on the surface to house utilities).
- Approaches repurposing existing underground infrastructure such as tunnels, pipelines, basements, or foundations.
- Non-technical solutions such as coordination/collaboration with other stakeholders to share the cost of construction.
- Approaches to improving job site management or workflow for conventional technologies.
- Approaches involving the installation and utilization of PILC (paper-insulated lead-covered) cables.
- Approaches to improving the installation of overhead power lines and the management of overhead assets.
- Approaches concerning the system operation, health monitoring, maintenance, and repair of completed underground power systems.
- Proposals to underground power lines without new technology development.

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 GOPHURRS FOAs: DE-FOA-0003048 (GOPHURRS SBIR/STTR), or DE-FOA-000 3047 (GOPHURRS). 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-0003048, 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.D.6 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.H.1 of the FOA and the "ARPA-E eXCHANGE User Guide" (https://arpa-e-foa.energy.gov/Manuals.aspx).

3. CONCEPT PAPERS

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

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

ARPA-E will encourage a subset of Applicants to submit Full Applications. Other Applicants will be discouraged from submitting a Full Application in order to save them the time and expense of preparing an application submission that is unlikely to be selected for award negotiations. By discouraging the submission of a Full Application, ARPA-E intends to convey its lack of programmatic interest in the proposed project. Such assessments do not necessarily reflect judgments on the merits of the proposed project. Unsuccessful Applicants should continue to submit innovative ideas and concepts to future FOAs.

4. FULL APPLICATIONS

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

ARPA-E performs a preliminary review of Full Applications to determine whether they are compliant and responsive, as described in Section III.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.2 and V.B.1 of the FOA.

5. REPLY TO REVIEWER COMMENTS

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

ARPA-E performs a preliminary review of Replies to determine whether they are compliant, as described in Section III.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.

6. 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.

7. SELECTION FOR AWARD NEGOTIATIONS

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

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

B. APPLICATION FORMS

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

C. CONTENT AND FORM OF CONCEPT PAPERS

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

- The Concept Paper (Sections 1a – 1d below) must not exceed 4 pages in length including graphics, figures, and/or tables.
- Responses to Question-and-Answer (Q&A) Tables are required for each Concept Paper and shall not exceed one (1) page each in length. Concept Papers must include responses to the applicable Q&A Table for each Category they apply to. The Q&A table responses do not count towards the 4-page limit on Sections 1a – 1d, but any text beyond 4 pages for the Concept Paper or 1 page for each response to applicable Q&A tables will be redacted. As no Concept Paper can address more than 2 categories, the maximum length of one submission will be 6 pages (applicants addressing only 1 category are limited to no more than 5 pages).
- The Concept Paper must be submitted in Adobe PDF format.

- The Concept Paper must be written in English.
- All pages must be formatted to fit on 8-1/2 by 11 inch paper with margins not less than one inch on every side. Single space all text and use Times New Roman typeface, a black font color, and a font size of 12 point or larger (except in figures and tables).
- The ARPA-E assigned Control Number, the Lead Organization Name, and the Principal Investigator's Last Name must be prominently displayed on the upper right corner of the header of every page. Page numbers must be included in the footer of every page.
- The first paragraph must include the Lead Organization's Name and Location, Principal Investigator's Name, Technical Category, Proposed Funding Requested (Federal and Cost Share [not required for this SBIR/STTR FOA]), and Project Duration.

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

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

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

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

1. CONCEPT PAPER

a. CONCEPT SUMMARY

- Describe the proposed concept with minimal jargon, and explain how it addresses the Program Objectives of the FOA.

b. INNOVATION AND IMPACT

- Clearly identify the problem to be solved with the proposed technology concept.
- Describe how the proposed effort represents an innovative and potentially transformational solution to the technical challenges posed by the FOA.
- Explain the concept's potential to be disruptive compared to existing or emerging technologies.
- To the extent possible, provide quantitative metrics in a table that compares the proposed technology concept to current and emerging technologies and to the

Technical Performance Targets in Section I.F of the FOA for the appropriate Technology Category in Section I.E of the FOA.

c. PROPOSED WORK

- Describe the final deliverable(s) for the project and the overall technical approach used to achieve project objectives.
- Discuss alternative approaches considered, if any, and why the proposed approach is most appropriate for the project objectives.
- Describe the background, theory, simulation, modeling, experimental data, or other sound engineering and scientific practices or principles that support the proposed approach. Provide specific examples of supporting data and/or appropriate citations to the scientific and technical literature.
- Describe why the proposed effort is a significant technical challenge and the key technical risks to the project. Does the approach require one or more entirely new technical developments to succeed? How will technical risk be mitigated?
- Identify techno-economic challenges to be overcome for the proposed technology to be commercially relevant.
- Estimated federal funds requested; total project cost including cost share (if cost share is being provided – cost share is not required under this FOA).

d. TEAM ORGANIZATION AND CAPABILITIES

- Indicate the roles and responsibilities of the organizations and key personnel that comprise the Project Team.
- Provide the name, position, and institution of each key team member and describe in 1-2 sentences the skills and experience that he/she brings to the team.
- Identify key capabilities provided by the organizations comprising the Project Team and how those key capabilities will be used in the proposed effort.
- Identify (if applicable) previous collaborative efforts among team members relevant to the proposed effort.

e. QUESTION AND ANSWER TABLES

- Applicants must submit responses to the following Q&A tables based on the following combinations of categories (see Section I.F Technical Performance Targets for more):
    - (Max. 1 Page) Applications solely addressing Category 1, 2.1, 2.2, 3.1, or 3.2 – Q&A Table 1, 2, 3, 4, or 5, respectively
    - (Max 2. Pages) Applicants addressing Categories 1 and 2.1 – Q&A Tables 1 and 2
    - (Max 2. Pages) Applicants addressing Categories 1 and 2.2 – Q&A Tables 1 and 3
    - (Max 2. Pages) Applicants addressing Category 3.1 and 3.2 – Q&A Tables 4 and 5

D. CONTENT AND FORM OF FULL APPLICATIONS

[TO BE INSERTED BY FOA MODIFICATION IN JUNE 2023]

E. CONTENT AND FORM OF REPLIES TO REVIEWER COMMENTS

[TO BE INSERTED BY FOA MODIFICATION IN JUNE 2023]

F. INTERGOVERNMENTAL REVIEW

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

G. 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.G.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. Project Teams have the option of spending a portion of 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.

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 choose to not include TT&O activities if appropriate, and do not need a waiver to do so.

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 grant 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 requirement does not apply to an award where the Prime Recipient is a for-profit entity.

H. OTHER SUBMISSION REQUIREMENTS

1. USE OF ARPA-E eXCHANGE

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

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

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

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

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

ARPA-E 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 Concept Papers and 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 CONCEPT PAPERS

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

- The potential for a transformational and disruptive (not incremental) advancement compared to existing or emerging technologies;
- Achievement of the technical performance targets defined in Section I.F of the FOA for the appropriate technology Category in Section I.E of the FOA;
- Identification of techno-economic challenges that must be overcome for the proposed technology to be commercially relevant; and
- Demonstration of awareness of competing commercial and emerging technologies and identifies how the proposed concept/technology provides significant improvement over existing solutions.

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

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

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

2. CRITERIA FOR FULL APPLICATIONS

[TO BE INSERTED BY FOA MODIFICATION IN JUNE 2023]

3. CRITERIA FOR REPLIES TO REVIEWER COMMENTS

[TO BE INSERTED BY FOA MODIFICATION IN JUNE 2023]

B. REVIEW AND SELECTION PROCESS

1. PROGRAM POLICY FACTORS

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

I. **ARPA-E Portfolio Balance**. Project balances ARPA-E portfolio in one or more of the following areas:
   a. Diversity 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 their knowledge and understanding of the relevant field and application, their experience and skills, and their ability to provide constructive feedback on applications.

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

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

3. ARPA-E SUPPORT CONTRACTOR

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

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

C. ANTICIPATED ANNOUNCEMENT AND AWARD DATES

[TO BE INSERTED BY FOA MODIFICATION IN JUNE 2023]

VI. AWARD ADMINISTRATION INFORMATION

A. AWARD NOTICES

1. REJECTED SUBMISSIONS

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

2. CONCEPT PAPER NOTIFICATIONS

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

Applicants may submit a Full Application even if they receive a notification discouraging them from doing so. By discouraging the submission of a Full Application, ARPA-E intends to convey its lack of programmatic interest in the proposed project. Such assessments do not necessarily reflect judgments on the merits of the proposed project. The purpose of the Concept Paper phase is to save Applicants the considerable time and expense of preparing a Full Application that is unlikely to be selected for award negotiations.

A notification letter encouraging the submission of a Full Application does not authorize the Applicant to commence performance of the project. Please refer to Section IV.G of the FOA for guidance on pre-award costs.

3. FULL APPLICATION NOTIFICATIONS

[TO BE INSERTED BY FOA MODIFICATION IN JUNE 2023]

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;
- 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/.[78] Prime Recipients are required to report to FSRS the names and total compensation of each of the

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

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).

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

[TO BE INSERTED BY FOA MODIFICATION IN JUNE 2023]

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."

B. DEBRIEFINGS

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

VIII. OTHER INFORMATION

A. 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.

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

H. RETENTION OF SUBMISSIONS

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

I. MARKING OF CONFIDENTIAL INFORMATION

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

Concept Papers, Full Applications, Replies to Reviewer Comments, and other submissions containing confidential, proprietary, or privileged information 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 Concept Paper, Full Application, Reply to Reviewer Comments, or other submission must be marked as follows and identify the specific pages containing confidential, proprietary, or privileged information:

Notice of Restriction on Disclosure and Use of Data:

Pages [___] of this document may contain confidential, proprietary, or privileged information that is exempt from public disclosure. Such information shall be used or disclosed only for evaluation purposes or in accordance with a financial assistance or loan agreement between the submitter and the Government. The Government may use or disclose any information that is not appropriately marked or otherwise restricted, regardless of source.
The header and footer of every page that contains confidential, proprietary, or privileged information must be marked as follows: "Contains Confidential, Proprietary, or Privileged Information Exempt from Public Disclosure." In addition, every line and paragraph containing proprietary, privileged, or trade secret information must be clearly marked with double brackets or highlighting.

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 Concept Papers, 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 award 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.

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.

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

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

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