

**FINANCIAL ASSISTANCE  
FUNDING OPPORTUNITY ANNOUNCEMENT**



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

***GRID-FREE RENEWABLE ENERGY ENABLING NEW WAYS TO  
ECONOMICAL LIQUIDS AND LONG-TERM STORAGE  
(GREENWELLS)***

Announcement Type: Initial Announcement  
Funding Opportunity No. DE-FOA-0003234  
CFDA Number 81.135

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| <b>Funding Opportunity Announcement (FOA) Issue Date:</b>   | December 12, 2023  |
| <b>First Deadline for Questions to <a href="mailto:ARPA-E-CO@hq.doe.gov">ARPA-E-CO@hq.doe.gov</a>:</b>  | 5 PM ET, January 16, 2024  |
| <b>Submission Deadline for Concept Papers:</b>  | 9:30 AM ET, January 25, 2024   |
| <b>Second Deadline for Questions to <a href="mailto:ARPA-E-CO@hq.doe.gov">ARPA-E-CO@hq.doe.gov</a>:</b> | 5 PM ET, TBD   |
| <b>Submission Deadline for Full Applications:</b>   | 9:30 AM ET, TBD  |
| <b>Submission Deadline for Replies to Reviewer Comments:</b>  | 5 PM ET, TBD   |
| <b>Expected Date for Selection Notifications:</b>   | August 2024  |
| <b>Total Amount to Be Awarded</b>   | Approximately \$38 million, subject to the availability of appropriated funds to be shared between FOAs DE-FOA-0003234 and DE-FOA-0003235. |
| <b>Anticipated Awards</b>   | ARPA-E may issue one, multiple, or no awards under this FOA. The Federal share of awards may vary between \$1 million and \$5 million.     |

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

Questions about this FOA? Check the Frequently Asked Questions available at <http://arpa-e.energy.gov/faq>. For questions that have not already been answered, email [ARPA-E-CO@hq.doe.gov](mailto: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](mailto: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/<br>MANDATORY | FOA<br>SECTION | DEADLINE                           |
|----------------------------------|--|------------------------|----------------|------------------------------------|
| Concept Paper                    | <ul style="list-style-type: none"><li>Each Applicant must submit a Concept Paper in Adobe PDF format by the stated deadline. The Concept Paper must not exceed six (6) total pages in length including graphics, figures, and/or tables, and must include the following:<ul style="list-style-type: none"><li>Concept Summary</li><li>Innovation and Impact</li><li>Proposed Work</li><li>Team Organization and Capabilities</li><li>Two Appendices, each not to exceed one (1) page:<ul style="list-style-type: none"><li>Appendix 1: Process Flow Diagram</li><li>Appendix 2: Material Balance</li></ul></li></ul></li></ul> | Mandatory              | IV.C           | 9:30 AM ET,<br>January 25,<br>2024 |
| Full Application                 | [TO BE INSERTED BY FOA MODIFICATION IN MARCH 2024]   | Mandatory              | IV.D           | 9:30 AM ET,<br>TBD                 |
| Reply to<br>Reviewer<br>Comments | [TO BE INSERTED BY FOA MODIFICATION IN MARCH 2024]   | Optional               | IV.E           | 5 PM ET, TBD                       |

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## **I. FUNDING OPPORTUNITY DESCRIPTION**

### **A. AGENCY OVERVIEW**

The Advanced Research Projects Agency – Energy (ARPA-E), an organization within the Department of Energy (DOE), is chartered by Congress in the America COMPETES Act of 2007 (P.L. 110-69), as amended by the America COMPETES Reauthorization Act of 2010 (P.L. 111-358), as further amended by the Energy Act of 2020 (P.L. 116-260):

- “(A) to enhance the economic and energy security of the United States through the development of energy technologies that—
- (i) reduce imports of energy from foreign sources;
  - (ii) reduce energy-related emissions, including greenhouse gases;
  - (iii) improve the energy efficiency of all economic sectors;
  - (iv) provide transformative solutions to improve the management, clean-up, and disposal of radioactive waste and spent nuclear fuel; and
  - (v) improve the resilience, reliability, and security of infrastructure to produce, deliver, and store energy; and
- (B) to ensure that the United States maintains a technological lead in developing and deploying advanced energy technologies.”

ARPA-E issues this Funding Opportunity Announcement (FOA) under its authorizing statute codified at 42 U.S.C. § 16538. The FOA and any cooperative agreements or grants made under this FOA are subject to 2 C.F.R. Part 200 as supplemented by 2 C.F.R. Part 910.

ARPA-E funds research on, and the development of, transformative science and technology solutions to address the energy and environmental missions of the Department. The agency focuses on technologies that can be meaningfully advanced with a modest investment over a defined period of time in order to catalyze the translation from scientific discovery to early-stage technology. For the latest news and information about ARPA-E, its programs and the research projects currently supported, see: <http://arpa-e.energy.gov/>.

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

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

**ARPA-E funds applied research and development.** The Office of Management and Budget defines “applied research” as an “original investigation undertaken in order to acquire new knowledge...directed primarily towards a specific practical aim or objective” and defines “experimental development” as “creative and systematic work, drawing on knowledge gained from research and practical experience, which is directed at producing new products or processes or improving existing products or processes.”<sup>1</sup> 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”)<sup>2</sup> 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. PROGRAM OVERVIEW**

The Grid-free Renewable Energy Enabling New Ways to Economical Liquids and Long-term Storage (GREENWELLS) program is targeted at producing sustainable carbon-containing liquids from renewable energy and carbon dioxide (CO<sub>2</sub>) by developing dynamically operable reactor systems that can take advantage of cheap, intermittent energy sources such as wind and solar.

To meet current climate goals, dramatic increases in renewable energy deployment are required. Yet construction of renewables (particularly wind and solar) is hampered by

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<sup>1</sup> OMB Circular A-11 ([https://www.whitehouse.gov/wp-content/uploads/2018/06/a11\\_web\\_toc.pdf](https://www.whitehouse.gov/wp-content/uploads/2018/06/a11_web_toc.pdf)), Section 84, pg. 3.

<sup>2</sup> OMB Circular A-11 ([https://www.whitehouse.gov/wp-content/uploads/2018/06/a11\\_web\\_toc.pdf](https://www.whitehouse.gov/wp-content/uploads/2018/06/a11_web_toc.pdf)), Section 84, pg. 3.

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challenges in interconnection to the electric grid. Wait times for wind and solar projects from interconnection request to operation now approach four years.<sup>3</sup> A method to use renewable energy without grid interconnection can accelerate renewable deployment. This method could provide cost-effective energy carriers for long- and medium-term energy storage and potentially moderate imbalances of supply and demand in a high renewable penetration scenario.

Simultaneously, transportation sectors, like aviation, marine, and heavy-duty vehicles, require technological solutions to lower their emissions. Alternative fuels and power trains are being developed for these difficult-to-decarbonize sectors with no clear economic winner. Low-carbon fuels can be a drop-in replacement, but are currently expensive, around \$10 per gallon (gal) for sustainable aviation fuel (SAF) derived from power-to-liquids (PtL) from a concentrated CO<sub>2</sub> source.<sup>4</sup> Costs can be reduced by minimizing high capital expenditure (CAPEX) units like hydrogen (H<sub>2</sub>) storage and by using cheaper electricity sources like wind and solar power with no connection to the grid. Projects that are independent from the grid can achieve lower overall costs and minimize project timelines and uncertainty, but this renewables-to-liquids (RtL) approach must grapple with the intermittency of wind and solar.

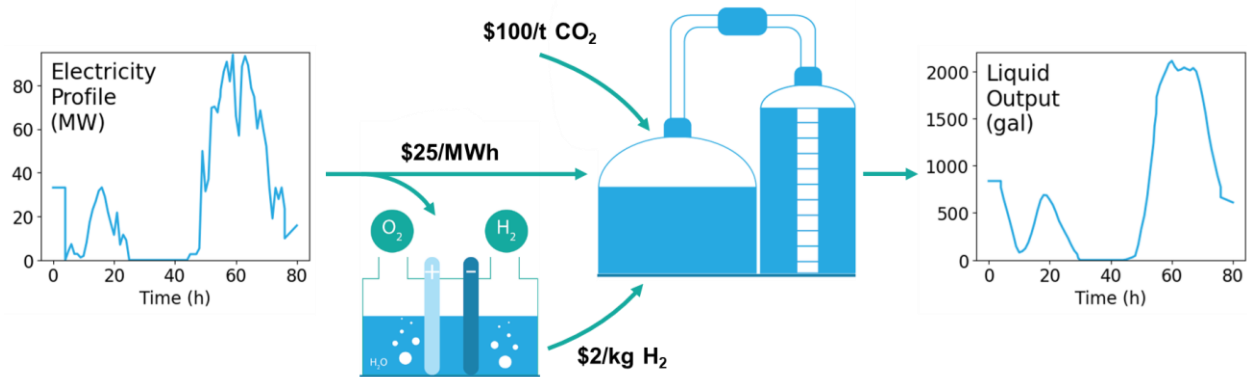
The primary objective of the GREENWELLS program is the development of chemical reactors and supporting units that economically store at least 50% of incoming intermittent electrical energy in carbon-containing liquids. To achieve attractive economics, ARPA-E expects that chemical reactors will need to be dynamically operable to optimize the entire system of renewable energy production, electrolysis capital, and energy storage. Thermal, electrochemical, plasmonic, photonic, biological, and other technical process approaches are expected to potentially address this problem. The integration of these novel and known processes (e.g., oligomerization, water separation) in a dynamic system will be needed.

If successful, the GREENWELLS program will provide low-cost carbon-containing liquids that (i) enable the transportation and storage of renewable energy, (ii) are suitable as-is or with upgrading for use in the difficult-to-decarbonize sectors, and (iii) will speed the development of new renewable energy projects by alleviating requirements for connection to an electric grid. With these goals, this program contributes to the ARPA-E statutory goals of “improv[ing] the resilience, reliability, and security of infrastructure to produce, deliver, and store energy,” “reduc[ing] energy-related emissions, including greenhouse gases,” and “reduc[ing] imports of energy from foreign sources,” as seen in Section I.A of the FOA.

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<sup>3</sup> Rand, J. “[Record Amounts of Zero-Carbon Electricity Generation and Storage Now Seeking Grid Interconnection](#),” *Electricity Markets and Policy Group*, Lawrence Berkeley National Laboratory, (2022)

<sup>4</sup> Raksha, T. et. al., “Power-to-Liquids as Renewable Fuel Option for Aviation: A Review” *Chemie Ingenieur Technik*, 90, 127-140 (2018)



**Figure 1.** Black box diagram of system inputs and outputs for the reactor systems in GREENWELLS. Based on data from Iowa State University’s Automated Surface Observing System (ASOS).<sup>5</sup>

### C. PROGRAM OBJECTIVES

ARPA-E expects projects funded through the GREENWELLS FOA to focus on the development of reactor systems—including the necessary catalysts, manufacturing methods, and balance of plant—to efficiently convert CO<sub>2</sub> and an intermittent feedstock of electricity or H<sub>2</sub> to carbon-containing liquids. The inputs and outputs (Figure 1) for reactor systems in this program are:

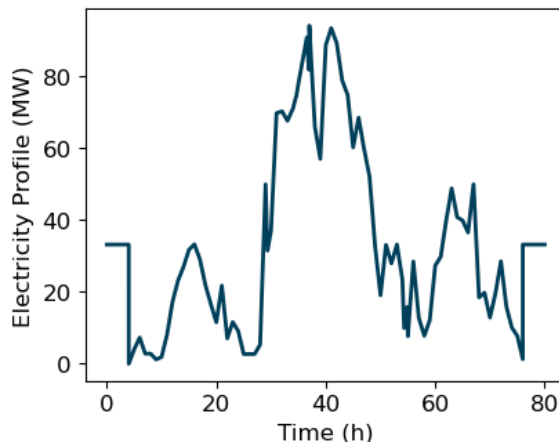
**Inputs:** ARPA-E envisions systems that would operate at the site of stranded renewable energy (i.e., wind, solar, or hybrid). Systems would use the intermittent electricity source, CO<sub>2</sub> either delivered or captured on site, and H<sub>2</sub>O either delivered or available on site. Applicants may assume:

- Electricity at \$25 per megawatt-hour (MWh) following the profile in Figure 2. Applicants may propose an alternative geographic location in the United States and use the wind and solar profile from that location.
- H<sub>2</sub> at \$2 per kilogram (kg) for high purity at 30 bar. Applicants may assume that electricity is instantaneously converted to H<sub>2</sub> following their electricity profile (i.e., Figure 2 or a specific geographic location) with 65% system energy efficiency for the electrolysis plant (set by DOE 2026 proton exchange membrane (PEM) targets).<sup>6</sup> The use of H<sub>2</sub> and water electrolysis, however, are not required.
- Delivered CO<sub>2</sub> at \$100 per tonne (t) for high purity at 30 bar. Process intensification with direct air capture (DAC) is in scope.

Applicants may also use different parameters than the above, if appropriately justified. During the Period of Performance, as technoeconomic analyses (TEA) and tech-to-market (T2M) plans are developed, updated values should be substituted.

<sup>5</sup> [Iowa State University Automated Surface Observation System \(ASOS\)](https://www.iastate.edu/asos/)

<sup>6</sup> **U.S. Department of Energy**, “Technical Targets for Proton Exchange Membrane Electrolysis,” Hydrogen and Fuel Cell Technologies Office. [Technical Targets for Proton Exchange Membrane Electrolysis | Department of Energy](https://www.energy.gov/eere/fuelcells/technical-targets-for-proton-exchange-membrane-electrolysis)



**Figure 2.** Representative electricity profile based on data from Iowa State University's ASOS.<sup>5</sup> The data is also provided on ARPA-E eXCHANGE in an Excel document.

**Outputs:** The final product may be any carbon-containing liquid or liquid mixture at ambient temperature and less than 20 bar. If appropriate, Applicants may include information on how that product would be upgraded offsite. ARPA-E may preference submissions that produce liquids of higher economic value (e.g., SAF).

Given the high costs of H<sub>2</sub> storage, particularly if a consistent H<sub>2</sub> output is required year-round, Applicants are required to propose a synthesis plant that is dynamically operable to minimize the H<sub>2</sub> storage or other energy storage CAPEX. This design must account for the dynamic nature of streams through the entire process, including, for example, separations and recycle streams. Otherwise, ARPA-E is not placing restrictions on the system design between input and final liquid product. Conversion of the inputs to liquids may occur by first electrolyzing water to produce H<sub>2</sub> and hydrogenating CO<sub>2</sub>, through a direct reduction of CO<sub>2</sub>, or via another route.

#### **D. TECHNICAL APPROACHES OF INTEREST**

ARPA-E expects that a range of different reactor types (including thermal, electrochemical, plasmonic, photonic, biological, and other technical process approaches) may be applied to meet the technical performance targets described in Section I.E. The GREENWELLS program does not require submissions to align themselves to a technical category.

Technical approaches of interest to this program include, but are not limited to, combinations of the following research areas:

- **Dynamic Reactor Design.** There has been recent interest in the development of reactors that are able to rapidly ramp to follow the intermittent availability of renewable energy. Process-intensified reactor systems that are of interest to ARPA-E in this program include:
  - Novel reactor designs that enable fast and efficient heat transfer such as microchannel reactors;

- Reactors that are capable of rapid heating through electrically driven processes, such as induction heating via magnetic nanoparticles or resistively heated reactors with directly integrated catalysts;
  - Reactors that utilize non-thermal approaches to drive chemical transformations, such as:
    - Plasma-driven reactions with or without catalysts
    - Photocatalytic or plasmonic methods
    - Electrocatalytic methods
  - Biological reactor systems that can operate with intermittent energy availability;
  - Methods for handling dynamic streams in separations and recycling; and
  - Controls for managing a dynamic system.
- **Novel Catalyst Development and Optimization.** Current catalyst approaches to CO<sub>2</sub> reduction are generally optimized for steady-state operation of commercialized processes such as Fischer-Tropsch (FT) synthesis and Reverse Water-Gas Shift (RWGS). A focus on developing and optimizing catalysts for operation and stability under dynamic conditions will be critical. Areas for catalyst development may include:
    - Novel reaction pathways
    - Product distribution optimization
    - Stability and durability optimization under dynamic conditions
    - High-throughput screening
  - **Manufacturing of Modular Reaction Systems.** The small scale of typical renewable installations (compared to industrial-scale refining and chemical plants) coupled with the distributed nature of such resources means that many small RtL plants will be needed at numerous locations. Design for mass production and modularity (minimizing installation costs), even at the expense of efficiency, may lead to a lower overall cost.
  - **Transient Modelling and Process Optimization.** Understanding how dynamic streams impact overall performance through the creation of digital twins or other simulations may speed up development timelines. The optimization of equipment sizing will also be needed to minimize cost.

ARPA-E anticipates that many submissions will comprise more than one of these areas. For example, Applicants may propose co-optimization of catalysts and reactors or Applicants may use known catalysts and reactor types and emphasize manufacturability.

## **E. TECHNICAL PERFORMANCE TARGETS**

The targets that systems must meet are described in Table 1. Applicants must include a table of metrics (included in submission template) with their expected performance in their submission as well as information supporting how each target is achievable.

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](mailto: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](mailto:ExchangeHelp@hq.doe.gov) (with FOA name and number in subject line).

**Table 1.** Program Metrics.

| ID        | Metric Name                                     | Target | Description and Rationale  |
|-----------|---|--------|--|
| <b>M1</b> | Electricity-to-Liquid Efficiency                | >50%   | This metric includes the overall system efficiency: renewable electricity to liquid lower heating value (LHV). Where possible, include energy efficiencies for subsystems (e.g., if going through H <sub>2</sub> , include H <sub>2</sub> -to-liquid efficiency). Electricity used for carbon capture is excluded from this metric.  |
| <b>M2</b> | Multi-pass Carbon Yield for Liquids             | >70%   | High carbon yield is required to achieve attractive economics particularly if expensive CO <sub>2</sub> is used, as may be the case for DAC-derived CO <sub>2</sub> . A process flow diagram (PFD) and material balance are required supporting information for this metric. The full system, including separations and recycling, necessary to achieve this target must be included in the TEA. |
| <b>M3</b> | Steady State Yield Loss After Dynamic Operation | <2%    | Systems must run following the 72 hours (h) electricity availability profile from renewable sources in Figure 2 or a U.S. renewable profile approved by ARPA-E. Steady-state operation periods before and after dynamic operation will be used to assess yield loss on a megajoule (MJ) Liquid LHV basis.  |
| <b>M4</b> | Dormancy  | 3 days | After 3 days of no electricity, plant can restart and achieve M1 efficiency and M2 yield within an hour. Any storage necessary to achieve this target must be included in the TEA.   |

In addition to describing how the systems can meet the targets in Table 1, ARPA-E is also requiring Applicants to answer the questions in Table 2. For these questions, no specific target is required, but the answers are intended to provide sufficient granular technical information to make informed selection decisions.

ARPA-E prefers that these questions are answered in a table. However, if some questions require longer answers than are easily included in a table, they may be answered in the body of the submission with the appropriate ID cited to indicate the answer.

**Table 2.** Required Short Answer Questions.

| ID        | Question  |
|-----------|---|
| <b>Q1</b> | How does your technology work and how does it compare to alternative established and emerging technologies? |
| <b>Q2</b> | What is (are) your core innovation(s)?  |
| <b>Q3</b> | What is your expected minimum selling price for liquids? (\$/MJ Liquid LHV)                                 |
| <b>Q4</b> | What is your product slate?   |
| <b>Q5</b> | Describe your current testing to date.  |

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](mailto: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](mailto:ExchangeHelp@hq.doe.gov) (with FOA name and number in subject line).

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|             |   |
|-------------|---|
| <b>Q6</b>   | What is the water balance of the system?  |
| <b>Q7</b>   | What ramp rate is achievable for the system? (% nameplate capacity/h)   |
| <b>Q8</b>   | What is the lowest stable state of the system? (% nameplate capacity)   |
| <b>Q9</b>   | What are the operating conditions in the Q8 reference state (e.g., product slate, power efficiency, C atom efficiency)? |
| <b>Q10</b>  | How long does it take to return to 100% capacity from the Q8 reference state?   |
| <b>Q11*</b> | What is your approach to flexible operation?  |
| <b>Q12</b>  | What is the range of reactor conditions expected (e.g., temperature, pressure, space velocity)?                         |
| <b>Q13</b>  | If applicable, describe what is currently known about the catalyst and its performance.                                 |
| <b>Q14</b>  | If applicable, at what scale has the catalyst been produced?  |
| <b>Q15</b>  | How is your reactor design suited for mass production?  |

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\*Answers should describe the overall system optimization strategy. For example, teams may choose to ramp instantaneously and operate either “on” or “off” or teams may minimize ramp rate using a H<sub>2</sub> storage buffer.

The required deliverables at the end of the Period of Performance of this program are shown in Table 3. ARPA-E expects that work plans will include regular (at a minimum annual) milestones on progress toward each of these deliverables. A work plan is not required at the Concept Paper stage of the application process.

**Table 3.** Required Final Deliverables.

---

| <b>ID</b>  | <b>Description</b>   |
|------------|--|
| <b>D1</b>  | 30 MJ Liquid LHV per day (d) production delivered with intermittent energy profile achieving the targets of Table 1                            |
| <b>D2*</b> | TEA for a total system at 100-megawatt electricity capacity facility (MWe) scale   |
| <b>D3</b>  | Carbon Intensity (CI) for liquid produced at 100 MWe scale, measured in gram CO <sub>2</sub> equivalents per megajoule (gCO <sub>2</sub> e/MJ) |
| <b>D4</b>  | Description of supply chain to manufacture system  |

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\*TEA should be developed with scenarios assuming no government incentives. However, scenarios including government incentives may be included if appropriate for the business case.

In the Concept Paper, one additional page is permitted for each of (1) a Process Flow Diagram (PFD) and (2) material balance (see Section IV.C). Ensure that text is legible in the diagram, including consistent labeling of streams and units between the documents. ARPA-E understands that simplification may be required for the PFD to fit on one page. In the Full Application, a PFD, heat and material balance, preliminary TEA, and T2M strategy discussion will be required.

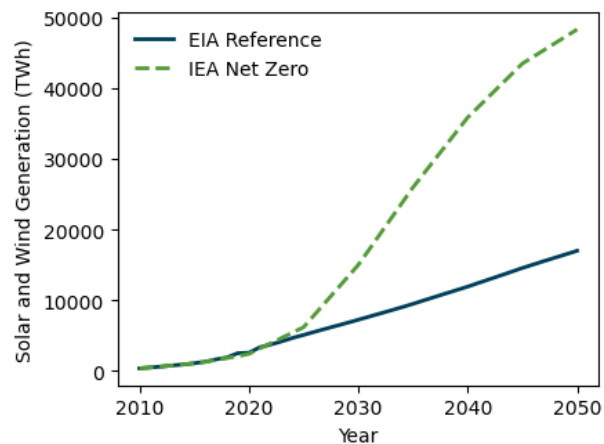
Questions about this FOA? Check the Frequently Asked Questions available at <http://arpa-e.energy.gov/faq>. For questions that have not already been answered, email [ARPA-E-CO@hq.doe.gov](mailto:ARPA-E-CO@hq.doe.gov) (with FOA name and number in subject line); see FOA Sec. VII.A. Problems with ARPA-E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

## F. DETAILED TECHNICAL BACKGROUND

This section provides background and context of Rtl generally and ARPA-E's interest in Rtl systems specifically, as well as technical context relevant for potential Applicants to the GREENWELLS program.

### 1. GENERAL BACKGROUND ON RENEWABLE ENERGY AND INTERCONNECTION

To meet decarbonization goals, the International Energy Agency (IEA) projects a need for deployment of about 48,000 terawatt-hours (TWh) of solar and wind renewable energy by 2050. The current Energy Information Administration (EIA) global projection shows that actual global deployment will be about 17,000 TWh, or 31,000 TWh short of the IEA goal (Figure 3).



**Figure 3.** Projected generation of electricity from solar and wind power from IEA (2021) Net Zero by 2050 Scenario (dashed green) and U.S. EIA Net Generation Renewables, Reference Case Scenario (solid blue).<sup>7,8</sup>

In the United States, the average time to deploy new projects from an interconnection request to plant operation has nearly doubled in the last decade from 2.1 to 3.7 years. From 2000-2016, 72% of requests for interconnection of new projects to the grid were withdrawn.<sup>3</sup> Given these challenges and the extent of deployment needed for net zero by 2050, technologies that can spur the deployment of renewables are critical.

Fortunately, the need to deploy large amounts of solar and wind coincide with a decrease in the costs of these technologies. The National Renewable Energy Lab's Annual Technology Baseline predicts 2050 levelized cost of electricity for utility-scale solar at \$18.482/MWh and land-based wind at \$18.768/MWh (both for the moderate technology development scenario).<sup>9</sup> By using these resources behind the meter, projects can realize significant cost savings (as compared to

<sup>7</sup> International Energy Agency, "Net Zero by 2050," IEA, Paris, France (2021).

<sup>8</sup> U.S. Energy Information Administration, International Energy Outlook 2021, Net generation Renewables (Case Reference Region Total World) (2021)

<sup>9</sup> National Renewable Energy Laboratory, "Annual Technology Baseline," available online at [atb.nrel.gov](http://atb.nrel.gov), Golden, CO (accessed Oct. 3, 2023).

North American Q4 2022 solar power purchase agreements: \$47-\$67/MWh).<sup>10</sup> These behind-the-meter electricity costs are low enough that economically competitive liquids could be produced if technologies exist to efficiently convert these intermittent energy sources to liquids.

Wind and solar power also provide tremendous technical potential for power generation: 38,000 TWh and 260,000 TWh, respectively, in the U.S. alone.<sup>11</sup> Though not all this potential can or would be tapped for conversion to liquids, this represents 480 million barrels per day (MMbbl/d) of oil equivalents, far exceeding the maximum global technical potential of biofuels and global oil demand (see Section I.F.3).

Technologies like RtL could encourage the construction of new renewable energy installations in places that are difficult to connect to the electrical grid due to their remote location or the overburdened grid. Grid-connected electrons have a plethora of uses more impactful than fuel production, but if fuel production can increase the deployment of renewable energy, RtL is a viable path to further decarbonization goals in parallel with grid modernization.

## 2. ADVANTAGES OF LIQUID FUELS

Liquid fuels can be easily transported, allowing for the export of energy from areas of high renewable energy production to areas of lower renewable energy production. Electricity transmission is particularly expensive, with transmission by high voltage direct current line costing \$41.5/MWh/1000 miles. Pipeline transmission for any chemical fuel, including H<sub>2</sub>, is an order of magnitude cheaper (Table 4).<sup>12</sup>

**Table 4.** Costs for transmission of different energy carriers.<sup>12</sup>

| Energy Carrier                   | Amortized cost<br>(\$/MWh/1000 miles) |
|----------------------------------|---------------------------------------|
| High Voltage Direct Current line | 41.5                                  |
| H <sub>2</sub> pipeline          | 5                                     |
| Methanol (MeOH) pipeline         | 2.2                                   |
| Ethanol (EtOH) pipeline          | 1.7                                   |
| Crude Oil pipeline               | 0.77                                  |

Liquid fuels can be easily stored, enabling the smoothing of energy across the annual variation in renewable energy production. Costs dramatically decrease moving from battery to liquid storage (Table 5). Battery storage is expensive, but its high round trip efficiency is suited to

<sup>10</sup> Kennedy, R., "US renewable PPA price hikes cool off as material costs fall," PV Magazine USA (Jan 26, 2023)

<sup>11</sup> Connelly, E., et. al., "Resource Assessment for Hydrogen Production," NREL, Golden, CO (2020)

<sup>12</sup> DeSantis, D. et al., "Cost of long-distance energy transmission by different carriers." *iScience*, **24**, 103495 (2021).

short duration storage. H<sub>2</sub> can be stored somewhat cheaply in salt caverns, but this is geographically constrained. Many regions that have high renewable resources, like the Midwest, do not have appropriate geology for salt caverns. Pressure vessel storage in these locations becomes economically prohibitive for long duration storage. With liquids, however, costs are much lower (with some additional costs for corrosive liquids).

**Table 5.** Cost comparison of storage of different energy carriers with different methods.

| Method                         | Typical Units | Comparable Units | See Footnote |
|--------------------------------|---------------|------------------|--------------|
| Battery                        | 206 \$/kWh    | 206,000 \$/MWh   | 13           |
| H <sub>2</sub> Pressure Vessel | 516 \$/kg     | 13,100 \$/MWh    | 13           |
| H <sub>2</sub> Salt Cavern     | 33 \$/kg      | 840 \$/MWh       | 13           |
| MeOH                           | 53 \$/t       | 10 \$/MWh        | 14           |
| Oil Above Ground               | 15 \$/bbl     | 0.88 \$/MWh      | 15           |
| Oil Salt Cavern                | 3.5 \$/bbl    | 0.21 \$/MWh      | 15           |

Liquid fuels have high energy density, a requirement for some difficult-to-decarbonize sectors such as transportation. Light-duty vehicles are well on their way to electrification, but electrification remains a challenge for heavy-duty vehicles, marine, and aviation. This program intersects well with the aviation and maritime industries' push towards decarbonized fuels.

Liquids produced in this program may also serve as feedstocks for the chemical industry. The modern chemical industry is dependent on petroleum-based feedstocks and the liquids produced in this program could also be used to offset some of that dependence.

### 3. WHY POWER-TO-LIQUIDS APPROACHES ARE NEEDED IN ADDITION TO BIOFUELS

Biofuels—liquid fuels produced from biomass feedstocks like plant material, algae, vegetable oils, etc.—are the most technologically advanced of the low-carbon fuels and are commercially available. Due to the limits imposed by land and water requirements, biofuels are unable to fully meet the future demand for liquid fuels.

<sup>13</sup> **Mallapragada, D. S. et al.**, "Can Industrial-Scale Solar Hydrogen Supplied from Commodity Technologies Be Cost Competitive by 2030?" *Cell Reports Physical Science*, 1, 100174 (2020).

<sup>14</sup> **Chen, C., and A. Yang**, "Power-to-Methanol: The Role of Process Flexibility in the Integration of Variable Renewable Energy into Chemical Production," *Energy Conversion and Management*, **228**, 113673 (2021).

<sup>15</sup> **U.S. Department of Energy**, "[Strategic Petroleum Reserve: Frequently Asked Questions](https://www.energy.gov/ceser/spr-faqs)," U.S. Department of Energy, Office of Cybersecurity, Energy Security, and Emergency Response, Washington, DC, <https://www.energy.gov/ceser/spr-faqs>.

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Biofuels use at least an order of magnitude more land than comparable PtL approaches. An analysis of different biogenic and PtL routes to SAF found the biogenic routes required 400-1350 hectares per kilotonne (ha/kt) SAF while the PtL routes required only 33-42 ha/kt SAF.<sup>16</sup>

Biofuels use two orders of magnitude more water than comparable PtL approaches. Water use is dependent on the region and feedstock used, but as an illustrative example, corn ethanol has been estimated to require 350-1400 gal irrigation water/gal SAF (upgrading by alcohol-to-jet would add a trivial amount of water use).<sup>17</sup> PtL-derived SAF requires 3.2-4.5 gal irrigation water/gal SAF.<sup>18</sup>

Biofuel production will not be able to meet the global demand for liquid fuels. A recent analysis of the global bioenergy potential found the maximum technical potential for production of biofuels at 9 MMbbl/d oil equivalents, falling short of both the 14.4 MMbbl/d estimated demand for biofuels in 2050 by the IEA and the approximately 80 MMbbl/d conventional oil currently produced (Figure 4).<sup>19,20</sup> Given the demand for liquid alcohols and fuels, it is likely that multiple approaches, including both biofuels and PtL, are needed.

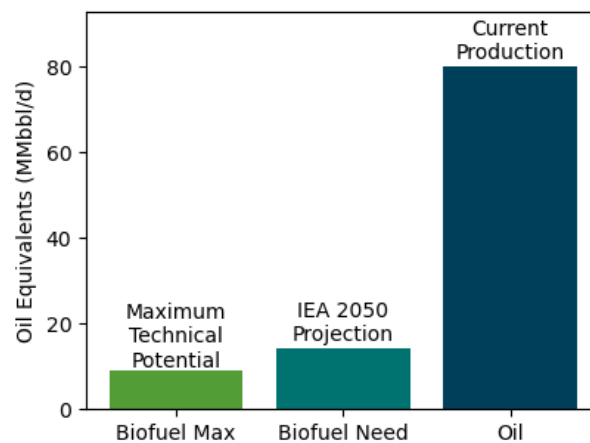


Figure 4. Biofuel projections versus current oil production.<sup>19,20</sup>

<sup>16</sup> Boter, T., "Bio-SAF vs. e-SAF: Land-Use Efficiency of Conversion Routes for Sustainable Aviation Fuel Production in the EU," Master's Thesis. Utrecht University, (2023).  
[https://studenttheses.uu.nl/bitstream/handle/20.500.12932/43990/Thesis Boter.pdf?sequence=1](https://studenttheses.uu.nl/bitstream/handle/20.500.12932/43990/Thesis%20Boter.pdf?sequence=1)

<sup>17</sup> U.S. Environmental Protection Agency, "Biofuels and the Environment: Second Triennial Report to Congress (Final Report, 2018)," EPA/600/R-18/195, EPA, Washington, DC, (2018).

<sup>18</sup> German Environment Agency, "Power-to-Liquids – A Scalable and Sustainable Fuel Supply Perspective for Aviation," Umwelt Bundesamt, Munich, Germany, (January, 2022).

<sup>19</sup> Searle, S., and C. Malins, "A Reassessment of Global Bioenergy Potential in 2050," *GCB Bioenergy*, 7(2), pp. 328-336 (2014).

<sup>20</sup> [Global oil production 2022 | Statista](https://www.statista.com/statistics/1102140/global-oil-production-2022/)

#### 4. CURRENT PRACTICES IN POWER-TO-LIQUIDS

There are two pathways for PtL: (1) Reverse Water-Gas Shift (RWGS) to produce syngas followed by Fischer-Tropsch (FT) synthesis, and (2) CO<sub>2</sub> hydrogenation to alcohol which is then further upgraded to a range of longer chain hydrocarbons.

Current commercialized FT processes typically rely on cheap natural gas sources for syngas feedstocks operating at scales greater than 10,000 bbl/d. Supplying these conventional FT processes with green hydrogen would require gigawatt-scale electrolyzers, which are prohibitively expensive for the pilot scale of FT-based PtL processes.<sup>4</sup> The aim of commercializing smaller scale FT chemistry has led to the development of novel approaches to reactor design, such as microchannel reactors, that operate more efficiently than currently deployed technologies.

Fuels produced via FT are well suited for current energy infrastructure and can be easily dropped in or blended at high percentages for transport needs.<sup>21</sup> Initial studies have shown that FT reactors can operate under fluctuating H<sub>2</sub> feeds, as would be needed in a dynamic reactor. However, a full, dynamic PtL FT system would need to integrate dynamic operation of both the RWGS and FT reactors.<sup>22</sup>

MeOH is typically produced from syngas via methane steam reforming. Direct CO<sub>2</sub> to MeOH is challenging—requiring pressures higher than 30 megapascal (MPa)—but small-scale commercialization pilots are in operation. MeOH is an extremely versatile chemical feedstock that can be upgraded to fuels and other valuable chemicals through Mobil's MeOH-to-olefins pathway.<sup>23</sup> MeOH to fuels was discovered in the 1980s but has only been commercialized in limited settings.

For either of these approaches to be successful, low CI electricity is needed. For a hypothetical system that converts 50% of incoming electricity to Jet A, the emissions from the electricity usage alone can be calculated (Table 6). Wind and solar have low CI, so a low-carbon fuel is possible. With the U.S. grid average CI, the emissions from the electricity use alone (without inclusion of any of the rest of the system) would exceed the emissions of conventional Jet A.

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<sup>21</sup> **ASTM International** "Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons" D7566, ASTM, West Conshohocken, PA (2022)

<sup>22</sup> **Pfeifer, P. et. al.** "[Dynamically Operated Fischer–Tropsch Synthesis in PtL—Part 2: Coping with Real PV Profiles](#)" Chem Engineering, 4, 27 (2020)

<sup>23</sup> **Porosof, M et. al.** "Catalytic reduction of CO<sub>2</sub> by H<sub>2</sub> for synthesis of CO, methanol and hydrocarbons: challenges and opportunities" Energy & Environmental Science, 1 (2016)

**Table 6.** Comparison of emissions for fuel production from different electricity sources with 50% electricity-to-Jet A efficiency.

|                      | Electricity CI<br>(gCO <sub>2</sub> e/kWh) | Emissions from electricity only<br>(gCO <sub>2</sub> e/MJ) | Emissions from electricity only<br>relative to conventional Jet A (84<br>gCO <sub>2</sub> e/MJ) |
|----------------------|--|--|---|
| Wind                 | 13 <sup>24</sup>                           | 7.2  | 9%  |
| Solar                | 43 <sup>25</sup>                           | 23.9   | 28%   |
| U.S. Grid<br>Average | 387 <sup>26</sup>                          | 215  | 256%  |

Existing PtL pilots have aimed to operate at steady state.<sup>25,27</sup> Ideal siting is needed for these projects to produce low-carbon energy at a high-capacity factor. While operating on a low carbon grid or using a non-intermittent renewable source like geothermal or hydroelectric is a viable strategy, it does not solve the primary problem of using stranded renewable energy.

The Solar Energies Technologies Office (SETO) has an interest in thermally driven conversion of sunlight to fuels (hydrogen, ammonia, liquid fuels such as gasoline, diesel, jet fuel, and solid fuels).<sup>28</sup> SETO's thermal approach is complementary to the GREENWELLS program's electricity driven approach.

## 5. ADVANCES IN ELECTROLYSIS

This program is made possible by dynamically operable electrolyzers which can produce cheap H<sub>2</sub>. PEM electrolyzers can follow intermittent renewable energy. Recent advances also suggest that alkaline electrolyzers may be able to operate dynamically, avoiding the harmful shunt currents that these systems have traditionally suffered from.<sup>29</sup>

Optimization studies have shown that achieving low cost H<sub>2</sub> from intermittent renewable energy relies on low capital cost of the renewable energy source, low capital cost of electrolyzers, and the availability of geologic storage.<sup>13</sup> The first two factors are discussed in greater detail elsewhere in the FOA. The third, geologic storage, is a geographic constraint, and the GREENWELLS program aims to remove this constraint by switching to a more cheaply storable product (i.e., liquids).

<sup>24</sup> **National Renewable Energy Laboratory**, "[Life Cycle Greenhouse Gas Emissions from Electricity Generation: Update \(nrel.gov\)](https://www.nrel.gov/publications/publication.html?pubid=22610)," NREL 22610, Golden, CO (2021)

<sup>25</sup> [Haru Oni - HIF Global](#)

<sup>26</sup> **U.S. Energy Information Administration**, "[Carbon intensity of U.S. power generation continues to fall but varies widely by state](#)" Washington, DC (2022)

<sup>27</sup> [Our Technology | Norsk e-Fuel \(norsk-e-fuel.com\)](#)

<sup>28</sup> **U.S. Department of Energy** "SOLAR-THERMAL FUELS AND THERMAL ENERGY STORAGE VIA CONCENTRATING SOLAR-THERMAL ENERGY" DE-FOA-0003028, Washington, DC (March 2023)

<sup>29</sup> [AquaHydrex - Redesigning Electrolysis for Green Hydrogen Production: AquaHydrex](#)

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DOE has invested significant funding in water electrolysis and is backing an Energy Earthshot effort to bring H<sub>2</sub> production to \$1/kg. The Hydrogen and Fuel Cell Technologies Office (HFTO) is interested in advanced electrolyzer development and coupling with low-cost variable intermittent renewable resources.<sup>30,31</sup> The Office of Clean Energy Demonstrations jointly with HFTO recognize demand-side support as components of regional Hydrogen Hubs. CO<sub>2</sub>-based synthetic fuels are specifically identified as a component of the H2@Scale initiative.<sup>32</sup> This program is a higher technology level program focused on production and deployment of H<sub>2</sub> which requires end uses for the H<sub>2</sub> to exist, rather than aiding in the improvement of carbon conversion technologies. The GREENWELLS program complements these existing efforts in H<sub>2</sub> production and use.

## 6. RATIONALE FOR DYNAMIC REACTORS

The availability of dynamically operable electrolyzers raises the possibility of dynamically operable synthesis plants for conversion of H<sub>2</sub>-to-liquids. When operating with 100% renewable energy, costs for hypothetical MeOH plants decreased by 21-34% in simulation (depending on location) when the synthesis plant was operated dynamically.<sup>14</sup> The primary driver for the cost reduction in the optimized system was a decrease in H<sub>2</sub> storage CAPEX which fell from 1248 t when operating steady state to 200 t with a 5% nameplate capacity/h ramp for a 1500 MWe facility. This dynamic operation removed \$788MM CAPEX, which was slightly offset by increases in CO<sub>2</sub> and MeOH storage CAPEX and an increase in reactor CAPEX. Dynamic operation has also been shown to reduce the cost of renewables-to-ammonia by up to 45% with the technology successfully tested at a small scale.<sup>33</sup>

As renewable penetration increases, the ability to use intermittent energy becomes increasingly necessary. Dynamically operable reactors could use intermittent energy and could lower system costs by optimizing component sizes.

## 7. ADVANCES IN DYNAMIC REACTORS

Recent successes in dynamic operation have primarily been for endothermic reactions. Rapid, efficient heating of a methane steam reforming reaction was achieved by directly integrating a catalyst structure onto a resistively heated reactor wall. This allowed for dramatically more efficient heat and mass transfer and a 90% decrease in reactor volume.<sup>34</sup> Induction heating using magnetic nanoparticles to directly heat catalysts is another approach to rapid heating

<sup>30</sup> [Hydrogen from Next-generation Electrolyzers of Water \(H2NEW\) | H2NEW \(energy.gov\)](#)

<sup>31</sup> **U.S. Department of Energy** "BIPARTISAN INFRASTRUCTURE LAW: CLEAN HYDROGEN ELECTROLYSIS, MANUFACTURING, AND RECYCLING" DE-FOA-0002922, Washington, DC (March 2023)

<sup>32</sup> **U.S. Department of Energy** "BIPARTISAN INFRASTRUCTURE LAW: ADDITIONAL CLEAN HYDROGEN PROGRAMS (SECTION 40314): REGIONAL CLEAN HYDROGEN HUBS FUNDING OPPORTUNITY ANNOUNCEMENT" DE-FOA-0002779, Washington, DC (Jan 2023)

<sup>33</sup> **Parvathikar, S.** "[Ammonia's Role in the Green Revolution | RTI](#)" RTI International, Insights Blog (2023)

<sup>34</sup> **Chorkendorff, I. and P. Mortensen et. al.** "[Electrified methane reforming: A compact approach to greener industrial hydrogen production](#)" Science 364, pp. 756–759 (2019)

that could be used to operate a reactor dynamically.<sup>35</sup> It remains an open question whether design principles from these processes are applicable to exothermic reactions.

Microchannel reactors are another approach to improving heat transfer and reducing reactor volumes. Several companies have applied these approaches to reducing the scale of FT synthesis.<sup>36</sup>

Non-thermal drivers for chemical reactions, such as plasma and photochemistry, are easily electrified and more easily follow energy availability than traditional thermochemical approaches. MeOH synthesis from CO<sub>2</sub> and H<sub>2</sub> has been shown at room temperature and atmospheric pressure through plasma-assisted catalysis. This technology could operate dynamically; however, energy efficiency and product yields would need to be improved substantially to achieve program targets.<sup>37</sup> Plasmon-based reaction systems have been developed for ammonia decompositions and have the potential to be operated dynamically as light is the primary driver of the reaction. Optimization of such systems for carbon-containing liquid synthesis and improvement of efficiency would be necessary for such systems to meet program targets.<sup>38</sup>

Several biological strategies for CO<sub>2</sub> reduction have shown promising results for producing a range of liquid products that are challenging to synthesize through traditional thermo- and electro-chemical methods, such as acetone and C<sub>2+</sub> alcohols. Non-photosynthetic microbes have the potential to be paired with electrochemical systems to access these products. Currently, these systems suffer from low yields and the need for specialized, costly reactor systems. Overcoming these limitations would be necessary to achieve program targets. Resilience to fluctuations in energy availability would also be crucial to the success of projects pursuing biological routes.<sup>39</sup>

## 8. SIZING AND CAPITAL COSTS

ARPA-E expects that for R<sub>TL</sub> to be economical, CAPEX must be minimized, and the system must be modular. For example, ARPA-E estimates that a 100 MW facility producing 400 bbl/d (at 50% capacity) purchasing H<sub>2</sub> at \$2/kg and CO<sub>2</sub> at \$100/t would likely need to keep CAPEX at or below \$40MM for the reactor system to turn a profit without subsidies. Modular construction would

<sup>35</sup> Giambastiani, G and C. Pham-Huu et. al. "[Induction Heating: An Enabling Technology for the Heat Management in Catalytic Processes](#)" ACS Catalysis, 9, pp. 7921-7935 (2019)

<sup>36</sup> Examples include: <https://velocys.com/technology/>, <https://www.ineratec.de/en/synthetic-fuels>

<sup>37</sup> Tu, X. "[Atmospheric Pressure and Room Temperature Synthesis of Methanol through Plasma-Catalytic Hydrogenation of CO<sub>2</sub>](#)" ACS Catalysis, 8, pp. 90-100 (2018)

<sup>38</sup> Hie, J. and C. Janaky. "[Recent Advances in Solar-Driven Carbon Dioxide Conversion: Expectations versus Reality](#)" ACS Energy Lett. 2020, 5, 6, pp. 1996–2014 (2020)

<sup>39</sup> Atsumi, S. et. Al., "[Nonphotosynthetic Biological CO<sub>2</sub> Reduction](#)" Biochemistry, 58, pp. 1470-1477 (2019)

also decrease project timelines by allowing the plant to be delivered to site rather than stick built in place.<sup>40</sup>

## 9. NEAR-TERM APPLICATION OF DYNAMIC REACTORS

The main technical feature developed in the GREENWELLS program is a dynamically operable chemical cell. Coupled with an electrolysis unit, the dynamically operable chemical cell provides operational flexibility for chemical manufacturing to diversify feedstocks and capture advantaged grid pricing.

This occurs in practice today. Alcoa, a steel manufacturer, is a registered Federal Energy Regulatory Commission utility and operates arc furnaces with specific turndown. By operating with this flexibility, Alcoa can participate in industrial demand response and independent system operator planning. This responsive load yielded “impressive preliminary plant performance results.”<sup>41</sup>

In the context of chemical manufacturing, for a case study where a new manufacturing train is installed to generate intermittent MeOH, the hypothetical dynamically operable chemical reactors exceeded existing project internal rate of return of 17%. This case study provides a pathway of near-term practical impact.

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<sup>40</sup> Baldea, M. et. al. “Modular Manufacturing Processes: Status, Challenges, and Opportunities” AIChE Journal, 63, 10, (2017)

<sup>41</sup> Todd, D. “Providing Reliability Services through Demand Response: A Preliminary Evaluation of the Demand Response” Oakridge National Lab. ORNL/TM-2008/233.  
<https://www.energy.gov/sites/prod/files/2015/04/f21/Alcoa%20%26%20ORNL%20Demand%20Response%20White%20Paper%20-%20Jan.%202009.pdf>. Oakridge, TN. (2009)

## **II. AWARD INFORMATION**

### **A. AWARD OVERVIEW**

ARPA-E expects to make approximately \$38 million available for new awards, subject to the availability of appropriated funds. ARPA-E anticipates making approximately 12 to 15 awards under this FOA. ARPA-E may, at its discretion, issue one, multiple, or no awards.

Individual awards may vary between \$1 million and \$5 million in Federal share.

The period of performance for funding agreements may not exceed 36 months. ARPA-E expects to issue funding agreements in August 2024, or as negotiated.

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

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

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

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

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

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

### **B. RENEWAL AWARDS**

At ARPA-E's sole discretion, awards resulting from this FOA may be renewed by adding one or more budget periods, extending the period of performance of the initial award, or issuing a new

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award. Renewal funding is contingent on: (1) availability of funds appropriated by Congress for the purpose of this program; (2) substantial progress towards meeting the objectives of the approved application; (3) submittal of required reports; (4) compliance with the terms and conditions of the award; (5) ARPA-E approval of a renewal application; and (6) other factors identified by the Agency at the time it solicits a renewal application.

## **C. ARPA-E FUNDING AGREEMENTS**

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

Congress directed ARPA-E to "establish and monitor project milestones, initiate research projects quickly, and just as quickly terminate or restructure projects if such milestones are not achieved."<sup>42</sup> Accordingly, ARPA-E has substantial involvement in the direction of every Cooperative Agreement, as described in Section II.D below.

### **1. COOPERATIVE AGREEMENTS**

ARPA-E generally uses Cooperative Agreements to provide financial and other support to Prime Recipients.<sup>43</sup>

Cooperative Agreements involve the provision of financial or other support to accomplish a public purpose of support or stimulation authorized by Federal statute. Under Cooperative Agreements, the Government and Prime Recipients share responsibility for the direction of projects.

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

### **2. FUNDING AGREEMENTS WITH FFRDCs/DOE LABS, GOGOs, AND FEDERAL INSTRUMENTALITIES**

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

When a FFRDC/DOE Lab (including the National Energy Technology Laboratory or NETL) is the

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<sup>42</sup> U.S. Congress, Conference Report to accompany the 21<sup>st</sup> Century Competitiveness Act of 2007, H. Rpt. 110-289 at 171-172 (Aug. 1, 2007).

<sup>43</sup> The Prime Recipient is the signatory to the funding agreement with ARPA-E.

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

When a FFRDC/DOE Lab is a *member* of a Project Team, ARPA-E executes a funding agreement directly with the FFRDC/DOE Lab and a single, separate Cooperative Agreement with the Prime Recipient, as the lead organization for 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 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.

### **3. OTHER TRANSACTIONS AUTHORITY**

ARPA-E may use its "other transactions" authority under the America COMPETES Reauthorization Act of 2010 and DOE's other transactions authority as codified at 42 USC §7256(a) and (g) to enter into an other transaction agreement with Prime Recipients, on a case-by-case basis.

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

The federal share of other transactions agreements should meet or exceed \$3,000,000. In general, an other transaction agreement normally requires a minimum cost share of 50%. See Section III.B.2 of the FOA.

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#### **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<sup>44</sup> 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.

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<sup>44</sup> The term "nonprofit organization" or "nonprofit" is defined in Section IX.

### **III. ELIGIBILITY INFORMATION**

#### **A. ELIGIBLE APPLICANTS**

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

##### **1. INDIVIDUALS**

U.S. citizens or permanent residents may apply for funding in their individual capacity as a Standalone Applicant,<sup>45</sup> as the lead for a Project Team,<sup>46</sup> or as a member of a Project Team. However, ARPA-E will only award funding to an entity formed by the Applicant.

##### **2. DOMESTIC ENTITIES**

For-profit entities (including large businesses and small businesses), educational institutions<sup>47</sup>, and nonprofits<sup>48</sup> that are incorporated in the United States, including U.S. territories, are eligible to apply for funding as a Standalone Applicant, as the lead organization for a Project Team, or as a member of a Project Team.

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

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

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

##### **3. FOREIGN ENTITIES**

Foreign entities, whether for-profit or otherwise, are eligible to apply for funding as Standalone Applicants, as the lead organization for a Project Team, or as a member of a Project Team. Foreign entities must designate in the Full Application a subsidiary or affiliate incorporated (or

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<sup>45</sup> A Standalone Applicant is an Applicant that applies for funding on its own, not as part of a Project Team.

<sup>46</sup> A Project Team consists of the Prime Recipient, Subrecipients, and others performing or otherwise supporting work under an ARPA-E funding agreement.

<sup>47</sup> Institutions of Higher Education (or educational institutions): Has the meaning set forth at 20 U.S.C. 1001.

<sup>48</sup> Nonprofit organizations described in section 501(c)(4) of the Internal Revenue Code of 1986 that engaged in lobbying activities after December 31, 1995 are not eligible to apply for funding as a Prime Recipient or Subrecipient.

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otherwise formed or to be formed) under the laws of a State or territory of the United States to receive funding. The Full Application must state the nature of the corporate relationship between the foreign entity and domestic subsidiary or affiliate. All work under the ARPA-E award must be performed in the United States. The Applicant may request a waiver of this requirement in the Business Assurances & Disclosures Form, which is submitted with the Full Application and can be found at <https://arpa-e-foa.energy.gov/> (see “View Template Application Documents”). Refer to the Business Assurances & Disclosures Form for guidance on the content and form of the request.

#### **4. CONSORTIUM ENTITIES**

Consortia, which may include domestic and foreign entities, must designate one member of the consortium as the consortium representative to the Project Team. The consortium representative must be incorporated in the United States. The eligibility of the consortium will be determined by reference to the eligibility of the consortium representative under Section III.A.4 of the FOA. Each consortium must have an internal governance structure and a written set of internal rules. Upon request, the consortium entity must provide a written description of its internal governance structure and its internal rules to the Contracting Officer ([ARPA-E-CO@hq.doe.gov](mailto:ARPA-E-CO@hq.doe.gov)).

Unincorporated consortia must provide the Contracting Officer with a collaboration agreement, commonly referred to as the articles of collaboration, which sets out the rights and responsibilities of each consortium member. This collaboration agreement binds the individual consortium members together and shall include the consortium's:

- Management structure;
- Method of making payments to consortium members;
- Means of ensuring and overseeing members' efforts on the project;
- Provisions for members' cost sharing contributions; and
- Provisions for ownership and rights in intellectual property developed previously or under the agreement.

#### **B. COST SHARING<sup>49</sup>**

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

##### **1. BASE COST SHARE REQUIREMENT**

ARPA-E generally uses Cooperative Agreements to provide financial and other support to Prime Recipients (see Section II.C.1 of the FOA). Under a Cooperative Agreement or Grant, the Prime

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<sup>49</sup> Please refer to Section VI.B.3-4 of the FOA for guidance on cost share payments and reporting.

Recipient must provide at least 20% of the Total Project Cost<sup>50</sup> as cost share, except as provided in Sections III.B.2 or III.B.3 below.<sup>51</sup>

## **2. INCREASED COST SHARE REQUIREMENT**

Large businesses<sup>52</sup> are strongly encouraged to provide more than 20% of the Total Project Cost as cost share. ARPA-E may consider the amount of cost share proposed when selecting applications for award negotiations (see Section V.B.1 of the FOA).

Under an “other transaction” agreement, the Prime Recipient is normally expected to provide at least 50% of the Total Project Cost as cost share. ARPA-E may reduce this cost share requirement, as appropriate.

## **3. REDUCED COST SHARE REQUIREMENT**

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

- A domestic educational institution or domestic nonprofit applying as a Standalone Applicant is required to provide at least 5% of the Total Project Cost as cost share.
- Project Teams composed exclusively of domestic educational institutions, domestic nonprofits, and/or FFRDCs/DOE Labs/Federal agencies and instrumentalities (other than DOE) are required to provide at least 5% of the Total Project Cost as cost share. Small businesses – or consortia of small businesses – may provide 0% cost share from the outset of the project through the first 12 months of the project (hereinafter the “Cost Share Grace Period”).<sup>53</sup> If the project is continued beyond the Cost Share Grace Period, then at least 10% of the Total Project Cost (including the costs incurred during the Cost Share Grace Period) will be required as cost share over the remaining period of performance.
- Project Teams where a small business is the lead organization and small businesses perform greater than or equal to 80% of the total work under the funding agreement (as measured by the Total Project Cost) are entitled to the same cost share reduction and Cost Share Grace Period as provided above to Standalone small businesses or consortia of small businesses.

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<sup>50</sup> The Total Project Cost is the sum of the Prime Recipient share and the Federal Government share of total allowable costs. The Federal Government share generally includes costs incurred by GOGOs and FFRDCs.

<sup>51</sup> Energy Policy Act of 2005, Pub.L. 109-58, sec. 988(c)

<sup>52</sup> See Section IX.

<sup>53</sup> The term “small business” is defined in Section IX.

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

#### **4. LEGAL RESPONSIBILITY**

Although the cost share requirement applies to the Project Team as a whole, the funding agreement makes the Prime Recipient legally responsible for paying, or ensuring payment of the entire cost share. The Prime Recipient's cost share obligation is expressed in the funding agreement as a static amount in U.S. dollars (cost share amount) and as a percentage of the Total Project Cost (cost share percentage). If the funding agreement is terminated prior to the end of the period of performance, the Prime Recipient is required to contribute at least the cost share percentage of total expenditures incurred through the date of termination.

The Prime Recipient is solely responsible for managing cost share contributions by the Project Team and enforcing cost share obligations assumed by Project Team members in subawards or related agreements.

#### **5. COST SHARE ALLOCATION**

Each Project Team is free to determine how much each Project Team member will contribute towards the cost share requirement. The amount contributed by individual Project Team members may vary, as long as the cost share requirement for the project as a whole is met.

#### **6. COST SHARE TYPES AND ALLOWABILITY**

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

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

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funding or property was not provided to the state or local government by the Federal Government.

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

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

In addition, Project Teams may not use independent research and development (IR&D) funds<sup>54</sup> to meet their cost share obligations under Cooperative Agreements. However, Project Teams may use IR&D funds to meet their cost share obligations under “other transaction” agreements.

Project Teams may not use the same cash or in-kind contributions to meet cost share requirements for more than one project or program.

Cost share contributions must be specified in the project budget, verifiable from the Prime Recipient’s records, and necessary and reasonable for proper and efficient accomplishment of the project. Every cost share contribution must be reviewed and approved in advance by the Contracting Officer and incorporated into the project budget before the expenditures are incurred.

Applicants may wish to refer to 2 C.F.R. Parts 200 and 910, and 10 C.F.R Part 603<sup>55</sup> for additional guidance on cost sharing, specifically 2 C.F.R. §§ 200.306 and 910.130, and 10 C.F.R. §§ 603.525-555.

## **7. COST SHARE CONTRIBUTIONS BY FFRDCs AND GOGOS**

Because FFRDCs are funded by the Federal Government, costs incurred by FFRDCs generally may not be used to meet the cost share requirement. FFRDCs may contribute cost share only if the contributions are paid directly from the contractor’s Management Fee or a non-Federal source.

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

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<sup>54</sup> As defined in Federal Acquisition Regulation Subsection 31.205-18.

<sup>55</sup> In the case of Technology Investment Agreements under 42 USC §7256(g).

## **8. COST SHARE VERIFICATION**

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

### **C. OTHER**

#### **1. COMPLIANT CRITERIA**

Concept Papers are deemed compliant if:

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

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

Full Applications are deemed compliant if:

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

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

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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.

*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](mailto: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](mailto:ExchangeHelp@hq.doe.gov) (with FOA name and number in subject line).*

### 3. SUBMISSIONS SPECIFICALLY NOT OF INTEREST

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

- Approaches that solely or mostly focus on development of water electrolysis.
- Approaches that solely or mostly focus on development of direct air capture.
- Approaches that use any carbon source other than CO<sub>2</sub>.
- Approaches that only focus on catalyst development without application in a dynamically operable reactor.
- Approaches that propose production of non-carbon containing liquids.
- Approaches that propose reactors that operate solely or mostly at steady state.
- Approaches that primarily aim to reduce the cost of battery or H<sub>2</sub> storage.

### 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”<sup>56</sup> may apply to only one of the two ARPA-E GREENWELLS FOAs: DE-FOA-0003235 (GREENWELLS SBIR/STTR), or DE-FOA-0003234 (GREENWELLS). 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-0003235 (SBIR/STTR), please review the eligibility requirements in Section III of that FOA.

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<sup>56</sup> Please refer to the U.S. Small Business Administration (SBA) website. 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.

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## **IV. APPLICATION AND SUBMISSION INFORMATION**

### **A. APPLICATION PROCESS OVERVIEW**

#### **1. REGISTRATION IN ARPA-E eXCHANGE**

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

#### **2. CONCEPT PAPERS**

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

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

#### **3. FULL APPLICATIONS**

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

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

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#### **4. REPLY TO REVIEWER COMMENTS**

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

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

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

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

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

#### **6. SELECTION FOR AWARD NEGOTIATIONS**

ARPA-E carefully considers all of the information obtained through the application process and makes an independent assessment of each compliant and responsive Full Application based on the criteria and program policy factors in Sections V.A.2 and V.B.1 and the risk analysis in Section VI.B.10 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.

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## **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 shall not exceed six (6) pages in length including graphics, figures, and/or tables. Specifically, Sections 1-4 of the Concept Paper (Sections 1a – 1d below) shall not exceed four (4) pages, and Sections 5-6 (the Appendices, Sections 1e and 1f below) shall each not exceed one (1) page, for a maximum of two (2) pages in length for the Appendices.
- 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), and Project Duration.

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

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

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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 technical 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.
- Please fill in Tables 1 and 2 in the Concept Paper Template to illustrate the project's ability to meet FOA targets and provide additional detail on the technology proposed.

### **c. PROPOSED WORK**

- Describe the final deliverable(s) for the project and the overall technical approach used to achieve project objectives. Reference the deliverables in Table 3 in Section I.E of the FOA.
- 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 sharing.

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**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. APPENDIX 1: PROCESS FLOW DIAGRAM (1-PAGE MAXIMUM)**

- Develop a PFD to support Metric #2 from Table 1 (see Section I.E of the FOA).
- Ensure that text is legible in the diagram, including consistent labeling of streams and units between the documents. ARPA-E understands that simplification may be required for the PFD to fit on one page.

**f. APPENDIX 2: MATERIAL BALANCE (1-PAGE MAXIMUM)**

- Develop a material balance to support Metric #2 from Table 1 (see Section I.E of the FOA).
- Ensure that text is legible in the tables, including consistent labeling of streams and units between Appendix 1 and Appendix 2.

**D. CONTENT AND FORM OF FULL APPLICATIONS**

[TO BE INSERTED BY FOA MODIFICATION IN MARCH 2024]

**E. INTERGOVERNMENTAL REVIEW**

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

**F. FUNDING RESTRICTIONS**

**1. ALLOWABLE COSTS**

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

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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.

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## **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. However, Applicants may request a waiver of this requirement where their project would materially benefit from, or otherwise requires, certain work to be performed overseas.

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

## **7. PURCHASE OF NEW EQUIPMENT**

All equipment purchased under ARPA-E funding agreements must be made or manufactured in the United States, to the maximum extent practicable. This requirement does not apply to used or leased equipment. The Prime Recipients are required to notify the ARPA-E Contracting Officer reasonably in advance of purchasing any equipment that is not made or manufactured in the United States with a total acquisition cost of \$250,000 or more. Purchases of foreign equipment with a total acquisition cost of \$1,000,000 or more require the approval of the Head of Contracting Activity (HCA). The ARPA-E Contracting Officer will provide consent to purchase or reject within 30 calendar days of receipt of the Recipient's notification.

## **8. TECHNOLOGY TRANSFER AND OUTREACH**

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

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

- Documented travel and registration for the ARPA-E Energy Innovation Summit and other energy-related conferences and events;
- Documented travel to meet with potential suppliers, partners, or customers;

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- Documented work by salaried or contract personnel to develop technology-to-market models or plans;
- Documented costs of acquiring industry-accepted market research reports; and
- Approved patent costs.

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

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

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

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

## **9. LOBBYING**

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

Prime Recipients and Subrecipients are required to complete and submit SF-LLL, "Disclosure of Lobbying Activities" (<https://www.gsa.gov/forms-library/disclosure-lobbying-activities>) if any non-Federal funds have been paid or will be paid to any person for influencing or attempting to influence any of the following in connection with your application:

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

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## 10. CONFERENCE SPENDING

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

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

## 11. INDEPENDENT RESEARCH AND DEVELOPMENT COSTS

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

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

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

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

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

## **13. BUY AMERICA REQUIREMENT FOR PUBLIC INFRASTRUCTURE PROJECTS**

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

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

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

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

## **14. REQUIREMENT FOR FINANCIAL PERSONNEL**

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

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## G. OTHER SUBMISSION REQUIREMENTS

### 1. USE OF ARPA-E eXCHANGE

To apply to this FOA, Applicants must register with ARPA-E eXCHANGE (<https://arpa-e-foa.energy.gov/Registration.aspx>). 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.C.1 of the FOA). The following errors could cause an application to be deemed “incomplete” and thus noncompliant:

- Failing to comply with the form and content requirements in Section IV of the FOA;
- Failing to enter required information in ARPA-E eXCHANGE;
- Failing to upload required document(s) to ARPA-E eXCHANGE;

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](mailto: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](mailto:ExchangeHelp@hq.doe.gov) (with FOA name and number in subject line).

- 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.

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## **V. APPLICATION REVIEW INFORMATION**

### **A. CRITERIA**

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

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

#### **1. CRITERIA FOR CONCEPT PAPERS**

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

- The potential for a transformational and disruptive (not incremental) advancement compared to existing or emerging technologies;
- Achievement of the technical performance targets defined 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.

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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 MARCH 2024]

## **3. CRITERIA FOR REPLIES TO REVIEWER COMMENTS**

[TO BE INSERTED BY FOA MODIFICATION IN MARCH 2024]

### **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.

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- IV. **Low likelihood of other sources of funding.** High technical and/or financial uncertainty that results in the non-availability of other public, private or internal funding or resources to support the project.
- V. **High-Leveraging of Federal Funds.** Project leverages Federal funds to optimize advancement of programmatic goals by proposing cost share above the required minimum or otherwise accessing scarce or unique resources.
- VI. **High Project Impact Relative to Project Cost.**
- VII. **Qualified Opportunity Zone (QOZ).** Whether the entity is located in an urban and economically distressed area including a Qualified Opportunity Zone (QOZ) or the proposed project will occur in a QOZ or otherwise advance the goals of QOZ. The goals include spurring economic development and job creation in distressed communities throughout the United States. For a list or map of QOZs go to:  
<https://www.cdfifund.gov/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](mailto:ARPA-E-CO@hq.doe.gov)) if they have knowledge of a potential conflict of interest or a reasonable belief that a potential conflict exists.

## 3. ARPA-E SUPPORT CONTRACTORS

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

By submitting an application to ARPA-E, Applicants represent that they are not performing support contractor services for ARPA-E in any capacity and did not obtain the assistance of

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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 MARCH 2024]

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## **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 MARCH 2024]

### **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

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are required to flow down these requirements to their Subrecipients through subawards or related agreements.

- If an award 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 an award 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](http://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/>.<sup>57</sup> Prime Recipients are required to report to FSRS the names and total compensation of each of the Prime Recipient's five most highly compensated executives and the names and total compensation of each Subrecipient's five most highly compensated executives. Please refer to

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<sup>57</sup> The Federal Funding Accountability and Transparency Act, P.L. 109-282, 31 U.S.C. 6101 note.

<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. PROOF OF COST SHARE COMMITMENT AND ALLOWABILITY**

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

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

## **4. COST SHARE PAYMENTS<sup>58</sup>**

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

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

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<sup>58</sup> Please refer to Section III.B of the FOA for guidance on cost share requirements.

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

## **5. ENVIRONMENTAL IMPACT QUESTIONNAIRE**

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

To facilitate and expedite ARPA-E's environmental review, Prime Recipients are required to complete an Environmental Impact Questionnaire during award negotiations. This form is available at <https://arpa-e.energy.gov/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.

## **6. TECHNOLOGY-TO-MARKET PLAN**

During award negotiations, Prime Recipients are required to negotiate and submit an initial Technology-to-Market Plan to the ARPA-E Program Director and obtain the ARPA-E Program Director's approval prior to the execution of the award. Prime Recipients must show how 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.

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

## **7. INTELLECTUAL PROPERTY AND DATA MANAGEMENT PLANS**

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

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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>) to facilitate and expedite negotiations between Project Team members. ARPA-E does not mandate the use of this template. ARPA-E and DOE do not make any warranty (express or implied) or assume any liability or responsibility for the accuracy, completeness, or usefulness of the template. ARPA-E and DOE strongly encourage Project Teams to consult independent legal counsel before using the template.

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

## **8. U.S. 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.

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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.

## **9. CORPORATE FELONY CONVICTIONS AND FEDERAL TAX LIABILITY**

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

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

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

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## **10. APPLICANT RISK ANALYSIS**

If selected for award negotiations, ARPA-E may evaluate the risks posed by the Applicant using the criteria set forth at 2 CFR §200.206(b)(2). ARPA-E may require special award terms and conditions depending upon results of the risk analysis. As part of the research, technology, and economic security risk review, DOE may contact the applicant and/or proposed project team members for additional information to inform the review.

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

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

## **11. 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. §200.206.

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## 12. NONDISCLOSURE AND CONFIDENTIALITY AGREEMENTS REPRESENTATIONS

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

- (1) **It does not and will not** require its employees or contractors to sign internal nondisclosure or confidentiality agreements or statements prohibiting or otherwise restricting its employees or contractors from lawfully reporting waste, fraud, or abuse to a designated investigative or law enforcement representative of a Federal department or agency authorized to receive such information.
- (2) **It does not and will not** use any Federal funds to implement or enforce any nondisclosure and/or confidentiality policy, form, or agreement it uses unless it contains the following provisions:
  - a. *“These provisions are consistent with and do not supersede, conflict with, or otherwise alter the employee obligations, rights, or liabilities created by existing statute or Executive order relating to (1) classified information, (2) communications to Congress, (3) the reporting to an Inspector General of a violation of any law, rule, or regulation, or mismanagement, a gross waste of funds, an abuse of authority, or a substantial and specific danger to public health or safety, or (4) any other whistleblower protection. The definitions, requirements, obligations, rights, sanctions, and liabilities created by controlling Executive orders and statutory provisions are incorporated into this agreement and are controlling.”*
  - b. The limitation above shall not contravene requirements applicable to Standard Form 312, Form 4414, or any other form issued by a Federal department or agency governing the nondisclosure of classified information.
  - c. Notwithstanding 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.

### **13. INTERIM CONFLICT OF INTEREST POLICY FOR FINANCIAL ASSISTANCE**

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

### **14. 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.

### **15. FRAUD, WASTE, AND ABUSE**

The mission of the DOE Office of Inspector General (OIG) is to strengthen the integrity, economy, and efficiency of the Department's programs and operations, including deterring and detecting fraud, waste, abuse, and mismanagement. The OIG accomplishes this mission primarily through investigations, audits, and inspections of DOE activities to include grants, cooperative agreements, loans, and contracts.

The OIG maintains a hotline for reporting allegations of fraud, waste, abuse, or mismanagement. To report such allegations, please visit <https://www.energy.gov/ig/ig-hotline>.

Prime Recipients and subrecipients must disclose, in a timely manner, in writing to the Federal awarding agency or pass-through entity all violations of Federal criminal law involving fraud, bribery, or gratuity violations potentially affecting the Federal award.

*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](mailto: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](mailto:ExchangeHelp@hq.doe.gov) (with FOA name and number in subject line).*

Prime Recipients and subrecipients are encouraged to allocate sufficient costs in the project budget to cover the costs associated for personnel and data infrastructure needs to support performance management and program evaluation needs, including but not limited to independent program and project audits to mitigate risks for fraud, waste, and abuse.

**C. REPORTING**

[TO BE INSERTED BY FOA MODIFICATION IN MARCH 2024]

## **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](mailto: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](mailto: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](mailto: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](mailto: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.”

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**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.8. 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.8 of this FOA. A copy of the DEC may be found on the DoE website. Pursuant to 37 CFR § 401.4, any Bayh-Dole entity affected by this DEC has the right to appeal it by providing written notice to DOE within 30 working days from the time it receives a copy of the determination.

### **B. GOVERNMENT RIGHTS IN SUBJECT INVENTIONS**

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

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

## **1. GOVERNMENT USE LICENSE**

The U.S. Government retains a nonexclusive, nontransferable, irrevocable, paid-up license to practice or have practiced for or on behalf of the United States any subject invention throughout the world. This license extends to contractors doing work on behalf of the Government.

## **2. MARCH-IN RIGHTS**

The U.S. Government retains march-in rights with respect to all subject inventions. Through “march-in rights,” the Government may require a Prime Recipient or Subrecipient who has elected to retain title to a subject invention (or their assignees or exclusive licensees), to grant a license for use of the invention. In addition, the Government may grant licenses for use of the subject invention when Prime Recipients, Subrecipients, or their assignees and exclusive licensees refuse to do so.

The U.S. Government may exercise its march-in rights if it determines that such action is necessary under any of the four following conditions:

- The owner or licensee has not taken or is not expected to take effective steps to achieve practical application of the invention within a reasonable time;
- The owner or licensee has not taken action to alleviate health or safety needs in a reasonably satisfactory manner;
- The owner has not met public use requirements specified by Federal statutes in a reasonably satisfactory manner; or
- The U.S. Manufacturing requirement has not been met.

## **C. RIGHTS IN TECHNICAL DATA**

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

- Background or “Limited Rights Data”: The U.S. Government will not normally require delivery of technical data developed solely at private expense prior to issuance of an award, except as necessary to monitor technical progress and evaluate the potential of proposed technologies to reach specific technical and cost metrics.
- Generated Data: The U.S. Government normally retains very broad rights in technical data produced under Government financial assistance awards, including the right to distribute to the public. However, pursuant to special statutory authority, certain categories of data generated under ARPA-E awards may be protected from public disclosure for up to for up to ten years (or more, if approved by ARPA-E) in accordance with provisions that will be set forth in the award. In

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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>.

*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](mailto: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](mailto:ExchangeHelp@hq.doe.gov) (with FOA name and number in subject line).*

## **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.

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](mailto: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](mailto:ExchangeHelp@hq.doe.gov) (with FOA name and number in subject line).

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. 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.

**K. COMPLIANCE AUDIT REQUIREMENT**

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

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

## **IX. GLOSSARY**

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

**Application:** The entire submission received by ARPA-E, including the 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.

**For-Profit Organizations (or For-Profit Entities):** Entities organized for-profit that are Large Businesses or Small Businesses as those terms are defined elsewhere in this Glossary.

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

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

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

**Large Business:** Large businesses are entities organized for-profit other than small businesses as defined elsewhere in this Glossary.

**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.

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

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

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

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

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

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**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).