



**U.S. Department of Energy  
Advanced Research Projects Agency – Energy**

**Notice of Intent (NOI)  
DE-FOA-0001078**

**To Issue a Restricted Eligibility Funding Opportunity Announcement for  
Collaborative Grid Testing, Research and Valuation of Advanced Energy Storage Systems**

**Objective:**

ARPA-E intends to promptly issue a restricted-eligibility Funding Opportunity Announcement (FOA) for collaborative electrical power grid testing, research and valuation of advanced energy storage systems. The purpose of the FOA is to fund one or more research collaborations that facilitate rapid commercialization of energy storage systems resulting from ARPA-E funded research efforts. While new grid storage technologies are maturing quickly, their adoption is hindered by a lack of performance and reliability data, and by customers' perceptions of the technologies as unproven. The research collaboration(s) selected through the FOA will address this gap in adoption of new energy storage technologies.

As part of this initiative, ARPA-E Program Director(s) and technical teams will be substantially involved in the resulting research collaborations. Through the FOA, ARPA-E intends to issue one or more awards using Cooperative Agreement instruments.

Due to the technical capabilities necessary to conduct the planned research, ARPA-E has determined, based on market research, that there is a limited number of applicants/applicant teams capable of conducting the planned research (described below). In preparation for issuing the FOA, ARPA-E is issuing this NOI to notify interested potential FOA applicants, including teams, with the technical capabilities identified below.

FOA APPLICATIONS WILL BE BY INVITATION ONLY. IF YOU ARE INTERESTED IN AN INVITATION TO APPLY UNDER THE RESTRICTED-ELIGIBILITY FOA, YOU MUST PROVIDE THE INFORMATION (ANSWERS TO QUESTIONS SPECIFIED) BELOW THROUGH THE PROCESS – AND WITHIN THE TIMELIMIT – SPECIFIED BELOW. ARPA-E WILL THEN DETERMINE ELIGIBLE APPLICANTS TO INVITE TO SUBMIT FOA APPLICATIONS.

THIS IS AN NOI ONLY. THIS NOTICE DOES NOT CONSTITUTE A FUNDING OPPORTUNITY ANNOUNCEMENT (FOA). NO FOA EXISTS AT THIS TIME.

**Background:**

Advanced energy storage will play a key role in the modernization of our nation's electricity grid. While relatively little storage is deployed on today's grid, tomorrow's grid is likely to have widespread energy storage that improves the grid's operating capabilities, ensures high



reliability, enables integration of larger amounts of renewables, allows deferral of infrastructure investments, and provides backup power and grid stabilization during emergencies. In a recent assessment of grid storage<sup>1</sup>, DOE identified four principal challenges to widespread adoption. These challenges include:

1. Development of cost competitive energy storage technology
2. Validation of grid storage technologies' reliability and safety
3. Development of an equitable regulatory environment that enables storage adoption
4. Fostering industry acceptance of new storage technologies

Since 2009, ARPA-E has focused on the first challenge, funding over \$85M in research and development of breakthrough grid storage technologies<sup>2</sup>. These technologies have the potential for very low capital cost (<\$150/kWh), enabling widespread deployment to serve a variety of functions on the grid. Many of the ARPA-E technologies have successfully matured, but most still have not proven their performance, reliability, and safety in real grid applications during extended usage. Without data demonstrating that these systems perform as promised, customers have difficulty estimating the lifecycle costs and operating requirements of these systems, which is essential to establishing the value of energy storage on the grid. Electric utilities, independent power producers (IPPs), and end users are interested in new storage technologies, but they are reluctant to purchase and deploy these systems until there is more comprehensive data about how well they perform in accepted use cases, how long they will last, and whether they can be safely operated for long periods under real-world conditions.

To accelerate commercialization of grid storage technologies, ARPA-E plans to issue the above-referenced FOA, focusing on the second and fourth challenges in the list above. The FOA will fund research that will include evaluation of emerging grid-storage systems through both controlled laboratory testing as well as under real-world conditions on a utility grid or microgrid, with substantial participation from future adopters of energy storage systems. This will help ensure that owners of grid assets have reliable information about the performance characteristics, operating requirements, and life expectancy of emerging grid storage technologies as those systems are developed. **ARPA-E is interested in respondents – including teams - with facilities and expertise to conduct collaborative research described below, with substantial involvement of an ARPA-E Program Director and technical support personnel:**

- A. Assess the value of grid-connected storage devices at a specific location (one or several nodes) on a utility grid or microgrid;
- B. Develop test protocols, backed by economic modeling of real grid operation, based on a diverse set of applications, including (but not limited to) area regulation, renewable ramping support, transmission congestion relief, demand charge management, and energy time shift;

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<sup>1</sup> US DOE's grid storage strategy is outlined in the December 2013 publication *Grid Storage*, available at <http://energy.gov/oe/downloads/grid-energy-storage-december-2013>.

<sup>2</sup> Descriptions of active ARPA-E grid storage projects can be found at <http://arpa-e.energy.gov/?q=projects/search-projects> by selecting Technical Category "Stationary Storage: Grid-Scale Batteries."



- C. Conduct electrochemical testing and materials characterization of advanced energy storage devices;
- D. Conduct extended testing of emerging storage technologies on a microgrid<sup>3</sup> or utility grid; and
- E. Provide an objectively-supported pathway for tested technologies to be procured and deployed by utilities, IPPs, and/or end-users.

ARPA-E is seeking to identify potential FOA applicants (including teams) capable of addressing all of the five areas above. Listed below are 1) specific capabilities necessary to conduct the targeted research, and 2) questions that potential applicants must answer to ARPA-E’s satisfaction to be eligible for invitation to submit a FOA application. ARPA-E will only invite applications from respondents with the necessary capabilities for proposed research and development, as listed in Table 1 below:

**Table 1: Necessary Capabilities for Grid Testing, Research and Valuation**

#	Capability	Description
1	Economic Valuation of Grid Storage	Knowledge of modeling tools needed to assess the value of storage in real applications at a specific location, and access to key datasets (including electricity pricing data for one or more system nodes); capability to forecast electricity prices, to simulate grid/microgrid operations, and to develop algorithms for the operation of grid assets.
2	Test Protocols	Capability to develop test protocols for grid applications, and the ability to validate the technical and operational feasibility of these protocols.
3	Battery Testing and Analysis	Facility and staff to conduct analysis of novel energy storage systems, with past experience in assessing the performance of at least one type of battery or flow battery, including analysis of parameters such as area specific resistance, electrode kinetics, and limiting current values; capability to conduct simultaneous cycling of up to six modest-sized (<250W) battery and flow battery systems continuously using simulated loads for up to 12 months.
4	Grid/Microgrid Testing of Storage Systems	Facility capable of extended testing of storage devices under real-world conditions; specifically, operate a utility grid, or

<sup>3</sup> DOE’s Smart Grid R&D Program defines a microgrid as “a group of interconnected loads and distributed energy resources within clearly defined electrical boundaries that acts as a single controllable entity with respect to the grid. A microgrid can connect and disconnect from the grid to enable it to operate in both grid-connected or island-mode.” 2012 DOE Microgrid Workshop Report, available at <http://energy.gov/oe/articles/2012-microgrid-workshop-summary-released>



		<p>operate a microgrid with the following characteristics:</p> <ul style="list-style-type: none"> <li>• Is consistently energized and serves actual (not simulated) loads of at least 5MW<sub>PEAK</sub></li> <li>• Can operate in both grid-connected and islanded modes (for microgrids only)</li> <li>• Has one or more electrochemical storage devices (&gt;1kW rated power) deployed on the system</li> <li>• Offers a diverse set of distributed energy resources (DER), including at least 10% of nameplate capacity from variable renewables (wind and solar)</li> <li>• Can accommodate integration of up to 4 additional storage devices (1-5kW rated power)<sup>4</sup> and operation of those devices for up to 24 months</li> </ul>
5	Commercial Deployment Pathway	<p>Offer experience in working collaboratively with an owner of grid assets (generator, transmission owner, etc.) in evaluating new grid technologies and transitioning them to commercial use on the electric grid. Respondents must have an existing written agreement with a utility, IPP, or other partner and be able to provide at least one example of an emerging technology (generation, power conversion, transmission control, load control, storage, etc.) that was tested at the respondent’s facility and subsequently deployed on the electric grid.</p>

**QUESTIONS FOR POTENTIAL APPLICANTS (“RESPONDENTS”), AND GUIDELINES FOR SUBMISSION OF ANSWERS:**

In order to be considered for invitation to apply to the planned FOA, respondents must submit answers to the questions below. Responses should be submitted in PDF format to the email address [arpaestoragenoi@hq.doe.gov](mailto:arpaestoragenoi@hq.doe.gov). **The deadline for responses is extended one week to 5:00 PM Eastern Time on February 21, 2014.** ARPA-E will not review or consider responses submitted by other means. Emails should conform to the following guidelines:

- Please insert “Responses for NOI for FOA DE-FOA-0001078” in the subject line of your email, and include your name, organization, email address, and telephone number in the body of your email.
- Please include the following information as part of the response to this NOI:
  - Company/Institution name;
  - Individual contact name and title;

<sup>4</sup> ARPA-E recognizes that many commercial grid applications will require much larger systems than those described here. To minimize system cost, this program will test modest-sized units (1-5kW rated power) in a variety of applications to confirm performance of the devices before they are scaled to commercial capacities.



- Mailing address;
  - Phone number;
  - Email address;
  - Type of company/institution (e.g., university, non-governmental organization, small business, large business, federally funded research and development center (FFRDC), government-owned/government-operated (GOGO); and
  - Area of expertise.
- **QUESTIONS:** Responses must address all of the following questions:

#### **I. Economic Valuation of Grid Storage**

1. What previous work have you (or your team) conducted to assess the value of grid connected storage devices performing one or more applications at a specific location on a utility grid or on a specific microgrid?
2. What models, forecasting methods, and simulation tools were developed or used in this effort?
3. What grid applications were assessed? Did the work include analysis of storage devices that served multiple applications? If so, how did the work address compatibility of revenue streams from a single device?
4. What data was required, and how was it obtained?
5. How were the results validated?

#### **II. Test Protocols**

1. What experience do you (or your team) have in defining grid applications and developing use cases and test protocols for storage on the electric grid?
2. What grid applications were assessed?
3. What data was required, and how was it obtained?
4. How was the technical and operational feasibility of the protocols validated?
5. Have you employed these use cases and test protocols in testing actual storage devices? If so, how did the tested devices perform against the use case requirements (power, energy, ramp rates, dwell times, etc.)?
6. What grid applications are most important for ARPA-E to include in its future program?

#### **III. Battery Testing and Analysis**

1. What experience does your team have in testing the performance and cycle life of electrochemical storage systems, including pack-based batteries and flow batteries?
2. Which battery and flow battery systems have been analyzed and tested in your facility? What type of analysis was performed?
3. What capabilities does your team have to determine fundamental cell or module characteristics such as area specific resistance, electrode kinetics, and limiting current values?
4. What facilities does your team offer for battery and flow battery cycling? (Number of test channels, voltage and current ranges, etc.)
5. What data acquisition and analysis tools do you currently employ for cycling data?

#### **IV. Grid/Microgrid Testing of Storage Systems**



1. What experience does your team have in testing new technologies on a utility grid or microgrid? What specific technologies were tested, and what were the results?
2. Describe the utility grid or microgrid you would utilize in testing storage systems, including:
  - i. What is the size of the system (average and peak load)? What types of loads are served?
  - ii. What generation sources are included on the system? What are the relative capacities of each?
  - iii. For microgrids, is the system consistently energized? Can it be islanded from the utility grid and, if so, how often does this occur? How long can the system operate in islanded mode?
  - iv. What data acquisition, control system, and analysis tools are used for grid operation?
  - v. What storage technologies are already in use on the system? What is the size (power and energy) of the storage device(s)? What applications do the storage devices serve?
  - vi. Where are storage devices located on the system? How are the systems housed (outdoors, indoors, in portable shipping container, etc.)?
  - vii. What modifications would be required for the system to accommodate up to four additional 1kW/4kWh storage devices?
3. Please include a single-line diagram or other high-level depiction of the system to be used for storage testing.

#### **V. Commercial Deployment Pathway**

1. What experience do you (or your team) have in transitioning technologies into commercial use by an electric utility, IPP, or other owner of grid assets?
2. What technologies were transitioned? Who deployed them? Where were they deployed?
3. What key information was required by the customer before the transition occurred? How was the data obtained?
4. What formal partnerships do you (or your team) have with electric utilities, IPPs, or other owners of grid assets?
5. Have your partner(s) already conducted any testing or demonstrations of grid storage systems?
6. Are there specific market or regulatory requirements that make deployment of storage likely for your partner(s) in the near-term?

Responses to this NOI are limited to no more than 10 pages in length (12 point font size), including any graphics, figures, and/or tables, references, etc.

Respondents are strongly encouraged to include preliminary results, data, and figures that describe their potential methodologies.

ARPA-E will use data and other information contained in responses strictly for purposes of evaluation of capabilities. Respondents should not include confidential, proprietary, or privileged information in their responses unless such information is necessary to convey the capabilities of the respondent.



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

The cover sheet of the response 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.

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 of the response 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 containing confidential, proprietary, or privileged information must be clearly marked with double brackets or highlighting.

ARPA-E will not pay for information provided under this notice. No material submitted for review will be returned and there will be no formal or informal debriefing concerning the review of any submitted material. ARPA-E reserves the right to contact a respondent to request clarification or other information relevant to this notice.

For any administrative questions regarding this Notice, please submit the questions in an email to: [ARPA-E-CO@hq.doe.gov](mailto:ARPA-E-CO@hq.doe.gov) (with "NOI for FOA DE-FOA-0001078" in the subject line).