



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

**Request for Information (RFI)  
DE-FOA-0002307 on  
Next Generation Ammonia System Integration Project**

**Objective:**

The chemical process to synthesize ammonia – produced in huge amounts for its vital role in world agriculture – needs mitigation of its substantial negative energy and environmental consequences. To address these consequences, the Advanced Research Projects Agency – Energy (ARPA-E) of the US Department of Energy seeks information that could inform ARPA-E’s potential research and development (R&D) funding of a pre-production, integrated system involving a skid-mounted ammonia synthesis system connected to an intermittent renewable energy source at a production scale of several hundred kg to 1 metric ton of ammonia per day.

For this targeted application, ARPA-E is interested in addressing key challenges of integrating various technologies emerging from the ARPA-E REFUEL program - and related awards from other ARPA-E programs (both prior and ongoing) - that are ready for scaling and would comprise a system for the production of ammonia as described above. Specifically, ARPA-E seeks information about:

- Capabilities and needs of organizations to provide or evaluate such ARPA-E funded technologies (e.g. advanced catalysts for low pressure and temperature synthesis, novel ammonia separation methods, etc.);
- Capabilities and needs of organizations to integrate, build and test the ammonia synthesis system describe above;
- Ability of organizations – on their own, or by forming and leading a consortium of research teams - with investors and private sector partners to advance promising ammonia synthesis and related technologies to market.

The goal is to integrate developed technologies and validate their reliability under variable load and start/stop operations, manufacturability, and favorable economics at scale. Successful integration of ammonia synthesis technologies would establish a path forward to continued private sector development, scaling and deployment of these distributed ammonia synthesis technologies. Ideally, the designed and constructed ammonia synthesis unit would serve as a test site for future improved subsystems for the ammonia synthesis process.

This research effort, if successful, would reduce the energy intensity and carbon emissions of ammonia synthesis and establish a new manufacturing base for energy technology in the U.S.



More detailed information on the background of the technology and competitiveness challenges ARPA-E seeks to address can be found in the [REFUEL FOA](#). The REFUEL program is supporting projects focused on specific components of ammonia synthesis, e.g. improved catalysts or separation technologies, at scales up to 1 kg/day of ammonia. To prove that these technologies are viable, further work is required, including combining individual technologies, testing them at a larger scale, and subjecting them to intermittent power.

This RFI focuses only on integration R&D of promising ammonia-synthesis technologies that ARPA-E has funded for which technology verification and integration at a relevant scale would substantially build upon innovations achieved under the ARPA-E awards. Potential new research would be based upon inventions/technologies resulting from those ARPA-E awards, with the intent to advance the innovation to practical application. Cooperation between existing and former ARPA-E awardees is highly encouraged in responses to this RFI and any subsequent R&D work.

ARPA-E recognizes that new business and research arrangements may be needed to fund larger-scale research than the smaller proof of concept efforts supported under REFUEL. If sufficient interest and capability to integrate and test REFUEL technologies exist, ARPA-E may consider funding a public-private innovation collaboration or consortium to that end. For such a project, ARPA-E would expect significant industry participation, as well as an increased cost share (compared to the 5%-20% cost share typical of ARPA-E awards.)

In addition to greater financial commitments, ARPA-E seeks information that also addresses:

- Requiring substantial US manufacturing of resulting technologies for use/sale worldwide, subject to reasonable waiver requests that may be submitted before, during, or after completion of the pilot effort.
- Forming teams with more diversified professional engineering and management capabilities needed for large projects, in contrast to typical ARPA-E projects that tend to focus heavily on bench-scale research or early, small-scale proof-of-concept prototypes.
- Encouraging engagement with industry stakeholders providing in-kind support to the system integration effort. These stakeholders could be state development agencies, potential customers, investment diligence organizations, project financiers, or others with the ability and interest to facilitate the eventual translation of technology from the bench to commercial scale.

### **Purpose and Need for Information:**

The purpose of this RFI is solely to solicit input for ARPA-E's consideration, and to inform the possible initiation of the next generation ammonia synthesis research described above.

ARPA-E will not provide funding or compensation for any information submitted in response to this RFI, and ARPA-E may use information submitted to this RFI without any attribution to the source. This RFI provides the broader research community with an opportunity to contribute



views and opinions regarding the current state of the art of ammonia synthesis research and development.

**Carefully review the REQUEST FOR INFORMATION GUIDELINES below.** In particular, that the information you provide will be used by ARPA-E solely for program planning, without attribution. **THIS IS A REQUEST FOR INFORMATION ONLY. THIS NOTICE DOES NOT CONSTITUTE A FUNDING OPPORTUNITY ANNOUNCEMENT (FOA). NO FOA EXISTS AT THIS TIME.**

#### **Request for Information Guidelines:**

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 may contact respondents to request clarification or seek additional information relevant to this RFI. All responses provided will be considered, but ARPA-E will not respond to individual submissions or publish publicly a compendium of responses. **Respondents shall not include any information in the response to this RFI that might be considered proprietary or confidential.**

Responses to this RFI should be submitted in PDF format to [ARPA-E-RFI@hq.doe.gov](mailto:ARPA-E-RFI@hq.doe.gov) by **5:00 PM Eastern Time on March 25<sup>th</sup>, 2020**. Emails should conform to the following guidelines:

- Insert “Response to Ammonia RFI 2307 - <your organization name>” in the subject line of your email.
- In the body of your email, include your name, title, organization, type of organization (e.g. university, non-governmental organization, small business, large business, federally funded research and development center (FFRDC), government-owned/government-operated (GOGO), etc.), email address, telephone number, and area of expertise.
- Responses to this RFI are limited to no more than 10 pages in length (12 point font size).

**Responders should provide the following information though a response to each item on the list is not required:**

#### **TECHNICAL INFORMATION**

1. What is the optimal size (kg/day ammonia and related total power and material requirement) for a system validation that would adequately address technical and market risks? Is in-field testing (i.e., on or near agricultural sites or other ammonia consumer) required, and if so, what integration, ruggedness, transportability, and infrastructure requirements does this impose on a test system?
2. Describe the current state of the art in electrolyzer systems (available size, power consumption, reliability, unit cost) that could be provided under commercial terms. Also describe any breakpoints associated with cost.
3. Describe the current state of the art in air separation systems (size, nitrogen purity, power consumption, reliability, unit cost) that could be provided under commercial terms. Also describe any break points associated with cost.
4. Describe what you view as the major technical risks associated with integration of multiple technologies to produce ammonia from air, water and renewable energy?



5. What are the major challenges in industrial production using intermittent power and how can they be overcome? What duty cycles are appropriate for different regions, use cases, or customers? How do these transients affect the performance requirements for the individual components (e.g., ASU, reactor, and separations train)?
6. What are ranges of capacity factors for renewable sources of power? Provide duty cycle details by source and geography.

#### ORGANIZATIONAL INFORMATION

7. Describe your organization's ability to evaluate and integrate different chemical processing technologies (both established and emerging) including access to appropriate manufacturing and/or testing facilities.
8. Describe your organization's ability and experience to perform or supervise the construction of modular, flexible chemical systems.
9. Describe your organization's ability to perform preliminary and detailed design of skid-mounted chemical systems and working with 3<sup>rd</sup> parties as required.
10. Describe your organization's ability to secure a site for field testing of the system. The site should be capable of housing a skid-mounted system that produces ammonia at a rate of up to 1 ton per day from air and water. The site should have access to a source of intermittent renewable energy with enough power to support the target ammonia productivity. Data on power generation daily/seasonal variability should be available for modeling purposes. Experience in ammonia handling is highly desirable.
11. Describe your organization's experience with field testing of new technologies, including securing permits from relevant authorities and managing on-site construction/commissioning, operation and decommissioning.
12. Describe your organization's experience in developing and packaging new technologies, particularly from multiple sources, for licensing.
13. Assess the ability of potential research organizations to secure or provide 30% -50% cost share on a project for the above-described research that may cost up to \$15 million total. It is reasonable to expect that all team members would contribute to the cost share.
14. Describe your organization's plans, if any, for the utilization of ammonia produced from a project of this nature (e.g. use as a fertilizer, generation of heat or electricity). Multiple uses at different scales can be proposed.
15. Describe your organization's experience in managing of multi-partner projects including IP management (e.g. building and running a consortium).

#### Topics not of interest:

ARPA-E is not interested in integrators seeking to deploy established technologies that are already available for license.