Department of Energy (DOE)
Office of Energy Efficiency and Renewable Energy (EERE)

FISCAL YEAR 2019 H2@SCALE FUNDING OPPORTUNITY ANNOUNCEMENT

Funding Opportunity Announcement (FOA) Number: DE-FOA-0002022
FOA Type: Initial
CFDA Number: 81.087

FOA Issue Date:	March 4, 2019
Submission Deadline for Concept Papers:	April 8, 2019 5:00pm ET
Submission Deadline for Full Applications:	May 29, 2019 5:00pm ET
Expected Submission Deadline for Replies to Reviewer Comments:	June 28, 2019 5:00pm ET
Expected Date for EERE Selection Notifications:	August 2019
Expected Timeframe for Award Negotiations:	Fall 2019

- Applicants must submit a Concept Paper by 5:00pm ET on the due date listed above to be eligible to submit a Full Application.

- To apply to this FOA, applicants must register with and submit application materials through EERE Exchange at https://eere-Exchange.energy.gov, EERE's online application portal.

- Applicants must designate primary and backup points-of-contact in EERE Exchange with whom EERE will communicate to conduct award negotiations. If an application is selected for award negotiations, it is not a commitment to issue an award. It is imperative that the applicant/selectee be responsive during award negotiations and meet negotiation deadlines. Failure to do so may result in cancelation of further award negotiations and rescission of the Selection.

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I. Funding Opportunity Description

A. Background and Context

The Office of Energy Efficiency and Renewable Energy (EERE) is issuing, on behalf of the Fuel Cell Technologies Office (FCTO), Funding Opportunity Announcement (FOA) DE-FOA-0002022 entitled "Fiscal Year 2019 H2@Scale Funding Opportunity Announcement."

i. Background and Purpose

Hydrogen is one of the most essential chemical building blocks for many industries worldwide. Today it is primarily used to make ammonia, the key component of fertilizers, and in oil refining. For instance, hydrogen is used to remove sulfur contaminants from petroleum that would otherwise poison the catalytic convertors in our cars. Hydrogen is also needed to produce methanol and other chemicals used in manufacturing polymers, plastics and pharmaceuticals. It's used to hydrogenate oils to make fats, such as in making margarine, and in manufacturing glass, metals, and semiconductor chips.

There are many other applications that can benefit from using hydrogen – as a clean energy fuel, an energy carrier, and as an energy storage medium. One of these emerging applications is transportation.

The average American household spends nearly one fifth of its total family expenditures on transportation, making it the most expensive spending category after housing.[1] Hydrogen is starting to be used in highly efficient, commercially available fuel cell vehicles and several thousand are already on the roads. They can provide consumers with options other than gasoline, while simultaneously offering performance, driving ranges and fueling times comparable to conventional automobiles – all with completely zero pollution from the tailpipe. Hydrogen and fuel cells are also used in forklifts, buses, medium and heavy duty vehicles, stationary fuel cells or backup power, and are starting to be used for marine and rail applications.

In addition to transportation, an emerging opportunity is using hydrogen for largescale energy storage. By splitting water, using renewables such as solar or wind,

[1] U.S. Department of Transportation. Bureau of Transportation Statistics. (2017) *Transportation Economic Trends 2017.* Figure 6-4: Average Individual Household Expenditures (major categories), 2016. https://www.bts.gov/sites/bts.dot.gov/files/docs/browse-statistical-products-and-data/bts-publications/215901/transportation-economic-trends-2017.pdf

hydrogen can be produced and stored for use at later times when the renewable resource is not available. It can also be produced by nuclear plants or other baseload power generators that cannot be turned down easily during spikes in solar or wind generation. In some cases, hydrogen or chemical hydrogen carriers can be used to transport energy instead of building out electric transmission lines.

Over the past 40 years, fuel cell technologies have transitioned from highly specialized space applications to commercially available products. Thousands of fuel cells are already in use in commercial vehicles, forklifts, and backup power units throughout the United States. The global fuel cell market surpassed 650 MW shipped worldwide in 2017, with an annual revenue of approximately $2 billion.[2] Early market applications such as fuel cell forklifts and backup power units are demonstrating commercial viability with over 20,000 systems in the U.S. alone since 2009.[3]

Many of these advances were as a result of DOE's Hydrogen and Fuel Cell Program[4] which helped reduce automotive fuel cell costs by 60% since 2006, reduced platinum content by more than 80%, and quadrupled fuel cell durability.[5] Figure 1 shows historical cost reductions along with increased deployments.

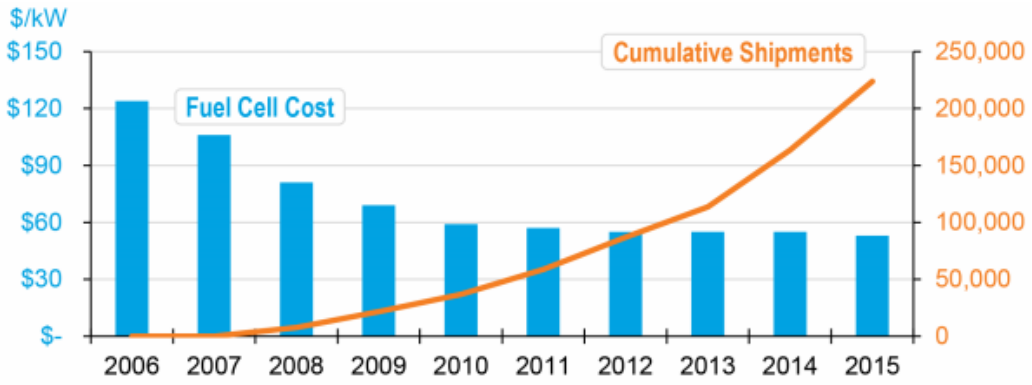

Figure 1. Fuel cell cost reductions based on modeled cost at high volume in nominal dollars and cumulative global fuel cell shipments for stationary, portable, and transportation applications.[6]

[2] https://www.energy.gov/sites/prod/files/2018/10/f57/01_satyapal_plenary_2018_amr_0.pdf
[3] Ibid
[4] The Hydrogen and Fuel Cell Program, which includes the DOE Fuel Cell Technologies Office as well as other offices within DOE, leads an Inter-Agency Working Group which consists of relevant Federal Agencies, including Department of Transportation and Environmental Protection Agency. *See* 42 U.S.C. §16155.
[5] https://www.energy.gov/eere/fuelcells/fuel-cell-technologies-office-accomplishments-and-progress
[6] https://www.energy.gov/sites/prod/files/2016/09/f33/Revolutiona%CC%82%E2%82%ACNow%202016%20Report_2.pdf

In addition to reducing the cost and improving the durability and performance of fuel cells, FCTO funded research and development (R&D) has accelerated technologies for producing, delivering, and storing hydrogen,[7] contributing to:

- Significantly reducing the cost of producing hydrogen from diverse domestic resources through electrolysis: Early stage advancements have reduced the cost of electrolyzers by 80% since 2002;
- Reducing the cost of dispensed hydrogen: Projected costs of hydrogen production, delivery and dispensing for 700 bar fueling (assuming high volume production and widespread deployment) have been reduced to ~$5-7/gasoline gallon equivalent (gge)[8], making it nearly cost competitive with gasoline; and
- Reducing the cost of advanced compressed onboard hydrogen storage systems: High volume cost projection for 700 bar compressed hydrogen storage systems to $15/kWh (a 12% reduction since 2013).

The next steps to increase the value proposition of hydrogen technologies are to expand hydrogen infrastructure, and determine additional applications where hydrogen has a strong business case.

For all these reasons, hydrogen is a part of DOE's all-of-the-above energy portfolio, and can offer options for affordable and secure energy for transportation, as well as for stationary and industrial applications. The United States produces over 10 million metric tons (tonnes) of hydrogen per year, but there are a number of opportunities to increase hydrogen generation and utilization across the country to provide economic growth, energy security, and resilience. Because hydrogen can be produced from diverse domestic resources in many regions across the country *and* used in multiple sectors, or even used for export, studies show the potential for substantial job creation and economic benefit.[9]

This FOA will provide up to $31,000,000 in Federal funding to enable affordable, reliable and secure energy through hydrogen production from diverse domestic resources and utilization across multiple sectors. The FOA focuses on advancing the H2@Scale[10] concept which will enable affordable and reliable largescale hydrogen generation, transport, storage, and utilization in the United States. The H2@Scale concept is based on producing hydrogen when power generation exceeds load, thereby reducing curtailment of renewables and optimizing baseload assets (such as

[7] https://www.energy.gov/sites/prod/files/2017/10/f37/fcto-progress-fact-sheet-august-2017.pdf
[8] The lower heating value of 1 kg of hydrogen is about equal to 1 gallon of gasoline.
[9] The Hydrogen Council estimates that by 2050 global hydrogen utilization at scale may result in up to 30 million jobs and $2.5 trillion in annual revenue: hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-scaling-up-Hydrogen-Council.pdf
[10] https://www.energy.gov/eere/fuelcells/h2-scale

nuclear power), as well as supporting grid stability and resiliency. The hydrogen can be stored, distributed, and/or used as a fuel for transportation, stationary power, process or building heat, and industrial and manufacturing sectors (such as steel manufacturing), creating an additional revenue stream and economic value.

Technologies to produce, deliver, store, and utilize hydrogen need to be more affordable to become mainstream, whether in transportation, stationary power, or industrial applications. This FOA seeks to improve affordability, reliability and performance of hydrogen technologies, through materials and systems innovations, as well as other technological improvements.

ii. Technology Space and Strategic Goals

FCTO focuses on research, development, and innovation projects to advance emerging hydrogen and fuel cell technologies for transportation and diverse applications enabling energy security, resiliency, and a strong domestic economy.[11]

To effectively focus and guide R&D, FCTO has developed market-driven targets for fuel cell cost, storage cost, and the cost of producing, delivering, and dispensing hydrogen (Figure 2). FCTO established these targets with the ultimate goal of enabling affordability competitiveness with existing and other advanced technologies. Costs must be further reduced to achieve these targets.

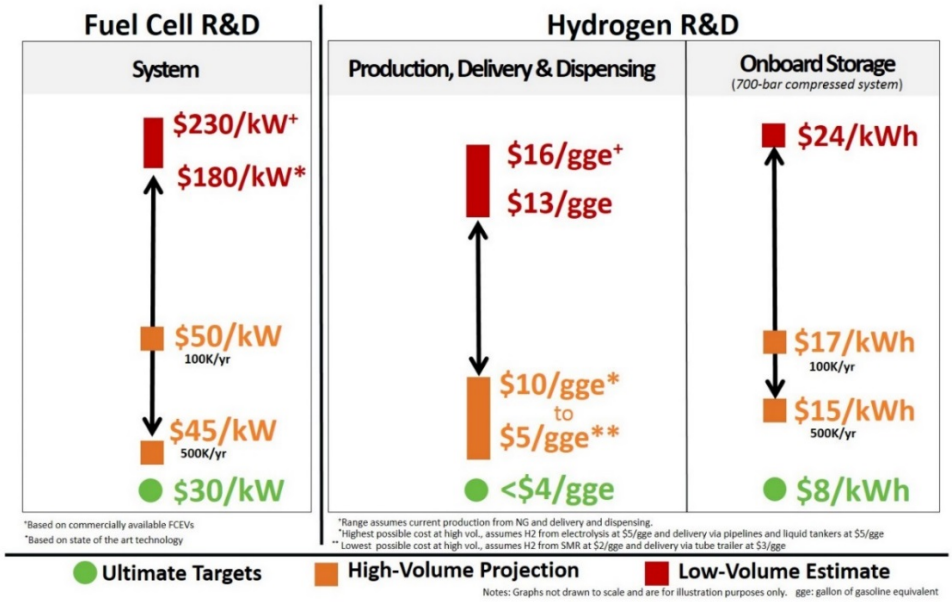

Figure 2 FCTO cost targets for fuel cell system, onboard storage, and hydrogen production, delivery and dispensing (ultimate targets in green; status is a function of technology and volume)

[11] https://energy.gov/eere/fuelcells/about-fuel-cell-technologies-office

The overarching strategy of the FCTO program is based on the versatility of hydrogen. Hydrogen is a unique and flexible energy carrier due to the diversity of domestic options for hydrogen production (including utilization of natural gas, coal, water, biomass, nuclear power, electricity, and direct sunlight) as well as the broad spectrum of industrial end uses, as shown in the H2@Scale vision illustrated in Figure 3. While much of the hydrogen is currently produced from low-cost natural gas, diversifying the approaches available for affordable hydrogen production from domestic feedstocks and energy resources can enhance the long-term resilience of industries to price volatility.

It is important to emphasize that across industrial sectors, H2@Scale should be viewed as an enabler and not a direct competitor to other energy pathways.

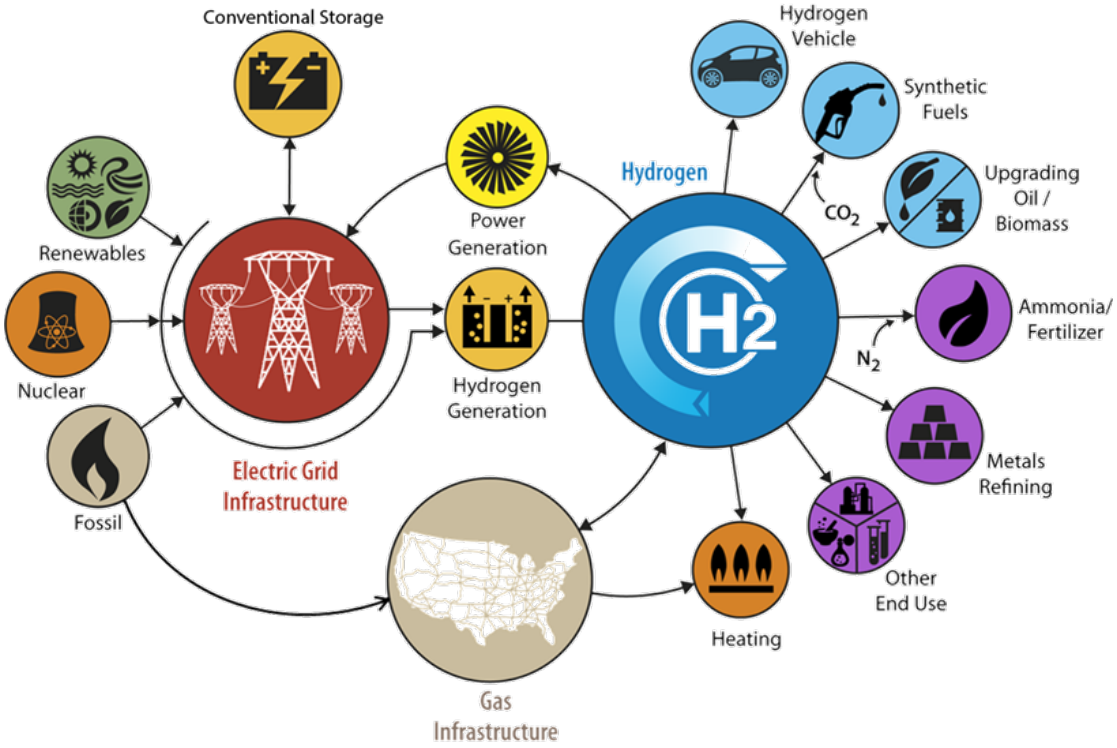

Figure 3 The H2@Scale Vision- Hydrogen can be produced from diverse domestic resources and is a central input to many important end uses in the industrial, chemical and transportation sectors

Significant benefits of H2@Scale include:

- Maintaining leadership in hydrogen technologies, including innovation, manufacturing, and exports.
- Creating domestic jobs in emerging industries, such as hydrogen and fuel cells.

- Using stranded/underutilized domestic energy resources, such as isolated natural gas reserves or remote wind and solar resources, for production of hydrogen and/or chemical hydrogen carriers.
- Reducing the frequency of power curtailment in regions of the country with growing non-dispatchable generation such as wind and solar power.
- Enhancing utilization of baseload power by enabling production of both electricity and hydrogen.
- Diversifying the energy resources available for hydrogen production, thereby freeing domestic resources, such as natural gas, for other applications.
- Supplying growing domestic demands for advanced transportation technologies, stationary power, and low-emission industrial processes.

This FOA solicits early stage H2@Scale-enabling R&D on innovative hydrogen production, storage, and utilization concepts as well as H2@Scale integrated systems prototypes. The pilot demonstration approach will guide future early-stage R&D, and enable viable business cases for increasing asset utilization across the entire energy system from production to end-use.

This FOA targets two Areas of Interest:

- **Area of Interest 1 - Early Stage H2@Scale-Enabling R&D**
  - Topic 1: Advanced Hydrogen Storage and Infrastructure R&D
  - Topic 2: Innovative Concepts for Hydrogen Production and Utilization
- **Area of Interest 2 - H2@Scale Pilot – Integrated Systems**
  - Topic 3: H2@Scale Pilot - Integrated Production, Storage, and Fueling System

EERE will have substantial involvement in work performed under the awards made as a result of this FOA. EERE does not limit its involvement to the administrative requirements of the awards. Instead, EERE will have substantial involvement in the direction and redirection of the technical aspects of the projects. EERE anticipates hands-on participation and involvement in the projects, including those expected to collaborate with lab-based consortia. See Section VI.B.ix, Statement of Substantial Involvement, for more details.

B. Topic Areas

The FOA includes the following Topic Areas:

Topic Number	Topic Area
Topic 1	**Advanced Hydrogen Storage and Infrastructure R&D**
1A	Novel Hydrogen Carrier Development
1B	H-Mat Materials Compatibility Consortium R&D: Hydrogen Effects in Materials for Fueling Infrastructure
Topic 2	**Innovative Concepts for Hydrogen Production and Utilization**
2A	Advanced Water Splitting Materials Research (integrated with HydroGEN Consortium)
2B	Affordable Biological Hydrogen Production from Biomass Resources
2C	Co-production of H_2 and Value-add Byproducts
2D	Reversible Fuel Cell Development and Validation
Topic 3	**H2@Scale Pilot - Integrated Production, Storage, and Fueling System**

Area of Interest 1 - Early Stage H2@Scale-Enabling R&D

Topic 1: Advanced Hydrogen Storage and Infrastructure R&D (up to $9,000,000 Federal funding)

As the use of hydrogen increases across a range of consumer and industrial applications, the performance of materials used in hydrogen storage and infrastructure is becoming more critical. As a result, EERE is interested in supporting early-stage R&D to understand the interaction of hydrogen with materials and to develop improved materials for use in hydrogen-related applications.

The Energy Materials Network (EMN)[12] leverages the world-class capabilities of the DOE national laboratories to accelerate progress in early-stage materials development efforts. FCTO manages the EMN consortia related to hydrogen and fuel cell technologies, and funds national laboratories, universities/non-profits, and companies as part of each consortium. Each EMN consortium has a specific focus area and a core team of national laboratories that provide a range of capabilities. The labs make these capabilities, or "nodes," available to collaborators to accelerate the development of solutions to the materials challenges within their focus area. Projects selected through this topic will collaborate with either 1A) Hydrogen Materials – Advanced Research Consortium (HyMARC), or 1B) Hydrogen Materials

[12] https://www.energy.gov/eere/energy-materials-network/energy-materials-network

(H-Mat[SM]) consortium. Projects under sub-topic 1A will develop materials for use as hydrogen carriers to improve hydrogen storage and transport. Projects under sub-topic 1B will develop improved materials for hydrogen service in infrastructure applications.

Topic 1A: Novel Hydrogen Carrier Development

Topic 1A Introduction/Background

Hydrogen is a versatile energy carrier with roughly three times more energy content by weight than conventional fuels like gasoline, diesel and natural gas. However, the low density of hydrogen (by volume) makes affordable, compact bulk storage and transport of hydrogen a challenge. To meet the goals of the H2@Scale initiative, safe, efficient, and low cost transport and bulk storage of hydrogen is of critical importance. Storage needs may range in duration from daily to seasonal, and transport distances may exceed hundreds of kilometers. Overall cost and efficiency are also critical in determining the viability of pathways for the various hydrogen production, usage, and energy storage options considered within the H2@Scale initiative.

Hydrogen is currently transported and stored as either a compressed gas or a cryogenic liquid. Compressed gaseous hydrogen is transported in tube trailers, typically at pressures in the range of 200 to 500 bar, with payloads in the range of 250 to 1,000 kilograms (kg) of hydrogen. Liquefied hydrogen is transported in trailers equipped with multi-layer vacuum insulated dewars, with payloads that can exceed 4,000 kg of hydrogen.[13]

Gaseous storage of hydrogen requires very large volumes, even when compressed to high pressures, and requires high operating and capital cost due to the need for compression and high-pressure storage vessels. The required storage volume can be further reduced and the energy density increased through liquefaction (density of liquid hydrogen [H_2] is 71 kg/cubic meter [m^3] at 1 bar and 20 Kelvin [K] versus 40 kg/m^3 for compressed H_2 at 700 bar and 288 K). However, hydrogen liquefaction is an energy intensive and expensive process, and long-term liquid hydrogen storage is challenging due to insulation inefficiencies and heat leakage causing boil-off loss of stored hydrogen.

EERE is interested in innovative hydrogen carriers to address the energy density and cost challenges associated with the bulk storage and transport of hydrogen. This activity provides affordable, safe, and accessible fuels for power generation in multiple applications.

[13] https://www.energy.gov/sites/prod/files/2015/08/f25/fcto_myrdd_delivery.pdf

Hydrogen carriers are hydrogen-rich liquid or solid phase materials from which hydrogen can be liberated on-demand. Ideal hydrogen carriers have relatively high hydrogen densities at low pressure and near ambient temperature. Additionally, the formation of the carrier (through the addition of hydrogen) and the release of hydrogen from the carrier should be as energy efficient as possible, thereby minimizing the energy penalty associated with the use of the hydrogen carrier and minimizing the impact on total lifecycle energy.[14]

Hydrogen carriers can be one-way or two-way carriers and either liquid or solid phase materials. One-way carriers are materials for which the discharge of hydrogen results in the formation of a benign byproduct that is released to the environment, for example hydrazine (N_2H_4), which decomposes into hydrogen and nitrogen gases. Two-way carriers are materials that can be cycled between the hydrogenated and dehydrogenated phases, for example methylcyclohexane ($C_6H_{11}CH_3$), which is dehydrogenated to form hydrogen and toluene ($C_6H_5CH_3$). The toluene can then be rehydrogenated back to methylcyclohexane.[15]

A potential liquid-phase hydrogen carrier is formic acid (HCOOH), while solid-phase hydrogen carrier examples include formate salts (HCO_2^-).[16] Formic acid can decompose into hydrogen and carbon dioxide, whereas the formate salts react with water to form hydrogen and a bicarbonate salt (HCO_3^-). Liquid and solid phase hydrogen carriers can have comparative advantages and disadvantages. For instance, liquids may be relatively easy to transfer between vessels (such as a tanker trailer and a stationary storage vessel), whereas solids may offer higher hydrogen capacities by mass and volume and offer advantages for long-term storage.

A study by Argonne National Laboratory (ANL) provides examples on the levelized cost and energy consumption for the use of hydrogen carriers. The project studied three carriers:

- Ammonia as a one-way carrier;
- Methylcyclohexane as a two-way carrier; and
- Methanol as a one-way carrier where it is directly formed from water and natural gas.

[14] https://www.hydrogen.energy.gov/pdfs/17008_levelized_cost_driving_future_icev.pdf
[15] Chiyoda Corporation, "Hydrogen Storage and Transportation System for Large-Scale – "SPERA Hydrogen®" System, https://www.jase-w.eccj.or.jp/technologies/pdf/factory/F-02.pdf
[16] Müller, K., K. Brooks, T. Autrey, "Hydrogen Storage in Formic Acid: A Comparison of Process Options", *Energy Fuels*, 2017, 31(11), pp 12603-12611, DOI: 10.1021/aca.energyfuels.7b02997

The study indicates that, when produced in relatively low capacity plants (sized to deliver 50 tonnes H_2 per day), these three carriers have a 30-46% higher levelized cost of delivered hydrogen and a 38-54% higher energy consumption compared with hydrogen delivered via high pressure tube trailer.[17] This demonstrates that the current state of technology for these carriers is insufficient to meet DOE targets, including $4/gge for hydrogen (produced, delivered, and dispensed at 700 bar).

An analysis of the cost of hydrogen derived from methanol produced in a conventional high capacity (10k tonnes methanol per day) plant, however, shows that the cost is very competitive with tube trailer delivery of compressed hydrogen. These are preliminary results and all of the potential advantages of hydrogen carriers have not been considered. The results do, however, highlight the need to identify hydrogen carriers that have lower energy intensity and lower costs to be competitive with conventional technologies.

FCTO's HyMARC,[18] an EMN consortium, has been expanded to include foundational research investigating hydrogen carriers. This early-stage R&D activity will be an analog to HyMARC's efforts on hydrogen storage materials targeted for onboard vehicular applications. The HyMARC national laboratory team will carry out foundational R&D activities and collaborate with independent projects selected through FOAs, Lab Calls, and Cooperative Research and Development Agreements (CRADAs), to accelerate their material development efforts for hydrogen carriers. EERE is specifically soliciting innovative concepts applicable for off-board storage and transport of hydrogen.

Topic 1A Description/Objective

EERE seeks applications to develop novel hydrogen carriers and/or mechanisms for the (de)hydrogenation of known carriers that have potential to provide advantages over conventional compressed and liquefied hydrogen for bulk storage and transport. One-way and two-way solid and liquid carriers are all of interest. This includes carriers that can be directly generated from renewable resources, including biomass and water, without first having to independently produce hydrogen gas.

EERE is seeking carriers that provide additional benefits, such as the ability to generate high pressure hydrogen directly upon release from the carrier, thus minimizing additional compression needs for automotive refueling. EERE is looking for innovative, early-stage, high-risk, and high-payoff concepts for hydrogen carriers. Applicants are expected to:

[17] https://www.energy.gov/sites/prod/files/2018/10/f56/fcto-infrastructure-workshop-2018-31-ahluwalia.pdf
[18] Hydrogen Materials – Advanced Research Consortium, https://hymarc.org

- Provide a review of the current hydrogen carrier state-of-the-art with a specific comparison to and discussion of additional benefits the proposed materials would provide;
- Consider energy requirements for hydrogen uptake and release from the carriers; and
- Clearly state the materials to be investigated, the key research activities to be addressed, the likelihood of meeting DOE targets,[19] and the research outcomes expected.

Topic 1A Project Structure

Applicants should propose projects up to 3 years in length for a maximum total DOE funding of $1,000,000 per project. The funding request should be commensurate with the level of work proposed. Applicants should plan projects as two or three multi-phase efforts with a quantitative Go/No-Go decision point separating each phase (budget period). Phase 1 should be planned for a maximum of $300,000 and a 12-18 month duration to demonstrate the feasibility of the proposed carrier material concept.

The phase 1 Go/No-Go milestone must show potential to result in a hydrogen carrier capable of outperforming existing bulk storage and transport options such as compressed gas or cryogenic liquid. Projects will need to demonstrate that they have met the agreed upon quantitative performance criteria for the phase 1 Go/No-Go decision before EERE will commit support for additional phases. EERE may also require that samples of materials developed be sent to a third party laboratory specified by EERE for independent material evaluation and testing.

Topic 1A Teaming Arrangements

Selected project teams will be integrated into HyMARC as individual seedling projects and will be expected to collaborate with the core national laboratory teams through their suite of synthetic, computational, and characterization capabilities. This action allows applicants to significantly accelerate progress as opposed to previously selected conventional FOA projects that were not included in the consortium approach.

Each project selected for award must execute the HyMARC standard non-disclosure agreement (NDA).[20] Since these projects will be integrated into HyMARC, the application and proposed work plan should include potential activities that leverage HyMARC's national lab core team capabilities such as synthetic, characterization, or computational activities. The applicant's proposed budget should not include funds

[19] https://www.energy.gov/sites/prod/files/2015/08/f25/fcto_myrdd_delivery.pdf

[20] See https://www.energy.gov/eere/fuelcells/hymarc-hydrogen-materials-advanced-research-consortium for the current draft of the standard NDA required of all awardees selected to work with HyMARC.

associated with the use of HyMARC resources. EERE will directly support national laboratory capabilities. EERE strongly discourages applications that propose duplication of capabilities and efforts already within HyMARC.

Topic 1A Applications Specifically Not of Interest

EERE is not interested in projects addressing hydrogen carrier materials that have already been extensively investigated, including efforts previously funded by EERE or the Advanced Research Projects Agency – Energy (ARPA-E).[21,22] Examples of material development NOT of interest for this topic include: methylcyclohexane[23]; dibenzyltoluene[24]; ammonia[25]; methanol[26]; n-ethylcarbazole[27]; or slurries of ammonia borane or alane.[28]

Topic 1B: H-Mat Materials Compatibility Consortium R&D: Hydrogen Effects in Materials for Fueling Infrastructure

Topic 1B Introduction/Background

When consumers fill up their vehicles with fuel, they expect refueling equipment (e.g., nozzles and hoses) operation to be safe, convenient, and efficient. This topic seeks materials to ensure that hydrogen refueling meets these requirements.

Metals and polymers used as structural materials at hydrogen fueling stations commonly experience high pressures, low temperatures, and/or cyclic loading in hydrogen environments. These routine stresses can cause failure through many mechanisms, including a reduction in decohesion energy in metal lattices,

[21] https://arpa-e.energy.gov/?q=program-projects/REFUEL
[22] https://arpa-e.energy.gov/?q=arpa-e-programs/open-2015
[23] Chiyoda Corporation, "Hydrogen Storage and Transportation System for Large-Scale – "SPERA Hydrogen®" System, https://www.jase-w.eccj.or.jp/technologies/pdf/factory/F-02.pdf
[24] Müller, K., K. Stark, et. al., "Liquid Organic Hydrogen Carriers: Thermophysical and Thermochemical Studies of Benzyl- and Dibenzyl-toluene Derivative", *Ind. Eng. Chem. Res.*, **2015**,54 (32), pp 7967-7976, DOI: 10.1021/acs.iecr.5b01840
[25] Soloviechik, G., "Ammonia as Virtual Hydrogen Carrier", presented at H2@Scale Workshop, Golden, CO, Nov. 16-17, 2016, https://www.energy.gov/sites/prod/files/2016/12/f34/fcto_h2atscale_workshop_soloveichik.pdf
[26] Plass, L., M. Bertau, et. al., "*Methanol as a Hydrogen and Energy Carrier*", in: Bertau, M., H. Offermanns, L. Plass, F. Schmidt, HJ Wernicke (eds.) Methanol: The Basic Chemical and Energy Feedstock of the Future (2014) Springer, Berlin, Heidelberg
[27] Cooper, A., "*Design and Development of New Carbon-based Sorbent Systems for an Effective Containment of Hydrogen*", Final Technical Report, DOE Award No. DE-FC36-04G14006, https://www.osti.gov/biblio/1039432-design-development-new-carbon-based-sorbent-systems-effective-containment-hydrogen , DOI: 10.2172/103432
[28] Brooks, K., E. Rönnebro, et. al., "*PNNL Development and Analysis of Material-Based Hydrogen Storage Systems for the Hydrogen Storage Engineering Center of Excellence*", Final Technical Report No. PNNL-25234 HT0202000, https://www.osti.gov/biblio/1330923-pnnl-development-analysis-material-based-hydrogen-storage-systems-hydrogen-storage-engineering-center-excellence , DOI: 10.2172/1330923

dislocation distribution and phase changes in metals, plasticization of polymers, and void formation and growth in both polymers and metals. These phenomena can reduce component life, or necessitate the use of costly materials to ensure reliability. Materials compatibility R&D is necessary to inform materials selection, and to enable cost-competitive enhancements in the performance of known materials.

DOE launched its H-Mat consortium[29] in FY 2018 to assemble world-class expertise and facilities in materials compatibility R&D at the national laboratories, and leverage these capabilities in priority R&D tasks led by industry and academia. H-Mat has two primary R&D thrusts: 1) hydrogen effects in metals, led by Sandia National Laboratories (SNL), and 2) hydrogen effects in polymers, led by Pacific Northwest National Laboratory (PNNL). Other core national laboratory members of H-Mat include: Oak Ridge National Laboratory (ORNL), Savannah River National Laboratory (SRNL), and ANL.

Capital-intensive metallic equipment at fueling stations includes compressors, storage vessels, and dispensers. Hydrogen compressors currently cost about $700,000 for 35 kg/hour of capacity,[30] and account for at least 24% of unscheduled maintenance hours at fueling station.[31] These components are usually made of a variety of steels and experience fatigue loading in high-pressure (875 bar) hydrogen. Nozzles also experience low temperatures (-40 °C), that can exacerbate hydrogen effects in certain steel alloys due to phase changes or other considerations. Fueling nozzles currently cost approximately $7,000 each (excluding the cost of communications components), and dispenser breakaway valves commonly cost about $3,000.[32]

Many previous R&D efforts have focused on understanding the mechanisms of hydrogen-induced damage in steels and on approaches that mitigate hydrogen effects. Examples include the development of coatings that prevent hydrogen ingress, the engineering of traps that immobilize diffused hydrogen, grain boundary engineering or alloying to stabilize steel, and development of new heat treatments to prevent hydrogen trapping during the manufacturing of steel.

Higher reliability and lower cost polymeric dispensing hoses will improve the viability of fueling stations. Hydrogen dispensing hoses can currently cost over $2,000, and experience dramatic fluctuations in pressure (ambient to 875 bar) and temperature (down to -40°C), which can cause material degradation. Hoses frequently fail within

[29] https://www.energy.gov/eere/fuelcells/fuel-cell-technologies-office-consortia
[30] Hydrogen Delivery Scenario Analysis Model, https://hdsam.es.anl.gov/index.php?content=hdsam
[31] https://www.nrel.gov/hydrogen/assets/images/cdp-infr-21.20180831.jpg
[32] https://www.hydrogen.energy.gov/pdfs/progress17/iii_7_harrison_2017.pdf

several months. Previous R&D efforts have shown that polymers cycling in high pressures and/or hydrogen at cold temperatures can cause both reversible and irreversible damage, including increases in glass transition temperature, increases in compression set, reductions in storage modulus, rapid decompression, and enhanced rates of wear.[33] Properties that influence the durability of these materials include:

- Chemical composition;
- Molecular weight of polymer chains;
- Processing techniques used; and
- Presence of additives, fillers, or plasticizers.

In addition to the challenges mentioned above, characterizing and predicting material behavior in hydrogen commonly requires access to high-pressure test facilities for many weeks at a time, which is an impediment and expensive. Accelerated test methods that can accurately predict behavior under real-world loading conditions, and the development of key metrics that can reliably inform materials selection, could expedite the development and adoption of novel materials.[34,35]

Topic 1B Description/Objective

EERE seeks applicants from industry and academia to lead projects in materials compatibility R&D on hydrogen infrastructure technologies. Applicants must collaborate with the H-Mat consortium to leverage their unique, world-class capabilities in this area.[36] EERE seeks R&D projects that focus on:

- Microstructural engineering of novel low-cost metals to enhance key properties (e.g., tensile strength, fracture toughness, fatigue life, or stability at cold temperatures), enabling their use in hydrogen compressor components, storage vessel components, or dispenser fittings.
- Development of low-cost novel polymers, including polymers with self-healing properties, to enable their use in hydrogen dispensing hoses.
- Development and validation of key metrics that can characterize the suitability of materials performance in hydrogen, thereby expediting the use of novel materials in industry.
- Development and validation of accelerated tests to reduce the cost of experimentation that predicts materials behavior in hydrogen.

[33] https://www.hydrogen.energy.gov/pdfs/review18/scs026_simmons_2018_o.pdf
[34] https://www.energy.gov/sites/prod/files/2014/03/f12/h2_compatible_proceedings.pdf
[35] http://publications.jrc.ec.europa.eu/repository/bitstream/JRC111028/kjna29146enn.pdf
[36] For more information about H-Mat, please see https://www.energy.gov/eere/fuelcells/fuel-cell-technologies-office-consortia. To contact H-Mat's national laboratory leads, please e-mail h-matinfo@pnnl.gov

Applicants are highly encouraged to team with industry participants. Projects developing novel materials should specify the estimated cost of current state-of-the-art materials used in the intended application, describe the degree of cost reduction targeted, and include development and experimental evaluation of novel material coupons by the end of the project. Metallic materials for use in fueling station compressors, dispensers, or storage should target equipment durability of 5 years, 10 years, and 30 years, respectively. Polymeric materials for use in hydrogen dispensing hoses should target operational lives of at least 25,000 cycles, and burst pressures of at least 3,500 bar, for potential compliance with ANSI/CSA HGV 4.2.[37]

Topic 1B Project Structure

Applicants should propose projects up to 3 years in length for a maximum total DOE funding of $2,000,000 per project. The funding request should be commensurate with the level of work proposed. Applicants should plan projects as two or three multi-phase efforts with a quantitative Go/No-Go decision point separating each phase (budget period).

In addition to funding associated with the FOA award ($2,000,000 maximum), each awardee will gain access to H-Mat resources. Applicants must describe how they will collaborate with H-Mat in their proposal; however, proposed budgets should not include funds associated with the use of these H-Mat resources. DOE will provide up to $500,000 per award directly to the national laboratories for the use of H-Mat capabilities.

Topic 1B Teaming Arrangements

Since applicants must partner with H-Mat national laboratories, all team partners for the selected awardees will be required to sign a standard NDA as part of the award negotiation process. [38] Team partners may also be required to sign CRADAs and materials transfer agreements (MTAs) with the national laboratory partners. EERE highly encourages projects to share nonproprietary data with the H-Mat data team for publication in the consortium's online materials database.

Topic 1B Applications Specifically Not of Interest

Applications focusing on development of materials for compressor or dispenser seals are not of interest, as H-Mat and other projects funded by EERE are already addressing these issues.

[37] American National Standards Institute (ANSI)/CSA Group (CSA) HGV 4.2-2013 – Hoses for Compressed Hydrogen Fuel Stations, Dispensers and Vehicle Fuel Systems, 2013 Edition.

[38] See https://www.h2awsm.org/sites/default/files/hydrogen-nda-template-example_0.pdf for an example of a standard NDA used by lab-based consortia.

Topic 2: Innovative Concepts for Hydrogen Production and Utilization (up to $12,000,000 Federal funding)

While much of the nearly 10 million metric tons of hydrogen used in the U.S. today[39] is produced from low-cost natural gas, diversifying and growing the options for affordable hydrogen production from domestic feedstocks and energy resources enhances the long-term resiliency of industries relying on hydrogen. As a result, EERE supports early-stage R&D to address critical challenges and barriers for large-scale hydrogen production using diverse domestic resources.

EERE seeks research in the development of innovative materials, processes, and technologies that enable affordable hydrogen from diverse resources such as solar, wind, water, nuclear, fossil, and biomass. This topic area focuses on the advancement of viable water-splitting technologies for large-scale hydrogen production. The topic also includes reversible fuel cells (RFCs) to increase grid reliability and resiliency, consistent with DOE's Beyond Batteries mission.

For Topics 2A, 2B, and 2C, applicants must clearly summarize the current technological state-of-the-art, including fundamental barriers and promising solutions toward meeting the long-term high-volume hydrogen production cost goal of <$2/gge, supporting the broader FCTO cost target of <$4/gge (untaxed) for hydrogen delivered and dispensed for use in light duty fuel cell vehicles.[40]

Topic 2A: Advanced Water Splitting Materials Research (integrated with HydroGEN Consortium)

Topic 2A Introduction/Background

EERE seeks to advance technologies that produce hydrogen from water using diverse thermal, chemical, and electrochemical processes. Ongoing development and scale-up of these processes relies on continued scientific and technological innovation, including identification and optimization of new low-cost, high-performance materials for energy conversion, heat transfer, separations, and catalysis. EERE encourages early-stage research proposals that effectively leverage the world-class capabilities in materials theory, synthesis and characterization at DOE's HydroGEN consortium.[41]

[39] U.S. Department of Energy Office of Energy Efficiency and Renewable Energy, Fuel Cell Technologies Office Program Record #16015: https://www.hydrogen.energy.gov/pdfs/16015_current_us_h2_production.pdf (accessed 11 November 2018).

[40] Program Record 12001, December 142012, http://www.hydrogen.energy.gov/pdfs/12001_h2_pd_cost_apportionment.pdf

[41] The HydroGEN consortium, established by EERE/FCTO under the DOE's EMN, comprises six core national laboratories: the National Renewable Energy Laboratory (NREL) - lead, SNL, Lawrence Berkeley National Laboratory

EERE is looking for innovative, high-risk, high-reward concepts for advanced water splitting materials in the technology pathways:

- Low temperature electrolysis (LTE)
- High-temperature electrolysis (HTE)
- Photoelectrochemical (PEC) water splitting[42]
- Solar thermochemical hydrogen (STCH) production[43]

Each of these pathways has its own unique materials and integration challenges, but they share common underlying physics and operational principles associated with the water splitting process. EERE expects that leveraging the HydroGEN consortium's staff of leading technical experts and broad collection of resource capabilities will expedite progress in all the water splitting technologies.

Topic 2A Description/Objective

EERE is soliciting applications that will leverage and support HydroGEN's mission in accelerated R&D of advanced water splitting materials. All applications must describe novel research on innovative materials systems relevant to one or more of the four HydroGEN advanced water splitting pathways. Applications must clearly identify the expected impact of its materials innovation in terms of well-articulated and quantitative technology-specific metrics. Outlined below are descriptions of major materials needs and challenges for each of the four water splitting pathways of interest to this topic, along with some example metrics and targets for each pathway.

Low Temperature Electrolysis (LTE)

EERE seeks LTE research projects focused on polymer-based technologies including, for example, alkaline exchange membrane (AEM) and proton exchange membrane (PEM) electrolysis systems. Areas of interest include materials stability/durability of membranes, ionomers, catalysts (including low platinum group metal [PGM] and PGM-free), porous transport layers (especially on the anode side), bipolar plates, and their interfaces when operating under electrochemical half reactions for water splitting.

(LBNL), Idaho National Laboratory (INL), Lawrence Livermore National Laboratory (LLNL), and SRNL. Applicants are encouraged to visit the HydroGEN website: https://www.h2awsm.org/

[42] The Office of Science's Joint Center for Artificial Photosynthesis has led substantial research in PEC hydrogen production since its inception. Many of their accomplishments are now being leveraged by the HydroGEN consortium.

[43] Over 300 STCH cycles have been investigated in the literature to date. In 2011, DOE down-selected 8 cycles to study in detail, and documented their evaluation here: http://energy.gov/sites/prod/files/2014/03/f9/solar_thermo_h2.pdf

EERE encourages applications that will advance the understanding of, and develop mitigation strategies for, degradation mechanisms associated with the effects of temperature, pressure, current density, cell potential, and water purity. Approaches that would be viable in gray/salt water are of particular interest. AEM electrolyzers that can effectively operate on a pure water feedstock (no added salt or base) are also of interest.

Materials selected should have the potential of meeting FCTO's Multi-year Research, Development, and Demonstration (MYRD&D) plan 2025 stack energy efficiency target of 43 kilowatt hours (kWh)/kg-H_2,[44] and achieving a degradation rate of less than 4 millivolt (mV)/1,000 hours. Applications must include quantifiable materials metrics goals and identify how the project will contribute to meeting the broader performance metrics and DOE production cost goals of $2/gge.

High-Temperature Electrolysis (HTE)

EERE seeks HTE research projects focused primarily on improving the durability of efficient high-temperature electrolysis materials. High hydrogen production rates can be obtained at stack electrical efficiencies close to 100% with high-temperature electrolysis technologies[45]; however, there is significant degradation, especially at high current densities. The material set proposed must be relevant to and capable of high performance (1 A/cm^2 at 1.4 V) with a goal of achieving lifetimes of at least 40,000 hours (degradation rates on the order of 4 mV/1,000 hours). Approaches that would be viable in gray/salt water are also of interest.

EERE encourages approaches which integrate materials theory, synthesis, and characterization techniques to develop both a better fundamental understanding of the degradation mechanisms in cell and stack materials and interfaces, as well as materials-based mitigation strategies to address degradation.

Development of accelerated stress tests that have a validated basis for the acceleration factor and the mechanism that it is accelerating are of interest. EERE does not encourage completely independent development of such protocols. Rather, the applicant should coordinate with the ongoing DOE-funded project on developing and validating appropriate protocols.[46] Applications must include quantifiable materials metrics goals and identify how they will contribute to meeting the broader performance metrics and DOE production cost goals of $2/gge.

[44] http://energy.gov/sites/prod/files/2015/06/f23/fcto_myrdd_production.pdf
[45] DOE FCTO Program Record 16014: Hydrogen Production Cost from Solid Oxide Electrolysis: https://www.hydrogen.energy.gov/pdfs/16014_h2_production_cost_solid_oxide_electrolysis.pdf
[46] Benchmarking Advanced Water Splitting Technologies, Proton OnSite: https://www.hydrogen.energy.gov/pdfs/review18/pd170_ayers_2018_o.pdf

Photoelectrochemical (PEC) Water Splitting

EERE seeks research projects focused on the development of materials or material systems for efficient and durable PEC water splitting. Specific areas of interest for this subtopic include innovations in bandgap and bandgap alignment, functional interfaces, and stable surface catalysis. EERE specifically seeks applications that advance the understanding of degradation mechanisms, and develop mitigation strategies, both thermodynamic and kinetic. Projects should include materials discovery, synthesis, and characterization of novel materials with the potential to meet the MYRD&D Ultimate Target of a 25% solar-to-hydrogen conversion efficiency (% STH) for a photoelectrode system or 10% STH for a particle based system.[47]

EERE will only consider materials or material systems with a demonstrable pathway for achieving an interim target of 10% STH for a photoelectrode system or 3% STH for a particle-based system. Further, applications must include quantifiable materials metrics goals (e.g., corrosion resistance and durability, absorber quantum efficiency, or catalyst activity) and identify how the project will contribute to meeting the broader MYRD&D performance metrics and DOE production cost target of $2/gge.[48]

Solar Thermochemical Hydrogen (STCH) Production

EERE seeks materials development for STCH technologies focused on two-step metal oxide cycles, but will also consider sufficiently impactful materials development relevant to the hybrid STCH cycles.[49] Applications should include materials discovery, synthesis, and characterization of novel materials that when incorporated with a feasible reactor design demonstrate significant progress towards the MYRD&D STCH Ultimate Targets of 26% STH and <$2/gge.

Of particular interest are materials and systems with reduction steps at temperatures <1400°C with efficient hydrogen production steps under practical operating conditions of temperature, pressure, steam/H_2 ratios (if applicable), etc. Further, applications must include quantifiable metrics for materials durability such as number of cycles to be demonstrated and maximum acceptable reactivity losses to achieve the MYRD&D cost goals. Enhanced fundamental understanding of material requirements in terms of thermodynamics and kinetics is also of particular interest. This will be key to accelerating materials discovery, development, and engineering high performing water splitting materials.

Topic 2A Project Structure

Applicants should propose projects up to 3 years in length for a maximum total DOE funding of $1,000,000 per project. The funding request should be commensurate

[47] http://energy.gov/sites/prod/files/2015/06/f23/fcto_myrdd_production.pdf
[48] Ibid.
[49] Examples include the hybrid sulfur STCH cycle and the hybrid copper-chloride STCH cycle.

with the level of work proposed. Applicants should plan projects as two or three multi-phase efforts with a quantitative Go/No-Go decision point separating each phase (budget period). Phase 1 should be planned for a maximum of $250,000 federal funding and a 12-18 month duration to demonstrate the feasibility of the proposed material concept.

Projects must satisfy the agreed upon quantitative performance criteria for the phase 1 Go/No-Go decision before DOE will commit support for additional phases. DOE expects that not all of the selected projects will achieve their phase 1 Go/No-Go criteria; a No-Go decision will result in a discontinuation of support beyond phase 1.

Topic 2A Teaming Arrangements

EERE encourages applicants to visit the HydroGEN website to identify consortium nodes that would benefit the project. Successful applicants will work closely with the HydroGEN consortium to leverage the unique node capabilities identified in their applications to facilitate the development of their water splitting materials and systems.

While applications should clearly identify the specific HydroGEN capabilities they would like to utilize, applicants should not include the cost of using HydroGEN nodes in their proposed budget or provide a detailed explanation of the HydroGEN scope of work. DOE will provide access to nodes in HydroGEN at no cost to the selected projects based on award negotiations. EERE encourages applicants to list by priority the HydroGEN nodes they would like to leverage with the understanding that the applicant is to perform the majority of the research effort. Depending on DOE resources and the level of availability of each consortium node, EERE may de-scope or negotiate this list during award negotiation.

Each project selected for award must execute the HydroGEN standard NDA.[50] Consistent with EMN guiding principles, non-proprietary results and data resulting from awards under this topic will be included in a HydroGEN data portal. Additional collaborative activities with HydroGEN will include providing relevant feedback to the consortium's development of best practices and protocols.

Topic 2A Applications Specifically Not of Interest

N/A

[50] The NDA can be reviewed at https://www.h2awsm.org/sites/default/files/hydrogen-nda-template-example_0.pdf

Topic 2B: Affordable Biological Hydrogen Production from Biomass Resources

Topic 2B Introduction/Background

Enabling affordable hydrogen production via microbial biomass conversion directly supports the H2@Scale concept by diversifying the approaches available for affordable hydrogen production from domestic feedstocks and energy resources, specifically biomass and waste streams.

Hydrogen production via microbial conversion technologies utilizing biomass feedstocks (including waste streams) require early stage R&D to determine the potential and feasibility of affordable hydrogen production. Recent analysis shows that the projected cost to produce hydrogen from dark fermentation of biomass (corn stover) using techniques and strains currently in development at the laboratory scale is greater than $50/gge (untaxed, high volume production rates). However, the cost could drop dramatically to less than $6/gge by 2025 if improvements in the technology and high volumes are realized. This will require improvements in the molar yield of the conversion of biomass to hydrogen, along with a substantially higher operating fermentation broth concentration while maintaining reasonable rates, among other advancements, such as integration with microbial-aided electrolysis systems.[51]

Topic 2B Description/Objective

EERE seeks applications for R&D of hydrogen production technologies in the area of microbial biomass conversion demonstrating a pathway to meet the FCTO cost goal for hydrogen production of <$2/gge. EERE is specifically interested in hydrogen production technologies using biomass (including waste streams) through microbial processes such as fermentation or microbial-aided electrolysis or hybrid processes that integrate multiple systems. Areas of emphasis could include, but are not limited to:

- Development of microbial strains or co-cultures with improved hydrogen yields;
- Reactor designs that improve hydrogen production yields or reduce costs at relevant scales;
- Hybrid systems to maximize the hydrogen produced per unit of biomass;
- Technologies that reduce external energy inputs by removing or reducing the need for feedstock heat-treatments or external electricity inputs, etc.; and/or
- Other innovative biological approaches to biomass and/or waste stream conversion.

[51] DOE Hydrogen and Fuel Cells Program Record 16016, Hydrogen Production Cost from Fermentation, http://energy.gov/sites/prod/files/2014/03/f12/appendix_c.pdf

In addition to the requirements defined in section IV, applicants must indicate how the work proposed complements on-going research in this area and advances the state-of-the-art[52,53] towards meeting the hydrogen production cost goal while also meeting the hydrogen purity standards specified in the DOE MYRD&D Plan.[54] Applicants should consider the projected impact of the proposed innovation on hydrogen cost based on available techno-economic and lifecycle assessments and studies. Applicants should base early stage R&D on a sound scientific basis and concentrate on scientific advances that will enable microbial biomass conversion for hydrogen production at relevant scales.

Deliverables of the proposed work must include demonstration of hydrogen production of at least 20 $Liter_{H2}/Liter_{reactor}$/day on average in a system operating for at least 48 hours continuously. Applications should include a pathway (systems analysis deliverable) to a large-scale system, of at least 1,000 kg/day production, along with projected capital and operating expenses.

Topic 2B Project Structure

Applicants should propose projects up to 3 years in length for a maximum total DOE funding of $1,000,000 per project. The funding request should be commensurate with the level of work proposed. Applicants should plan projects as two or three multi-phase efforts with a quantitative Go/No-Go decision point separating each phase (budget period). Each budget period should be 12-18 months long.

Topic 2B Applications Specifically Not of Interest

Pathways specifically not considered in this FOA include biological processes that utilize sunlight energy such as photolytic or photofermentative systems; these applications will be considered nonresponsive.

Topic 2C: Co-production of H_2 and Value-add Byproducts

Topic 2C Introduction/Background

Many thermochemical and electrochemical processes can co-produce hydrogen together with some other value-added products. The examples of such processes include, but are not limited to, industrial ethylene and propylene crackers, chlor-alkalai plants, natural gas pyrolysis to produce carbon black, carbon fibers or

[52] https://www.hydrogen.energy.gov/pdfs/review18/pd038_maness_2018_p.pdf
[53] https://www.hydrogen.energy.gov/pdfs/review18/pd129_liu_2018_p.pdf
[54] http://energy.gov/sites/prod/files/2015/06/f23/fcto_myrdd_production.pdf

chemicals, and co-production of hydrogen and electricity.[55,56] In these processes, sales of the value-added co-product may help reduce the cost of produced hydrogen to below the DOE target of $2/gge. EERE is soliciting R&D to identify and demonstrate industrial processes where low-cost hydrogen may be produced along with another value-added product and to understand their relative market potential and feasibility of low cost hydrogen production.

Topic 2C Description/Objective

EERE seeks applications for R&D of hydrogen production technologies demonstrating the potential to meet the FCTO cost goal of <$2/gge for hydrogen production (excluding delivery, compression, storage and dispensing) in a variety of thermochemical or electrochemical processes where sales of other co-produced chemicals of services can be used to lower the cost of hydrogen. For example, production of hydrogen through pyrolysis of natural gas sales of carbon by-products, such as carbon black, carbon fibers, or aromatic compounds, can help reduce the price of hydrogen. In production of hydrogen from waste water treatment or from municipal waste, the price of providing clean water or waste removal service can reduce the price of hydrogen.

Applications of interest for this topic may range from distributed hydrogen production on a scale of 1,000 kg/day to large centralized plants with production on a scale of 100 tonnes per day. For all cases when considering the market conditions for determining the price of the co-product sales, applicants should assume a technology penetration to production level of at least 1 million tonnes of hydrogen per year (which is on par with the current annual hydrogen use in the U.S. of about 10 million tonnes). Applications must clearly indicate the status of the proposed technology in terms of process feedstock, efficiency, durability, capital costs, hydrogen production rates versus the co-product rate, market price of the co-product or service, and any other relevant factors.

Applications must:

- Present a clear technology and market pathway that projects to meet the FCTO cost goal <$2/gge for hydrogen cost at the total production scale of at least one million tonnes per year, while not saturating the corresponding market for the value-added co-product;
- Demonstrate how sales of the co-product can reduce the cost of hydrogen to below the FCTO cost goal of $2/gge;

[55] An Overview of Natural Gas Conversion Technologies for Co-Production of Hydrogen and Value-Added Solid Carbon Products, November 2017, http://www.pnnl.gov/main/publications/external/technical_reports/PNNL-26726.pdf

[56] https://energy.gov/sites/prod/files/2017/05/f34/fcto_may_2017_h2_scale_wkshp_elgowainy.pdf

- Indicate how the project will reach hydrogen purity standards specified in the DOE MYRD&D plan;
- Identify and account for any costs of hydrogen purification required for meeting the purity standard in the techno-economic analysis; and
- Identify the current key barriers to meeting the cost goal as well as proposed technology innovations for addressing them.

Topic 2C Project Structure

Applicants should propose projects up to 3 years in length for a maximum total DOE funding of $1,000,000 per project. The funding request should be commensurate with the level of work proposed. Applicants should plan projects as two or three multi-phase efforts with a quantitative Go/No-Go decision point separating each phase (budget period). Each budget period should be 12-18 months long.

Topic 2C Applications Specifically Not of Interest

Pathways specifically not of interest for this topic include: 1) thermochemical or electrochemical processes where co-produced hydrogen is simply burned for its heating value; 2) water electrolysis processes where the only co-product is oxygen; and 3) hydrocarbon reforming processes where the only co-product is carbon monoxide or synthesis gas (H_2 and CO mixture).

Topic 2D: Reversible Fuel Cell Development and Validation

Topic 2D Introduction/Background

As a part of DOE's Grid Modernization Initiative (GMI), the Beyond Batteries effort focuses on advances in controllable loads, hybrid systems incorporating generation from all sources, and new approaches to energy storage, which are essential to increasing the reliability and resiliency of our energy systems. FCTO's R&D under the Beyond Batteries effort focuses on reversible fuel cells (RFCs). RFCs are capable of operating in both power production (fuel cell) and energy storage (electrolysis) modes and are a promising way to store large amounts of energy at low cost. RFCs offer a broad range of versatile energy services which can improve the grid's reliability and resiliency. For energy storage applications, RFCs hold promise as an enabler for the increased penetration of intermittent renewable energy technologies on the grid and for better utilization of existing baseload resources.

RFCs can effectively manage both power supply and demand by operating as a fuel cell when there is power demand and operating in electrolysis mode when there is an oversupply of electricity by storing this electrical energy as hydrogen. In electrolysis mode, RFCs (due to a fast, dynamic response capability) can be an effective supplier of ancillary grid services, such as frequency regulation and on

demand ramping/load following. These characteristics contribute to a more flexible, resilient, and reliable grid.

Considering other competing energy storage technologies, RFCs likely will be most competitive for longer duration energy storage (ranging from >8 hours up to seasonal storage). Since the energy conversion functionality of RFCs is decoupled from its energy storage capacity, the electrodes can be sized for rate capability instead of for the duration of storage needed. Simplistically, storing more energy only requires a bigger hydrogen storage tank or going to a higher pressure, which is less expensive than increasing the size of the RFC stack itself. Hydrogen can also be stored in large underground salt caverns, which opens up opportunities for low cost seasonal energy storage.

Topic 2D Description/Objective

EERE seeks applications to advance reversible fuel cell stack technologies and prototype systems. For the purpose of this topic, references to reversible fuel cells are specific to a unitized, single stack (as opposed to separate, discrete fuel cell and electrolyzer stacks) and all development and prototype work must be with a single stack capable of operating in both fuel cell and electrolysis modes. Multiple fuel cell technologies are of interest, including reversible polymer electrolyte membrane, alkaline exchange membrane, and solid oxide fuel cells.

The focus of this topic is not on material and cell component R&D, which was covered in last year's FCTO FOA (DE-FOA-0001874, FY18 Hydrogen and Fuel Cell R&D FOA), but on advancing the technology at the stack and system level. Applicants should organize projects such that the results from the stack and prototype system development and testing work will provide further insight on critical early stage R&D needs for RFCs.

The performance and durability of RFC stacks significantly lag behind that of discrete fuel cell and electrolyzer stacks. Since efficiently performing both fuel cell and electrolyzer functions in a single device can pose significant challenges, EERE seeks novel concepts and approaches for substantially improving stack and system performance characteristics leading to a low levelized cost of storage. For example, applicants could investigate opportunities for optimizing the stack performance for operation in one mode at the expense of the other one from a system and application-specific duty cycle perspective to determine if that could lead to more efficient, cost competitive solutions overall.

RFC stacks and prototype systems proposed should be applicable to large scale energy storage for grid support. This should include identification of representative grid profiles on which they operate, including solar and wind installations. Since the energy storage duty cycle requirements necessitated by the grid profile will impact

RFC operating requirements and stack design, applications should include a discussion on the approach projects will take to define the stack and system operating space based on duty cycle considerations. EERE encourages the participation of a utility provider to ensure relevancy of the energy storage application targeted and as a potential site for carrying out the final RFC system prototype testing.

The Electrical Energy Storage Technologies targets given in the DOE 2015 Quadrennial Technology Review (QTR)[57] can serve as a reference for the range of system level technical targets that the RFC technology will likely need to meet to be competitive with other energy storage technologies. Applications must consider these targets when developing realistic system performance and cost estimates for the first of its kind prototypes that EERE is soliciting here. Opportunities to consolidate balance of plant (BOP) components and simplify the system design with the unitized RFC stack should be considered.

Although proposing a well-defined operating space (including metrics for the RFC stack and system as well as the energy storage duty cycle characteristics) is preferred, EERE understands that it may be necessary to carry out some early analysis efforts in order to better narrow in on a stack/system design that will optimize the RFC performance characteristics for the specific application targeted. At a minimum, projects should target a stack roundtrip efficiency of >50% and should address the potential to meet the near term electrical energy storage targets given in the QTR (including system capital cost by energy and power of <$250/kWh and <$1,750/kW, respectively).

The minimum RFC stack and prototype system of interest for fabrication and validation under this FOA topic is 1 kW. EERE encourages substantially larger systems with higher cost share where that would enable larger scale stack and system fabrication and testing.

The project must:

- Include an RFC prototype that is a complete system instrumented to allow for determination of system level parameters such as roundtrip system efficiency;
- Demonstrate the ability to cycle repeatedly between fuel cell and electrolyzer mode;
- Address and investigate response times to both a fluctuating grid signal and for switching between fuel cell and electrolyzer modes as part of the research; and

[57] Quadrennial Technology Review, Chapter 3: Enabling Modernization of the Electric Power System, page 83, https://www.energy.gov/sites/prod/files/2017/03/f34/qtr-2015-chapter3.pdf

- Address any challenges related to thermal management, specific to high temperature RFCs.

Despite the focus on large scale energy storage applications, EERE will consider other nearer term, high value applications of RFCs, especially if they can show applicability to advancing energy storage-based RFCs. As an example, the need to deliver the hydrogen fuel is a drawback of existing telecommunications backup fuel cell systems. An RFC backup power system where H_2 can be generated onsite by the RFC operating as an electrolyzer on grid electricity would be of interest.

Topic 2D Project Structure

Applicants should propose projects up to 3 years in length for a maximum total DOE funding of $2,000,000 per project. The funding request should be commensurate with the level of work proposed. The projects should be planned as two or three multi-phase efforts with a quantitative Go/No-Go decision point separating each phase (budget period). Each budget period should be 12-18 months long. The work proposed needs to have both RFC stack and prototype system development aspects. The final deliverable should validate a ≥1 kW RFC system prototype meeting the requirements outlined under this FOA topic description. Applicants must clearly identify the status of their proposed technology as it relates to the state-of-the-art and provide sufficient justification that the approach proposed has the potential to lead to a competitive reversible fuel cell solution for the application/market targeted.

Topic 2D Applications Specifically Not of Interest

Applications which have only limited use outside of specialized military applications are not of interest.

Area of Interest 2 - H2@Scale Pilot – Integrated System R&D

The premise of the H2@Scale concept is that large-scale production, delivery, storage, and utilization of hydrogen across sectors can help create the volumes necessary to drive down cost and enable a viable hydrogen infrastructure. Applications that may utilize hydrogen include transportation (e.g., light, medium, and heavy duty vehicles, marine, and rail), energy storage, and industrial uses (e.g., steel manufacturing, petroleum refining, and fertilizer projection).

This first of-its-kind U.S. prototype systems demonstration of an H2@Scale integrated approach can help catalyze viable business cases for increasing asset utilization across the entire energy production to end-use value chain. The effort will serve as a real world laboratory with multi-sector industry-led validation of innovative technologies that will help guide future R&D needs. It will also help identify regulatory barriers and codes and standards that need to be addressed for

ultimate largescale commercial viability. Because the focus is on enabling hydrogen technologies "at scale," EERE encourages regional clusters or corridors that enable economies of scale, rather than disparate, geographically unconnected demonstrations.

Topic 3: H2@Scale Pilot - Integrated Production, Storage, and Fueling System (up to $10,000,000 Federal funding[58])

Topic 3 Introduction/Background

There is little information available on the integration, optimization, and performance evaluation of advanced technologies for a ***complete system*** encompassing hydrogen production, storage, distribution, and utilization to meet consumer needs. EERE solicits industry-led efforts to demonstrate a hydrogen-focused integrated energy production, storage, and transportation fuel distribution/retailing system. Applicants are encouraged to incorporate the use of renewable energy in their demonstrations, as well as nuclear baseload operations and systems optimization R&D. This includes innovative R&D activities integrated into first-of-a-kind demonstrations that assimilate end-to-end elements of the hydrogen fuel pathway (Figure 4). A critical component of the Pilot is verification testing to inform future early-stage R&D.

Figure 4 below includes examples of eligible energy technologies and production pathways, but EERE will consider other innovative concepts not listed in the figure that meet the intent of an integrated approach.

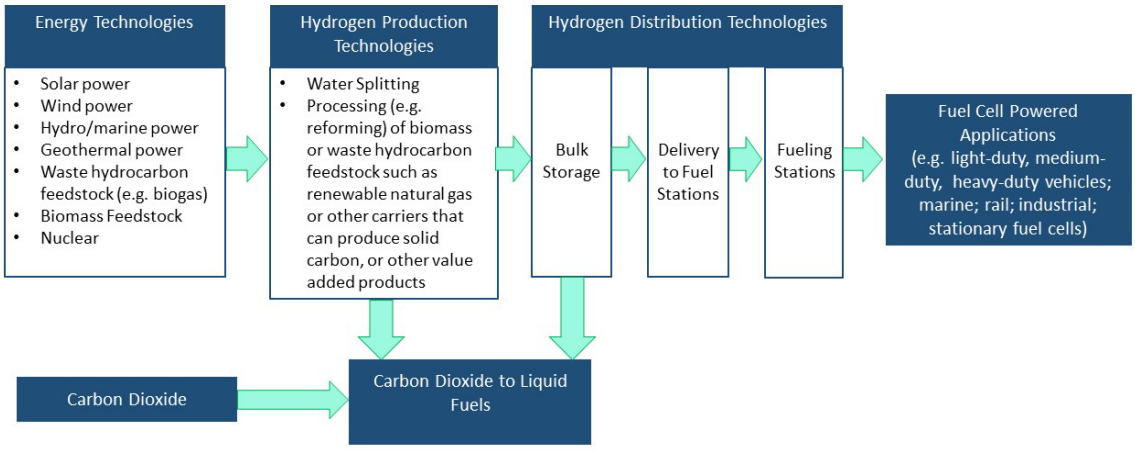

Figure 4 Hydrogen fuel pathway

The use of hydrogen and fuel cells in transportation is currently challenged by high capital costs, insufficient reliability, high energy consumption, and an unacceptably

[58] Does not include up to $7M in additional over-target funding available from other DOE offices, pending applications that use relevant technologies. Detailed information can be found within Topic 3.

large land area requirement. EERE anticipates R&D under this topic area to address these challenges and create an economically viable, uninterruptable supply of hydrogen, available at the point of use and at the required purity levels to meet specifications for various applications.

The topic description below presents some examples of hydrogen systems of interest and key associated research challenges. Any research conducted on individual components must be as part of a project that also addresses the integration of those components into a complete system (see Figure 4), as described above.

Topic 3 Description/Objective

EERE seeks applications to target innovative systems that integrate end-to-end elements of hydrogen production, storage and distribution, and dispensing pathway, as described in Figure 4. Applicants should avoid duplication or deployment of existing commercial integrated systems. Projects may include research to advance pre-commercial technologies (such as dispensing technology, pipelines, and hydrogen carriers) and facilitate their integration within the fuel pathway. Projects may also propose improvements to the overall system, including integration of energy storage or integration with an end-use application such as a datacenter for reliable power, a steel manufacturing plant, or other fuel cell powered applications.

Projects may include the use of multiple advanced technologies while focusing on innovative, efficient and viable *integration* of these technologies with other steps in the hydrogen fuel pathway as described in Figure 4. Examples of advanced technologies include low-temperature electrolyzers, geological storage such as caverns, innovative hydrogen delivery technologies including truck trailer delivery and converted pipeline, reforming of anaerobic digestion gas, and production of value-added co-products such as solid carbon.

Of particular interest are near- and long-term region-specific opportunities to leverage underutilized or economically challenged energy resources including nuclear, solar, wind, geothermal, natural gas, hydro/marine-power, and other resources. These energy resources can be used directly or indirectly to produce large quantities of affordable hydrogen in support of existing and emerging demand sectors.

Systems integration R&D is a key component of the FOA topic and innovative integration R&D and demonstrations are a priority. Examples of possible innovative integrations of technologies include, but are not limited to:

- Integration of large scale electrolyzers and advanced components with renewable power sources, the electricity grid, and/or nuclear energy to

support grid stability and/or leverage intermittent low-cost electricity or heat;
- Integration of components to demonstrate the viability of large scale energy storage using hydrogen, including addressing safety, codes and standards, siting and regulatory issues;
- Innovative strategies and components to increase the scale and improve efficiency of liquefaction plants, as well as improve the efficiency of liquid hydrogen transfer from tankers to bulk storage at fueling stations;
- Dynamic integration of fueling station technologies or components with the grid to leverage intermittently available low-cost electricity and surpass existing technologies in driving affordability, reliability, and performance; and/or
- Integration of multiple regional end users in one demonstration to generate economies of scale that reduce overall hydrogen cost. Examples of end users of interest include, but are not limited to, data centers that utilize megawatt-scale stationary hydrogen fuel cells for backup power, metals plants that use hydrogen as an inert gas for annealing, iron refining processes that use hydrogen as a reductant, other industrial applications, and hydrogen fueling stations for vehicles.

Applicants may also propose other innovative concepts aligned with the topic that enable clear advantages such as lower cost, improved performance, reliability, and efficiency through component/systems integration. Some of these examples are described in the Over-Target Activities section below. The demonstration project should include activities to help validate the R&D performed and to provide feedback to guide future early-stage R&D needs. Concepts should be aligned with the H2@Scale vision where hydrogen is an enabler that can contribute to overall goals for energy security, resilience, and economic growth.

Applicants should clearly describe plans for any applied R&D and for system performance verification testing, explaining the innovation. EERE expects applications to include an economic analysis for the integrated system as a part of the project. EERE strongly encourages applications that propose innovative methods to remove regulatory barriers along the hydrogen production, storage and distribution, and dispensing pathway.

One innovative end use application that is of particular interest to EERE is utilization of reliable power from hydrogen fuel cells to address society's data storage and safeguarding needs. EERE encourages applicants to demonstrate the feasibility of coupling hydrogen and fuel cell technologies to datacenters for primary and backup power applications as a part of the overall integrated system demonstration. An example could be to incorporate DC power electrochemically produced by hydrogen fueled fuel cells either at a single entry point, or alternatively supplying power to the

servers to replace power distribution by a gas distribution system. EERE expects that, if proposed, these activities would showcase innovation. Examples could include fuel cell power-plant architectures that incorporate novel low-cost, highly durable and performing materials and components, gas distribution schemes, and hydrogen storage designs.

In addition, work scope should be included to assess potential cybersecurity threats or vulnerabilities and address cybersecurity challenges, particularly related to grid integrated systems and hydrogen safety.

EERE also encourages applicants to include analysis work in their integration project to assess the business case for the proposed approaches and resource availability (for instance, primary energy resources, water, and storage requirements). The proposed work scope should also include an assessment of the status of both existing and required regulations, codes and standards applicable to H2@Scale. Examples may include siting of nuclear or other plants near large scale hydrogen storage facilities.

In addition, applicants may include activities to assess the status of relevant domestic vs. global hydrogen and fuel cell markets. For example, analysis of total fuel cell units, megawatts by region, and by application with a focus on polymer electrolyte membrane fuel cell systems (automotive and stationary) as well as annual revenues from sales of fuel cells. For global hydrogen markets analyses, EERE encourages applicants to leverage non-DOE resources to provide market data on electrolyzers that generate hydrogen, and on other relevant hydrogen generation systems. Such analysis would provide an indication of the market viability and potential demand for hydrogen at scale, consistent with the H2@Scale vision.

Applicants should quantify how their integrated systems project will advance hydrogen systems over the current baseline, toward the program's target for the delivered cost of hydrogen of $7/gge by 2025 (and ultimate target of $4/gge), at the pump for fueling hydrogen fuel cell vehicles (which use 700 bar hydrogen storage systems). Other cost targets may be applicable depending on end use, such as industrial applications, energy storage or grid services. Applicants should also address how their approaches could achieve a 40% reduction in station footprint from the current baseline by 2022. EERE encourages approaches that reduce the use of land, water, and other resources, and optimize systems based on efficiency, cost, capacity factors, siting requirements, and other aspects, while simultaneously ensuring highly reliable and durable systems and subsystems.

For concepts involving the utilization of carbon dioxide and hydrogen to make higher molecular weight fuels, applicants should clearly state the feedstock gases that the proposed innovations are most compatible with, and the targeted techno-economic

improvements relative to current state-of-the-art. Applicants are also encouraged to explore research already being pursued at other DOE offices, to avoid the proposal of duplicative efforts. Showing how the proposed work complements activities through other DOE offices (e.g., Fossil Energy for carbon dioxide capture, or Bioenergy Technologies Office for use of biological feedstock) but avoids overlap is of value. Additional funding may be available for R&D that targets needs of other DOE offices (see section on Over-Target Activities below).

Successful applicant teams would ideally include stakeholders from diverse industries, and leverage existing research capabilities where they add value in developing and implementing the proposed technologies. Applications should detail:

- Unique or first-of-its kind aspects of the demonstration proposed and how they can advance the H2@Scale concept;
- Manner in which the demonstration performed will inform future R&D as well as regulatory barriers or codes and standards that need to be addressed;
- The potential value proposition, including the proposed approach to match hydrogen demand with supply;
- Any proposed research advancements to cost-competitively enhance the performance and capabilities of integrated hydrogen systems/components (particularly infrastructure reliability and provide uninterruptable services or other advantages across sectors); and
- Proposed engagement and commitment of stakeholders for anticipated work (e.g., utilities, hydrogen providers, OEMs or other end users of hydrogen, state organizations, or other stakeholders).

EERE encourages coordination and leveraging of activities that can enable synergies with renewable energy technologies and nuclear power (e.g., enabling operation of baseload nuclear plants to generate hydrogen or hydrogen related systems integration R&D). DOE's Nuclear Energy office also has an open industry FOA, "U.S. Industry Opportunities for Advanced Nuclear Technology Development FOA Number DE-FOA-0001817," encouraging innovation and competitiveness of the U.S. nuclear industry. The Nuclear Energy FOA supports cost-shared industry identified projects for the integration of nuclear energy into micro-grid, non-electric, and/or hybrid applications, including those related to hydrogen production.

Topic 3 Project Structure

Applicants should propose projects 3 years in length (or more if warranted and justified in the application) for a maximum total DOE funding of $10,000,000 per project. EERE may select 2 projects, subject to availability of funding, particularly if the total cost per project is on the order of $5,000,000, depending on scope and size. The funding request should be commensurate with the level of work proposed.

Projects should be planned as two or three multi-phase efforts with a quantitative annual Go/No-Go decision point separating each phase (budget period).

EERE encourages teams to leverage national laboratory resources (equipment and expertise) as appropriate, accomplishments from other ongoing projects, and funding from external stakeholders. Projects must include a 50% cost share consistent with demonstration activities.

Topic 3 Teaming Arrangements

An effective application will include multi-disciplinary teams across the entire energy production to end-use value chain.

EERE is compiling a Teaming Partner List to facilitate the widest possible national participation in the formation of applicant teams for Topic 3. The list allows organizations who may wish to participate in an application, but do not wish to apply as the Prime applicant, to express their interest to potential applicants and to explore potential partners.

The Teaming Partner List will be available on EERE Exchange at https://eere-Exchange.energy.gov under FOA DE-FOA-0002022 during the time of its release through its closing. The Teaming Partner List will be updated at least weekly until the close of the Full Application period, to reflect new Teaming Partners who have provided their information. Any organization that would like to be included on this list should submit the following information to FCTOFOA@ee.doe.gov, with the subject line “Teaming Partner Information”:

Organization Name, Contact Name, Contact Address, Contact Email, Contact Phone, Organization Type, Area of Technical Expertise, and Brief Description of Capabilities.

By submitting a request to be included on the Teaming Partner List, the requesting organization consents to the publication of the above-referenced information. By facilitating this Teaming Partner List, EERE does not endorse or otherwise evaluate the qualifications of the entities that self-identify themselves for placement on the Teaming Partner List. EERE will not pay for the provision of any information, nor will it compensate any applicants or requesting organizations for the development of such information.

Topic 3 Over-target Activities

In addition to the $10,000,000 in federal funding available from FCTO for R&D activities associated with the Topic Area 3 description above, EERE encourages applicants to propose additional R&D (above the $10,000,000 allocated by FCTO) to meet the following R&D priorities of other DOE offices. Applicants interested in Topic 3 over-target funding must submit a full application for an integrated system

under Topic 3. Applicants must explain how the proposed over-target activities will be integrated into the pilot demonstration project. Topic 3 applications may be selected for funding with or without the proposed over-target activities.

Applications should submit each over-target narrative separately as an appendix to the application technical volume. The narrative should specify the amount requested and address what additional R&D the project would complete if over-target funds are made available for the award. The description should clearly describe the work that would be added to the full application scope, pending availability of funds, so that a final scope can be negotiated once budget availability is known. Funding for over-target activities can be used for national lab or private sector work provided that the overall project meets the cost sharing and eligibility requirements of the FOA. See section III.B.iii for eligibility restrictions for Topic 3. See Section III.C for cost sharing requirements.

Over-target narratives should be no more than 3 pages in length and should complement the primary project work described in the application. A high-level summary of proposed over-target activities should also be included in the Concept Paper.

Multi-fuel Over-Target Activities

The Office of Fossil Energy may make up to $300,000 available for team members proposing R&D to enable multi-fuel pipelines that transport hydrogen along with natural gas. Areas of R&D could include materials compatibility effects, integration of separation technologies in multi-fuel pipelines, and evaluation of technologies that can utilize mixed fuels (e.g., combustion turbines for blends of hydrogen and natural gas). Technology development and demonstration would be integrated with the H2@Scale Pilot project, and coordinated with FCTO.

Wind Over-Target Activities

The Wind Energy Technologies Office (WETO) may make up to $1,000,000 available for team members proposing integration of hydrogen production technologies with wind power plants. For example, projects integrating behind-the-meter systems, developing controls for integration of electrolyzers, and conducting grid system modeling could receive funds through the WETO, coordinated with FCTO. EERE encourages collaboration with the National Wind Technology Center at NREL as well as inclusion of cyber security considerations.

Geothermal Over-Target Activities

The Geothermal Technologies Office may make up to $300,000 available for team members proposing development of novel geographically agnostic storage technologies that leverage advanced drilling techniques and in-situ sensors, as well as high-temperature production technologies that leverage heat from geothermal

systems. Technology development and demonstration would be integrated with the H2@Scale Pilot project, and coordinated with FCTO.

Nuclear Over-Target Activities

The Office of Nuclear Energy (NE) may make up to $2,000,000 available for team members who integrate hydrogen production technologies with nuclear power generation technologies. Demonstrations of interest would include: 1) integration of low-, medium-, or high-temperature hydrogen production with existing light water reactors to support the viability of baseload power, and 2) integration of water splitting with advanced nuclear power generation technologies to enhance their profitability.

Areas of interest include the demonstration of electrical or thermal hydrogen production with nuclear generation and addressing areas such as: a) process flow or thermodynamic modeling, b) development of balance-of-plant equipment (e.g., heat exchangers), or c) management of oxygen generation. NE-funded work scopes must be led by industry and may partner with national laboratories. Regardless of funding source, applications should not duplicate the existing capabilities for high and low temperature electrolysis-nuclear integration.

NE also has an on-going FOA encouraging industry applicants to submit relevant projects. For industry applicants interested in the use of nuclear power as part of a micro-grid, non-electric, and/or hybrid applications, the NE FOA provides an opportunity to leverage NE funding in support of such a demonstration. Any over-target appendix submitted that proposes NE activities should indicate whether or not the applicant has also submitted a proposal in parallel for the NE open FOA. EERE does not encourage fundamental R&D on hydrogen production concepts at early stages of development (technology readiness level [TRL] 3 or below).

Solar Energy Over-Target Activities

The Solar Energy Technologies Office (SETO) may make up to $2,000,000 available for team members who enable integration of hydrogen production technologies with solar power. The primary area of interest is an analysis of a multi-system integrated approach that would result in a value proposition considering the low capacity factor typical for solar installations coupled with electrolyzers. After a completed cost analysis for various scenarios and a go/no go decision point, demonstrations of interest would include: 1) integration of solar power generation with technologies that can mitigate curtailment (e.g., energy storage or use of otherwise curtailed energy to produce high-value products, such as hydrogen), 2) R&D on power electronics to enable integration of electrolysis with power generation, and 3) integration of innovative chemical looping technologies with solar power generation to mitigate curtailment. Other innovative systems integration

development and demonstrate topics that can advance the mission of SETO by incorporating elements of the H2@Scale concept are also of interest.

Advanced Manufacturing Over-Target Activities

The Advanced Manufacturing Office (AMO) may make up to $1,000,000 available for team members who leverage unique capabilities at the national laboratories to reduce the manufacturing costs of components within H2@Scale relevant integrated energy systems. Examples of relevant AMO-funded laboratory capabilities include, but are not limited to: 1) the Rapid Advancement in Process Intensification Deployment Institute, 2) the Manufacturing Demonstration Facility, 3) PowerAmerica, and 4) the Institute for Advanced Composites Manufacturing Innovation. Other examples of AMO-spearheaded activities include roll-to-roll processing and water desalination. Because AMO focuses on cross-cutting R&D, rather than hydrogen or fuel cell specific R&D, the applicants should propose how the specific H2@Scale related topic would also advance the mission of AMO. AMO may fund future integration R&D efforts, such as the use of hydrogen at steel manufacturing plants, subject to appropriations.

Topic 3 Applications Specifically Not of Interest

Concepts that can only generate incremental improvements in existing commercial processes (e.g., Haber Bosch or Fischer-Tropsch) are not of interest.

All work under EERE funding agreements must be performed in the United States. See Section IV.K.iii. and Appendix B.

C. Applications Specifically Not of Interest

The following types of applications will be deemed nonresponsive and will not be reviewed or considered (See Section III.D. of the FOA):

- Applications that fall outside the technical parameters specified in Section I.A and I.B of the FOA
- Applications for proposed technologies that are not based on sound scientific principles (e.g., violates the laws of thermodynamics).
- Topic 1A: EERE is not interested in projects addressing hydrogen carrier materials that have already been extensively investigated, including efforts previously funded by EERE or the Advanced Research Projects Agency – Energy (ARPA-E). Examples of material development NOT of interest for this topic include: methylcyclohexane; dibenzyltoluene; ammonia; methanol; n-ethylcarbazole; or slurries of ammonia borane or alane.
- Topic 1B: Applications focusing on development of materials for compressor or dispenser seals are not of interest, as H-Mat and other projects funded by EERE are already addressing these issues.

- Topic 2B: Pathways specifically not considered in this FOA include biological processes that utilize sunlight energy such as photolytic or photofermentative systems; these applications will be considered nonresponsive.
- Topic 2C: Pathways specifically not of interest for this topic include: 1) thermochemical or electrochemical processes where co-produced hydrogen is simply burned for its heating value; 2) water electrolysis processes where the only co-product is oxygen; and 3) hydrocarbon reforming processes where the only co-product is carbon monoxide or synthesis gas (H_2 and CO mixture).
- Topic 2D: Applications which have only limited use outside of specialized military applications are not of interest.
- Topic 3: Concepts that can only generate incremental improvements in existing commercial processes (e.g., Haber Bosch or Fischer-Tropsch) are not of interest.

Organizations and individuals are encouraged to submit applications that are relevant to DOE's research and development mission in response to formal DOE solicitations. For applications specifically not of interest to this FOA, a process exists for submission of self-generated unsolicited proposals. For further information relating to the process for submitting unsolicited proposals, please visit https://www.eere-pmc.energy.gov/Unsolicited.aspx.

D. Authorizing Statutes

FCTO's programmatic statutory authority and goals are driven by the following legislation:

- Energy Policy Act of 2005 (EPAct 2005) Public Law 109-58, Section 801 et seq.

  Section 805, Activities, of EPAct 2005 states:

  The Secretary of Energy, in partnership with the private sector, shall conduct programs to address -

  6) Development of safe, durable, affordable, and efficient fuel cells, including fuel-flexible fuel cell power systems, improved manufacturing processes, high-temperature membranes, cost-effective fuel processing for natural gas, fuel cell stack and system reliability, low temperature operation, and cold start capability;

  Section 805, Program Goals, of EPAct states:

  3) FUEL CELLS — The goals for fuel cells and their portable, stationary, and transportation applications are to enable -

  A) safe, economical, and environmentally sound hydrogen fuel cells;
  B) fuel cells for light duty and other vehicles; and
  C) other technologies consistent with the Department's plan.

Awards made under this announcement will fall under the purview of 2 Code of Federal Regulation (CFR) Part 200 as amended by 2 CFR Part 910.

II. Award Information

A. Award Overview

i. Estimated Funding

EERE expects to make a total of approximately $31,000,000[59] of federal funding available for new awards under this FOA, subject to the availability of appropriated funds. EERE anticipates making approximately 20 to 30 awards under this FOA. EERE may issue one, multiple, or no awards. Individual awards may vary between $250,000 and $10,000,000.

Table 1: Anticipated Funding and Award Details

Topic Area	Total Funding Level	Anticipated Number of Awards	Max. Federal Funding per Award	Max. Project Duration (years)	Min. Required Non-Federal Cost Share %
Topic 1A: Novel Hydrogen Carrier Development	$ 3M	5-10	$1,000,000 (up to $300,000 for budget period 1)	3	20%
Topic 1B: H-Mat Materials Compatibility Consortium R&D: Hydrogen Effects in Materials for Fueling Infrastructure	$ 6M	3-4	$2,000,000	3	20%
Topic 2A: Advanced Water Splitting Materials Research (integrated with HydroGEN Consortium)	$ 4M	4-8	$1,000,000 (up to $250,000 for budget period 1)	3	20%
Topic 2B: Affordable Biological Hydrogen Production from Biomass Resources	$ 2M	2	$1,000,000	3	20%
Topic 2C: Co-production of H_2 and Value-add Byproducts	$ 2M	2	$1,000,000	3	20%
Topic 2D: Reversible Fuel Cell Development and Validation	$ 4M	2	$ 2,000,000	3	20%
Topic 3: H2@Scale Pilot - Integrated Production, Storage, and Fueling System	$ 10M	1-2	$10,000,000	3	50%
Total:	$ 31M	20-30			

[59] Additional federal funding may be available from other DOE EERE Offices subject to applications that use relevant technologies (e.g. solar, wind, etc.). Federal funding may also be available from the Office of Nuclear Energy if applicants/team member(s) propose the use of technologies relevant to that office (e.g. nuclear power generation for hydrogen production). Other DOE offices may also fund national lab efforts directly to support the industry-led project, separate from the FOA.

EERE may establish more than one budget period for each award and fund only the initial budget period(s). Funding for all budget periods, including the initial budget period, is not guaranteed.

The continuation for additional phases and funding will be contingent on meeting agreed-upon quantitative Go/No-Go criteria for budget period 1. Specifically, projects awarded through Topics 1A and 2A will only be initially funded for a single 12-18 month budget period at a maximum amount of $300,000 and $250,000, respectively.

ii. Period of Performance

EERE anticipates making awards that will run up to 36 months in length, comprised of one or more budget periods. Topic 3 may be more than 3 years if warranted. Project continuation will be contingent upon satisfactory performance and Go/No-Go decision review. At the Go/No-Go decision points, EERE will evaluate project performance, project schedule adherence, meeting milestone objectives, compliance with reporting requirements, and overall contribution to the program goals and objectives. As a result of this evaluation, EERE will make a determination to continue to fund the project, recommend re-direction of work under the project, place a hold on federal funding for the project, or discontinue funding the project.

iii. New Applications Only

EERE will accept only new applications under this FOA. EERE will not consider applications for renewals of existing EERE-funded awards through this FOA.

B. EERE Funding Agreements

Through Cooperative Agreements and other similar agreements, EERE provides financial and other support to projects that have the potential to realize the FOA objectives. EERE does not use such agreements to acquire property or services for the direct benefit or use of the United States Government.

i. Cooperative Agreements

EERE generally uses Cooperative Agreements to provide financial and other support to prime recipients.

Through Cooperative Agreements, EERE provides 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.

EERE has substantial involvement in all projects funded via Cooperative Agreement. See Section VI.B.ix of the FOA for more information on what substantial involvement may involve.

ii. Funding Agreements with Federally Funded Research and Development Center (FFRDCs)

In most cases, FFRDCs are funded independently of the remainder of the Project Team. The FFRDC then executes an agreement with any non-FFRDC Project Team members to arrange work structure, project execution, and any other matters. Regardless of these arrangements, the entity that applied as the prime recipient for the project will remain the prime recipient for the project.

iii. Grants

Although EERE has the authority to provide financial support to prime recipients through Grants, EERE generally does not fund projects through Grants. EERE may fund a limited number of projects through Grants, as appropriate.

III. Eligibility Information

To be considered for substantive evaluation, an applicant's submission must meet the criteria set forth below. If the application does not meet these eligibility requirements, it will be considered ineligible and removed from further evaluation.

A. Eligible Applicants

i. Individuals

U.S. citizens and lawful permanent residents are eligible to apply for funding as a prime recipient or subrecipient.

ii. Domestic Entities

For-profit entities, educational institutions, and nonprofits that are incorporated (or otherwise formed) under the laws of a particular State or territory of the United States and have a physical location for business operations in the United States are eligible to apply for funding as a prime recipient or subrecipient. 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.

State, local, and tribal government entities are eligible to apply for funding as a prime recipient or subrecipient.

DOE/NNSA FFRDCs are eligible to participate as a subrecipient, but are not eligible to apply as a prime recipient.

Non-DOE/NNSA FFRDCs are eligible to participate as a subrecipient, but are not eligible to apply as a prime recipient.

Federal agencies and instrumentalities (other than DOE) are eligible to participate as a subrecipient, but are not eligible to apply as a prime recipient.

iii. Foreign Entities

Foreign entities, whether for-profit or otherwise, are eligible to apply for funding under this FOA. Other than as provided in the "Individuals" or "Domestic Entities" sections above, all prime recipients receiving funding under this FOA must be incorporated (or otherwise formed) under the laws of a State or territory of the United States and have a physical location for business operations in the United States. If a foreign entity applies for funding as a prime recipient, it must designate in the Full Application a subsidiary or affiliate incorporated (or otherwise formed) under the laws of a State or territory of the United States to be the prime recipient. The Full Application must state the nature of the corporate relationship between the foreign entity and domestic subsidiary or affiliate.

Foreign entities may request a waiver of the requirement to designate a subsidiary in the United States as the prime recipient in the Full Application (i.e., a foreign entity may request that it remains the prime recipient on an award). To do so, the applicant must submit an explicit written waiver request in the Full Application. Appendix B lists the necessary information that must be included in a request to waive this requirement. The applicant does not have the right to appeal EERE's decision concerning a waiver request.

In the waiver request, the applicant must demonstrate to the satisfaction of EERE that it would further the purposes of this FOA and is otherwise in the economic interests of the United States to have a foreign entity serve as the prime recipient. EERE may require additional information before considering the waiver request.

A foreign entity may receive funding as a subrecipient.

iv. Incorporated Consortia

Incorporated consortia, which may include domestic and/or foreign entities, are eligible to apply for funding as a prime recipient or subrecipient. For consortia incorporated (or otherwise formed) under the laws of a State or territory of the

United States, please refer to "Domestic Entities" above. For consortia incorporated in foreign countries, please refer to the requirements in "Foreign Entities" above.

Each incorporated consortium must have an internal governance structure and a written set of internal rules. Upon request, the consortium must provide a written description of its internal governance structure and its internal rules to the EERE Contracting Officer.

v. Unincorporated Consortia

Unincorporated Consortia, which may include domestic and foreign entities, must designate one member of the consortium to serve as the prime recipient/consortium representative. The prime recipient/consortium representative must be incorporated (or otherwise formed) under the laws of a State or territory of the United States. The eligibility of the consortium will be determined by the eligibility of the prime recipient/consortium representative under Section III.A. of the FOA.

Upon request, unincorporated consortia must provide the EERE 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 agreement binds the individual consortium members together and should discuss, among other things, 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. Ineligible Applicants

i. DOE/NNSA FFRDCs/National Laboratories FFRDCs (only eligible as subrecipients)

DOE/NNSA FFRDCs/National Laboratories are restricted from applying for funding as a prime recipient. National Laboratories may participate as a subrecipient to the prime applicant, except where they are a core lab in a lab-based consortia (see below).

ii. Core EMN and Lab-based Consortia FFRDC Members

For Topics 1A, 1B, and 2A core FFRDC members of the HyMARC, H-Mat, and HydroGEN consortia are ineligible to apply to their associated FOA topic(s) as

prime or subrecipients. However, core FFRDCs that are core members of a consortium can participate as subrecipients to prime applicants under other consortium topics for which they are not core members (e.g., SRNL is ineligible to apply to Topic 1B and 2A since they are a core member of H-Mat and HydroGEN, but is eligible to apply to Topic 1A). The table below lists the core members of each consortium.

Topic	Consortium	Core FFRDCs that are Ineligible
1A	HyMARC	Sandia National Laboratories, Lawrence Livermore National Laboratory, Lawrence Berkeley National Laboratory, National Renewable Energy Laboratory, Pacific Northwest National Laboratory
1B	H-Mat	Sandia National Laboratories, Pacific Northwest National Laboratory, Oak Ridge National Laboratory, Savannah River National Laboratory, Argonne National Laboratory
2A	HydroGEN	National Renewable Energy Laboratory, Sandia National Laboratories, Lawrence Berkeley National Laboratory, Idaho National Laboratory, Savannah River National Laboratory, Lawrence Livermore National Laboratory

iii. Non-Industry Applicants

Only industry (for-profit) applicants are eligible to apply as prime recipients to Topic 3 in this FOA; however, all entities are eligible to participate as subrecipients.

C. Cost Sharing

The cost share must be at least 20% of the total allowable costs (i.e., the sum of the Government share, including FFRDC costs if applicable, and the recipient share of allowable costs equals the total allowable cost of the project) for research and development projects, and 50% of the total allowable costs for demonstration and commercial application projects, and must come from non-federal sources unless otherwise allowed by law. (See 2 CFR 200.306 and 2 CFR 910.130 for the applicable cost sharing requirements.)

Table 2: Cost Share Requirement by Topic Area

Topic Area	Min. Required Non-Federal Cost Share %
Topics 1 & 2	20%
Topic 3	50%

PLEASE NOTE: Section 108, "Short-Term Cost-Share Pilot Program" of the recently enacted Department of Energy Research and Innovation Act (RIA), Pub. L. 115-246 removes the minimum statutory cost share requirement for Institutions of Higher Education and Non-Profit Organizations for research and development for a two year pilot period. Nevertheless, RIA does not automatically change the cost share requirements as set forth in 2 CFR 910.130 of DOE's financial assistance regulation without first amending the regulation. Therefore, until the regulation is updated and aligned with RIA or a cost share waiver is issued, DOE programs and Contracting Officers must adhere to the cost share requirements as set forth in 2 CFR 910.130 and the FOA.

To assist applicants in calculating proper cost share amounts, EERE has included a cost share information sheet and sample cost share calculation as Appendix A to this FOA.

i. Legal Responsibility

Although the cost share requirement applies to the project as a whole, including work performed by members of the project team other than the prime recipient, the prime recipient is legally responsible for paying the entire cost share. If the funding agreement is terminated prior to the end of the project period, 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 obligation assumed by project team members in subawards or related agreements.

ii. Cost Share Allocation

Each project team is free to determine how best to allocate the cost share requirement among the team members. 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.

iii. Cost Share Types and Allowability

Every cost share contribution must be allowable under the applicable federal cost principles, as described in Section IV.J.1 of the FOA. In addition, cost share must be verifiable upon submission of the Full Application.

Project teams may provide cost share in the form of cash or in-kind contributions. Cost share may be provided by the prime recipient, subrecipients, or third parties (entities that do not have a role in performing the scope of work). Vendors/contractors may not provide cost share. Any partial donation of goods or services is considered a discount and is not allowable.

Cash contributions include, but are not limited to: personnel costs, fringe costs, supply and equipment costs, indirect costs and other direct costs.

In-kind contributions are those where a value of the contribution can be readily determined, verified and justified but where no actual cash is transacted in securing the good or service comprising the contribution. Allowable in-kind contributions include, but are not limited to: the donation of volunteer time or the donation of space or use of equipment.

Project teams may use funding or property received from state or local governments to meet the cost share requirement, so long as the funding 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 including, but not limited to:

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

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. As all sources of cost share are considered part of total project cost, the cost share dollars will be scrutinized under the same federal regulations as federal dollars to 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 are encouraged to refer to 2 CFR 200.306 as amended by 2 CFR 910.130 for additional guidance on cost sharing.

iv. Cost Share Contributions by FFRDCs

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 another non-federal source.

v. Cost Share Verification

Applicants are required to provide written assurance of their proposed cost share contributions in their Full Applications.

Upon selection for award negotiations, applicants are required to provide additional information and documentation regarding their cost share contributions. Please refer to Appendix A of the FOA.

vi. Cost Share Payment

EERE requires prime recipients to contribute the cost share amount incrementally over the life of the award. Specifically, the prime recipient's cost share for each billing period must always reflect the overall cost share ratio negotiated by the parties (i.e., the total amount of cost sharing on each invoice when considered cumulatively with previous invoices must reflect, at a minimum, the cost sharing percentage negotiated). As FFRDC funding will be provided directly to the FFRDC(s) by DOE, prime recipients will be required to provide project cost share at a percentage commensurate with the FFRDC costs, on a budget period basis, resulting in a higher interim invoicing cost share ratio than the total award ratio.

In limited circumstances, and where it is in the government's interest, the EERE Contracting Officer may approve a request by the prime recipient to meet its cost share requirements on a less frequent basis, such as monthly or quarterly. Regardless of the interval requested, the prime recipient must be up-to-date on cost share at each interval. Such requests must be sent to the Contracting Officer during award negotiations and include the following information: (1) a detailed justification for the request; (2) a proposed schedule of payments, including amounts and dates; (3) a written commitment to meet that schedule; and (4) such evidence as necessary to demonstrate that the prime recipient has

complied with its cost share obligations to date. The Contracting Officer must approve all such requests before they go into effect.

D. Compliance Criteria

Concept Papers, Full Applications and Replies to Reviewer Comments must meet all compliance criteria listed below or they will be considered noncompliant. EERE will not review or consider noncompliant submissions, including Concept Papers, Full Applications, and Replies to Reviewer Comments that were: submitted through means other than EERE Exchange; submitted after the applicable deadline; and/or submitted incomplete. EERE will not extend the submission deadline for applicants that fail to submit required information due to server/connection congestion.

i. Compliance Criteria

1. *Concept Papers*
Concept Papers are deemed compliant if:

- The Concept Paper complies with the content and form requirements in Section IV.C. of the FOA; and
- The applicant successfully uploaded all required documents and clicked the "Submit" button in EERE Exchange by the deadline stated in this FOA.

2. *Full Applications*
Full Applications are deemed compliant if:

- The applicant submitted a compliant Concept Paper;
- The Full Application complies with the content and form requirements in Section IV.D. of the FOA; and
- The applicant successfully uploaded all required documents and clicked the "Submit" button in EERE Exchange by the deadline stated in the FOA.

3. *Replies to Reviewer Comments*
Replies to Reviewer Comments are deemed compliant if:

- The Reply to Reviewer Comments complies with the content and form requirements in Section IV.E. of the FOA; and
- The applicant successfully uploaded all required documents to EERE Exchange by the deadline stated in the FOA.

E. Responsiveness Criteria

All "Applications Specifically Not of Interest," as described in Section I.C. of the FOA, are deemed nonresponsive and are not reviewed or considered.

F. Other Eligibility Requirements

i. Requirements for DOE/NNSA and non-DOE/NNSA Federally Funded Research and Development Centers Included as a Subrecipient

DOE/NNSA and non-DOE/NNSA FFRDCs may be proposed as a subrecipient on another entity's application subject to the following guidelines:

1. *Authorization for non-DOE/NNSA FFRDCs*
The federal agency sponsoring the FFRDC must authorize in writing the use of the FFRDC on the proposed project and this authorization must be submitted with the application. The use of a FFRDC must be consistent with its authority under its award.

2. *Authorization for DOE/NNSA FFRDCs*
The cognizant Contracting Officer for the FFRDC must authorize in writing the use of the FFRDC on the proposed project and this authorization must be submitted with the application. The following wording is acceptable for this authorization:

Authorization is granted for the Laboratory to participate in the proposed project. The work proposed for the laboratory is consistent with or complementary to the missions of the laboratory, and will not adversely impact execution of the DOE assigned programs at the laboratory.

3. *Value/Funding*
The value of and funding for the FFRDC portion of the work will not normally be included in the award to a successful applicant. Usually, DOE will fund a DOE/NNSA FFRDC contractor through the DOE field work proposal (WP) system and non-DOE/NNSA FFRDC through an interagency agreement with the sponsoring agency.

4. *Cost Share*
Although the FFRDC portion of the work is usually excluded from the award to a successful applicant, the applicant's cost share requirement will be based on the total cost of the project, including the applicant's, the subrecipient's, and the FFRDC's portions of the project.

5. *Responsibility*
The prime recipient will be 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 the FFRDC contractor.

6. *Limit on FFRDC Effort*
   The scope of work to be performed by the FFRDC may not be more significant than the scope of work to be performed by the applicant.

G. Limitation on Number of Concept Papers and Full Applications Eligible for Review

An entity may submit more than one Concept Paper and Full Application to this FOA, provided that each application describes a unique, scientifically distinct project and provided that an eligible Concept Paper was submitted for each Full Application.

H. Questions Regarding Eligibility

EERE will not make eligibility determinations for potential applicants prior to the date on which applications to this FOA must be submitted. The decision whether to submit an application in response to this FOA lies solely with the applicant.

IV. Application and Submission Information

A. Application Process

The application process will include two phases: a Concept Paper phase and a Full Application phase. **Only applicants who have submitted an eligible Concept Paper will be eligible to submit a Full Application**. At each phase, EERE performs an initial eligibility review of the applicant submissions to determine whether they meet the eligibility requirements of Section III of the FOA. EERE will not review or consider submissions that do not meet the eligibility requirements of Section III. All submissions must conform to the following form and content requirements, including maximum page lengths (described below) and must be submitted via EERE Exchange at https://eere-exchange.energy.gov/, unless specifically stated otherwise. **EERE will not review or consider submissions submitted through means other than EERE Exchange, submissions submitted after the applicable deadline, or incomplete submissions**. EERE will not extend deadlines for applicants who fail to submit required information and documents due to server/connection congestion.

A **Control Number** will be issued when an applicant begins the EERE Exchange application process. This control number must be included with all application documents, as described below.

The Concept Paper, Full Application, and Reply to Reviewer Comments must conform to the following requirements:

- Each must be submitted in Adobe PDF format unless stated otherwise;
- Each must be written in English;
- All pages must be formatted to fit on 8.5 x 11 inch paper with margins not less than one inch on every side. Use Times New Roman typeface, a black font color, and a font size of 12 point or larger (except in figures or tables, which may be 10 point font). A symbol font may be used to insert Greek letters or special characters, but the font size requirement still applies. References must be included as footnotes or endnotes in a font size of 10 or larger. Footnotes and endnotes are counted toward the maximum page requirement;
- The Control Number must be prominently displayed on the upper right corner of the header of every page. Page numbers must be included in the footer of every page; and
- Each submission must not exceed the specified maximum page limit, including cover page, charts, graphs, maps, and photographs when printed using the formatting requirements set forth above and single spaced. If applicants exceed the maximum page lengths indicated below, EERE will review only the authorized number of pages and disregard any additional pages.

Applicants are responsible for meeting each submission deadline. **Applicants are strongly encouraged to submit their Concept Papers and Full 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, Full Application, or Reply to Reviewer Comments. Once the Concept Paper, Full Application, or Reply to Reviewer Comments is submitted in EERE Exchange, applicants may revise or update that submission until the expiration of the applicable deadline. If changes are made to any of these documents, the applicant must resubmit the Concept Paper, Full Application, or Reply to Reviewer Comments before the applicable deadline.

EERE urges applicants to carefully review their Concept Papers, and Full Applications and to allow sufficient time for the submission of required information and documents. All Full Applications that pass the initial eligibility review will undergo comprehensive technical merit review according to the criteria identified in Section V.A.ii. of the FOA.

i. Additional Information on EERE Exchange

EERE Exchange is designed to enforce the deadlines specified in this FOA. The "Apply" and "Submit" buttons will automatically disable at the defined submission deadlines. Should applicants experience problems with EERE Exchange, the following information may be helpful.

Applicants that experience issues with submission PRIOR to the FOA deadline: In the event that an applicant experiences technical difficulties with a submission, the applicant should contact the EERE Exchange helpdesk for assistance (EERE-ExchangeSupport@hq.doe.gov). The EERE Exchange helpdesk and/or the EERE Exchange system administrators will assist applicants in resolving issues.

Applicants that experience issues with submissions that result in late submissions: In the event that an applicant experiences technical difficulties so severe that they are unable to submit their application by the deadline, the applicant should contact the EERE Exchange helpdesk for assistance (EERE-ExchangeSupport@hq.doe.gov). The EERE Exchange helpdesk and/or the EERE Exchange system administrators will assist the applicant in resolving all issues (including finalizing submission on behalf of and with the applicant's concurrence). Please note, network traffic is at its heaviest during the final hours and minutes prior to submittal deadline. Applicants who experience this during the final hours or minutes and are unsuccessful in uploading documents will not be able to use this process.

B. Application Forms

The application forms and instructions are available on EERE Exchange. To access these materials, go to https://eere-Exchange.energy.gov and select the appropriate funding opportunity number.

Note: The maximum file size that can be uploaded to the EERE Exchange website is 10MB. Files in excess of 10MB cannot be uploaded, and hence cannot be submitted for review. If a file exceeds 10MB but is still within the maximum page limit specified in the FOA, it must be broken into parts and denoted to that effect. For example:
ControlNumber_LeadOrganization_Project_Part_1
ControlNumber_LeadOrganization_Project_Part_2

C. Content and Form of the Concept Paper

To be eligible to submit a Full Application, applicants must submit a Concept Paper by the specified due date and time.

i. Concept Paper Content Requirements

EERE will not review or consider ineligible Concept Papers (see Section III of the FOA).

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

The Concept Paper must conform to the following content requirements:

Section	Page Limit	Description
Cover Page	1 page maximum	The cover page should include the project title, the specific FOA Topic Area being addressed (if applicable), both the technical and business points of contact, names of all team member organizations, and any statements regarding confidentiality.
Technical Description and Impacts	3 pages maximum	Applicants are required to describe succinctly: • The proposed technology, including its basic operating principles and how it is unique and innovative; • The proposed technology's target level of performance (applicants should provide technical data or other support to show how the proposed target could be met); • The current state-of-the-art in the relevant field and application, including key shortcomings, limitations, and challenges; • How the proposed technology will overcome the shortcomings, limitations, and challenges in the relevant field and application; • The potential impact that the proposed project would have on the relevant field and application; • The key technical risks/issues associated with the proposed technology development plan; and • The impact that EERE funding would have on the proposed project.
Addendum	1 page maximum	Applicants are required to describe succinctly the qualifications, experience, and capabilities of the proposed Project Team, including: • Whether the Principal Investigator (PI) and Project Team have the skill and expertise needed to successfully execute the project plan; • Whether the applicant has prior experience which demonstrates an ability to perform tasks of similar risk and complexity; • Whether the applicant has worked together with its teaming partners on prior projects or programs; and • Whether the applicant has adequate access to equipment and facilities necessary to accomplish the effort and/or clearly explain how it intends to obtain access to the necessary equipment and facilities. Applicants may provide graphs, charts, or other data to supplement their Technology Description.

EERE makes an independent assessment of each Concept Paper based on the criteria in Section V.A.i. of the FOA. EERE will encourage a subset of applicants to submit Full Applications. Other applicants will be discouraged from submitting a Full Application. An applicant who receives a "discouraged" notification may still submit a Full Application. EERE will review all eligible Full Applications. However, by discouraging the submission of a Full Application, EERE intends to convey its lack of programmatic interest in the proposed project in an effort to save the applicant the time and expense of preparing an application that is unlikely to be selected for award negotiations.

EERE may include general comments provided from reviewers on an applicant's Concept Paper in the encourage/discourage notification posted on EERE Exchange at the close of that phase.

D. Content and Form of the Full Application

Applicants must submit a Full Application by the specified due date and time to be considered for funding under this FOA. Applicants must complete the following application forms found on the EERE Exchange website at https://eere-Exchange.energy.gov/, in accordance with the instructions.

Applicants will have approximately 30 days from receipt of the Concept Paper Encourage/Discourage notification on EERE Exchange to prepare and submit a Full Application. Regardless of the date the applicant receives the Encourage/Discourage notification, the submission deadline for the Full Application remains the date and time stated on the FOA cover page.

All Full Application documents must be marked with the Control Number issued to the applicant. Applicants will receive a control number upon clicking the "Create Concept Paper" button in EERE Exchange, and should include that control number in the file name of their Full Application submission (i.e., *Control number_Applicant Name_Full Application*).

i. Full Application Content Requirements

EERE will not review or consider ineligible Full Applications (see Section III. of the FOA).

Each Full Application shall be limited to a single concept or technology. Unrelated concepts and technologies shall not be consolidated in a single Full Application. Full Applications must conform to the following requirements:

Submission	Components	File Name
Full Application (PDF, unless stated otherwise)	Technical Volume (PDF format. See Chart in Section IV.D.ii.)	ControlNumber_LeadOrganization_TechnicalVolume
	Statement of Project Objectives (SOPO) (Microsoft Word format. 10 page limit)	ControlNumber_LeadOrganization_SOPO
	SF-424 Application for Federal Assistance (PDF format)	ControlNumber_LeadOrganization_App424
	Budget Justification (Microsoft Excel format. Applicants must use the template available in EERE Exchange)	ControlNumber_LeadOrganization_Budget_Justification
	Summary for Public Release (PDF format. 1 page limit)	ControlNumber_LeadOrganization_Summary
	Summary Slide (Microsoft PowerPoint format. 1 page limit)	ControlNumber_LeadOrganization_Slide
	Subrecipient Budget Justification, if applicable (Microsoft Excel format. Applicants must use the template available in EERE Exchange)	ControlNumber_LeadOrganization_Subrecipient_Budget_Justification
	DOE WP for FFRDC, if applicable (PDF format. See DOE O 412.1A, Attachment 3)	ControlNumber_LeadOrganization_WP
	Authorization from cognizant Contracting Officer for FFRDC, if applicable (PDF format)	ControlNumber_LeadOrganization_FFRDCAuth
	SF-LLL Disclosure of Lobbying Activities, required for the Prime Applicant and all Subrecipients (PDF format)	ControlNumber_LeadOrganization_SF-LLL
	Foreign Entity and Performance of Work in the United States waiver requests, if applicable (PDF format)	ControlNumber_LeadOrganization_Waiver
	U.S. Manufacturing Plan (PDF format)	ControlNumber_LeadOrganization_USMP

Note: The maximum file size that can be uploaded to the EERE Exchange website is 10MB. Files in excess of 10MB cannot be uploaded, and hence cannot be submitted for review. If a file exceeds 10MB but is still within the maximum page limit specified in the FOA it must be broken into parts and denoted to that effect. For example:

ControlNumber_LeadOrganization_TechnicalVolume_Part_1
ControlNumber_LeadOrganization_TechnicalVolume_Part_2

EERE will not accept late submissions that resulted from technical difficulties due to uploading files that exceed 10MB.

EERE provides detailed guidance on the content and form of each component below.

ii. Technical Volume

The Technical Volume must be submitted in Adobe PDF format. The Technical Volume must conform to the following content and form requirements, including maximum page lengths. If applicants exceed the maximum page lengths indicated below, EERE will review only the authorized number of pages and disregard any additional pages. This volume must address the Merit Review Criteria as discussed in Section V.A.ii. of the FOA. Save the Technical Volume in a single PDF file using the following convention for the title: "ControlNumber_LeadOrganization_TechnicalVolume".

Applicants must provide sufficient citations and references to the primary research literature to justify the claims and approaches made in the Technical Volume. However, EERE and reviewers are under no obligation to review cited sources.

The Technical Volume to the Full Application may not be more than 15 pages for Topics 1 and 2; 25 pages for Topic 3, including the cover page, table of contents, and all citations, charts, graphs, maps, photos, or other graphics, and must include all of the information in the table below. The applicant should consider the weighting of each of the evaluation criteria (see Section V.A.ii of the FOA) when preparing the Technical Volume.

The Technical Volume should clearly describe and expand upon information provided in the Concept Paper. The Technical Volume must conform to the following content requirements:

SECTION/PAGE LIMIT	DESCRIPTION
Cover Page	The cover page should include the project title, the specific FOA Topic Area being addressed, both the technical and business points of contact, names of all team member organizations, and any statements regarding confidentiality.
Project Overview (This section should constitute approximately 10% of the Technical Volume)	The Project Overview should contain the following information: • Background: The applicant should discuss the background of their organization, including the history, successes, and current research and development status (i.e., the technical baseline) relevant to the technical topic being addressed in the Full Application. • Project Goal: The applicant should explicitly identify the targeted improvements to the baseline technology and the critical success factors in achieving that goal. • DOE Impact: The applicant should discuss the impact that DOE funding would have on the proposed project. Applicants should specifically explain how DOE funding, relative to prior, current, or anticipated funding from other public and private sources, is necessary to achieve the project objectives.
Technical Description, Innovation, and Impact (This section should constitute approximately 30% of the Technical Volume)	The Technical Description should contain the following information: • Relevance and Outcomes: The applicant should provide a detailed description of the technology, including the scientific and other principles and objectives that will be pursued during the project. This section should describe the relevance of the proposed project to the goals and objectives of the FOA, including the potential to meet specific DOE technical targets or other relevant performance targets. The applicant should clearly specify the expected outcomes of the project. • Feasibility: The applicant should demonstrate the technical feasibility of the proposed technology and capability of achieving the anticipated performance targets, including a description of previous work done and prior results. • Innovation and Impacts: The applicant should describe the current state of the art in the applicable field, the specific innovation of the proposed technology, the advantages of proposed technology over current and emerging technologies, and the overall impact on advancing the state of the art/technical baseline if the project is successful.
Workplan and Market Transformation Plan (This section should constitute approximately 40% of the Technical Volume)	The Workplan should include a summary of the Project Objectives, Technical Scope, Work Breakdown Structure (WBS), Milestones, Go/No-Go Decision Points, and Project Schedule. A detailed SOPO is separately requested. The Workplan should contain the following information: • Project Objectives: The applicant should provide a clear and concise (high-level) statement of the goals and objectives of the project as well as the expected outcomes.

	• Technical Scope Summary: The applicant should provide a summary description of the overall work scope and approach to achieve the objective(s). The overall work scope is to be divided by performance periods that are separated by discrete, approximately annual decision points (see below for more information on Go/No-Go decision points). The applicant should describe the specific expected end result of each performance period. • WBS and Task Description Summary: The Workplan should describe the work to be accomplished and how the applicant will achieve the milestones, will accomplish the final project goal(s), and will produce all deliverables. The Workplan is to be structured with a hierarchy of performance period (approximately annual), task and subtasks, which is typical of a standard WBS for any project. The Workplan shall contain a concise description of the specific activities to be conducted over the life of the project. The description shall be a full explanation and disclosure of the project being proposed (i.e., a statement such as "we will then complete a proprietary process" is unacceptable). It is the applicant's responsibility to prepare an adequately detailed task plan to describe the proposed project and the plan for addressing the objectives of this FOA. The summary provided should be consistent with the SOPO. The SOPO will contain a more detailed description of the WBS and tasks. • Milestone Summary: The applicant should provide a summary of appropriate milestones throughout the project to demonstrate success. A milestone may be either a progress measure (which can be activity based) or a SMART technical milestone. SMART milestones should be **S**pecific, **M**easurable, **A**chievable, **R**elevant, and **T**imely, and must demonstrate a technical achievement rather than simply completing a task. Unless otherwise specified in the FOA, the minimum requirement is that each project must have at least one milestone per quarter for the duration of the project with at least one SMART technical milestone per year (depending on the project, more milestones may be necessary to comprehensively demonstrate progress). The applicant should also provide the means by which the milestone will be verified. The summary provided should be consistent with the Milestone Summary Table in the SOPO. • Go/No-Go Decision Points: The applicant should provide a summary of project-wide Go/No-Go decision points at appropriate points in the Workplan. A Go/No-Go decision point is a risk management tool and a project management best practice to ensure that, for the current phase or period of performance, technical success is definitively achieved and potential for success in future phases or periods of performance is evaluated, prior to actually beginning the execution of future phases. Unless otherwise specified in the FOA, the minimum requirement is that each project must have at least one project-wide Go/No-Go

	decision point for each budget period (12 to 18-month period) of the project. The applicant should also provide the specific technical criteria to be used to make the Go/No-Go decision. The summary provided should be consistent with the SOPO. Go/No-Go decision points are considered "SMART" and can fulfill the requirement for an annual SMART milestone.
	• End of Project Goal: The applicant should provide a summary of the end of project goal(s). Unless otherwise specified in the FOA, the minimum requirement is that each project must have one SMART end of project goal. The summary provided should be consistent with the SOPO.
	• Project Schedule (Gantt Chart or similar): The applicant should provide a schedule for the entire project, including task and subtask durations, milestones, and Go/No-Go decision points.
	• Project Management: The applicant should discuss the team's proposed management plan, including the following:
	  ○ The overall approach to and organization for managing the work
	  ○ The roles of each Project Team member
	  ○ Any critical handoffs/interdependencies among Project Team members
	  ○ The technical and management aspects of the management plan, including systems and practices, such as financial and project management practices
	  ○ The approach to project risk management
	  ○ A description of how project changes will be handled
	  ○ If applicable, the approach to Quality Assurance/Control
	  ○ How communications will be maintained among Project Team members
	• Market Transformation Plan: The applicant should provide a market transformation plan, including the following:
	  ○ Identification of target market, competitors, and distribution channels for proposed technology along with known or perceived barriers to market penetration, including a mitigation plan
	  ○ Identification of a product development and/or service plan, commercialization timeline, financing, product marketing, legal/regulatory considerations including intellectual property, infrastructure requirements, data dissemination, U.S. manufacturing plan, and product distribution.

Technical Qualifications and Resources (Approximately 20% of the Technical Volume)	The Technical Qualifications and Resources should contain the following information: • Describe the Project Team's unique qualifications and expertise, including those of key subrecipients. • Describe the Project Team's existing equipment and facilities that will facilitate the successful completion of the proposed project;

	include a justification of any new equipment or facilities requested as part of the project.
	• This section should also include relevant, previous work efforts, demonstrated innovations, and how these enable the applicant to achieve the project objectives.
	• Describe the time commitment of the key team members to support the project.
	• Attach one-page resumes for key participating team members as an appendix. Resumes do not count towards the page limit. Multi-page resumes are not allowed.
	• Describe the technical services to be provided by DOE/NNSA FFRDCs, if applicable.
	• Attach letters of commitment from all subrecipient/third party cost share providers as an appendix. Letters of commitment do not count towards the page limit.
	• Attach any letters of commitment from partners/end users as an appendix (1 page maximum per letter). Letters of commitment do not count towards the page limit. Letters of commitment are not necessary from core consortia members being leveraged in an application.
	• For multi-organizational or multi-investigator projects, describe succinctly:
	  ○ The roles and the work to be performed by each PI and Key Participant;
	  ○ Business agreements between the applicant and each PI and Key Participant;
	  ○ How the various efforts will be integrated and managed;
	  ○ Process for making decisions on scientific/technical direction;
	  ○ Publication arrangements;
	  ○ Intellectual Property issues; and
	  ○ Communication plans

iii. Statement of Project Objectives (SOPO)

Applicants are required to complete a SOPO. A SOPO template is available on EERE Exchange at https://eere-Exchange.energy.gov/. The SOPO, including the Milestone Table, must not exceed 10 pages when printed using standard 8.5 x 11 paper with 1" margins (top, bottom, left, and right) with font not smaller than 12 point. Save the SOPO in a single Microsoft Word file using the following convention for the title "ControlNumber_LeadOrganization_SOPO".

iv. SF-424: Application for Federal Assistance

Complete all required fields in accordance with the instructions on the form. The list of certifications and assurances in Field 21 can be found at http://energy.gov/management/office-management/operational-

management/financial-assistance/financial-assistance-forms, under Certifications and Assurances. Note: The dates and dollar amounts on the SF-424 are for the complete project period and not just the first project year, first phase or other subset of the project period. Save the SF-424 in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_App424".

v. Budget Justification Workbook

- Applicants are required to complete the Budget Justification Workbook. This form is available on EERE Exchange at https://eere-Exchange.energy.gov/.
- Prime recipients must complete each tab of the Budget Justification Workbook for the project as a whole, including all work to be performed by the prime recipient and its subrecipients and contractors.
- Applicants should include costs associated with required annual audits and incurred cost proposals in their proposed budget documents. The "Instructions and Summary" included with the Budget Justification Workbook will auto-populate as the applicant enters information into the Workbook.
- Applicants must carefully read the "Instructions and Summary" tab provided within the Budget Justification Workbook.
- Save the Budget Justification Workbook in a single Microsoft Excel file using the following convention for the title "ControlNumber_LeadOrganization_Budget_Justification".

vi. Summary/Abstract for Public Release

Applicants are required to submit a one-page summary/abstract of their project. The project summary/abstract must contain a summary of the proposed activity suitable for dissemination to the public. It should be a self-contained document that identifies the name of the applicant, the project director/principal investigator(s), the project title, the objectives of the project, a description of the project, including methods to be employed, the potential impact of the project (e.g., benefits, outcomes), and major participants (for collaborative projects). This document must not include any proprietary or sensitive business information as DOE may make it available to the public after selections are made. The project summary must not exceed 1 page when printed using standard 8.5 x 11 paper with 1" margins (top, bottom, left, and right) with font not smaller than 12 point. Save the Summary for Public Release in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_Summary".

vii. Summary Slide

Applicants are required to provide a single PowerPoint slide summarizing the proposed project. The slide must be submitted in Microsoft PowerPoint format. This slide is used during the evaluation process. Save the Summary Slide in a single file using the following convention for the title "ControlNumber_LeadOrganization_Slide".

The Summary Slide template requires the following information:

- A technology summary;
- A description of the technology's impact;
- Proposed project goals;
- Any key graphics (illustrations, charts and/or tables);
- The project's key idea/takeaway;
- Project title, prime recipient, Principal Investigator, and Key Participant information; and
- Requested EERE funds and proposed applicant cost share.

viii. Subrecipient Budget Justification (if applicable)

Applicants must provide a separate budget justification for each subrecipient that is expected to perform work estimated to be more than $250,000 or 25 percent of the total work effort (whichever is less). The budget justification must include the same justification information described in the "Budget Justification" section above. Save each subrecipient budget justification in a Microsoft Excel file using the following convention for the title "ControlNumber_LeadOrganization_Subrecipient_Budget_Justification".

ix. Budget for DOE/NNSA FFRDC (if applicable)

If a DOE/NNSA FFRDC contractor is to perform a portion of the work, the applicant must provide a DOE WP in accordance with the requirements in DOE Order 412.1A, Work Authorization System, Attachment 3, available at: https://www.directives.doe.gov/directives-documents/400-series/0412.1-BOrder-a/@@images/file. Save the WP in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_WP".

x. Authorization for non-DOE/NNSA or DOE/NNSA FFRDCs (if applicable)

The federal agency sponsoring the FFRDC must authorize in writing the use of the FFRDC on the proposed project and this authorization must be submitted with the application. The use of a FFRDC must be consistent with the contractor's authority under its award. Save the Authorization in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_FFRDCAuth".

xi. SF-LLL: Disclosure of Lobbying Activities (required)

Prime recipients and subrecipients may not use any federal funds to influence or attempt to influence, directly or indirectly, congressional action on any legislative or appropriation matters.

Prime recipients and subrecipients are required to complete and submit SF-LLL, "Disclosure of Lobbying Activities" (https://www.grants.gov/web/grants/forms/sf-424-individual-family.html) to ensure that non-federal funds have not been paid and will not be paid to any person for influencing or attempting to influence any of the following in connection with the 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.

Save the SF-LLL in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_SF-LLL".

xii. Waiver Requests: Foreign Entities and Performance of Work in the United States (if applicable)

1. **Foreign Entity Participation:**
   As set forth in Section III.A.iii., all prime recipients receiving funding under this FOA must be incorporated (or otherwise formed) under the laws of a State or territory of the United States. To request a waiver of this requirement, the applicant must submit an explicit waiver request in the Full Application. Appendix B lists the necessary information that must be included in a request to waive this requirement.

2. **Performance of Work in the United States**
   As set forth in Section IV.K.iii., all work under EERE funding agreements must be performed in the United States. This requirement does not apply to the purchase of supplies and equipment, so a waiver is not required for foreign purchases of these items. However, the prime recipient should make every effort to purchase supplies and equipment within the United States. Appendix B lists the necessary information that must be included in a request to waive the Performance of Work in the United States requirement.

Save the Waivers in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_Waiver".

xiii. U.S. Manufacturing Commitments

Pursuant to the DOE Determination of Exceptional Circumstances (DEC) dated September 9, 2013, each applicant is required to submit a U.S. Manufacturing Plan as part of its application. The U.S. Manufacturing Plan represents the applicant's measurable commitment to support U.S. manufacturing as a result of its award.

Each U.S. Manufacturing Plan must include a commitment 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 applicant can show to the satisfaction of DOE that it is not commercially feasible to do so (referred to hereinafter as "the U.S. Competitiveness Provision"). The applicant further agrees to make the U.S. Competitiveness Provision binding on any subawardee and any assignee or licensee or any entity otherwise acquiring rights to any subject invention, including subsequent assignees or licensees. A subject invention is any invention conceived of or first actually reduced to practice under an award.

Due to the lower technology readiness levels of this FOA, DOE does not expect the U.S. Manufacturing Plans to be tied to a specific product or technology. However, in lieu of the U.S. Competitiveness Provision, an applicant may propose a U.S. Manufacturing Plan with more specific commitments that would be beneficial to the U.S. economy and competitiveness. For example, an applicant may commit specific products to be manufactured in the U.S., commit to a specific investment in a new or existing U.S. manufacturing facility, keep certain activities based in the U.S. or support a certain number of jobs in the U.S. related to the technology. An applicant which is likely to license the technology to others, especially universities for which licensing may be the exclusive means of commercialization the technology, the U.S. Manufacturing Plan may indicate the applicant's plan and commitment to use a specific licensing strategy that would likely support U.S. manufacturing.

If DOE determines, at its sole discretion, that the more specific commitments would provide a sufficient benefit to the U.S. economy and industrial competitiveness, the specific commitments will be part of the terms and conditions of the award. For all other awards, the U.S. Competitiveness Provision shall be incorporated as part of the terms and conditions of the award as the U.S. Manufacturing Plan for that award.

The U.S. Competitiveness Provision is also a requirement for the Class Patent Waiver that applies to domestic large business under this FOA (see Section VIII.K. Title to Subject Inventions).

Save the U.S. Manufacturing Plan in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_USMP".

E. Content and Form of Replies to Reviewer Comments

EERE will provide applicants with reviewer comments following evaluation of all eligible Full Applications. Applicants will have a brief opportunity to review the comments and to prepare a short Reply to Reviewer Comments responding to comments however they desire or supplementing their Full Application. The Reply to Reviewer Comments is an optional submission; applicants are not required to submit a Reply to Reviewer Comments. EERE will post the Reviewer Comments in EERE Exchange. The expected submission deadline is on the cover page of the FOA; however, it is the applicant's responsibility to monitor EERE Exchange in the event that the expected date changes. The deadline will not be extended for applicants who are unable to timely submit their reply due to failure to check EERE Exchange or relying on the expected date alone. Applicants should anticipate having approximately three (3) business days to submit Replies to Reviewer Comments.

EERE will not review or consider ineligible Replies to Reviewer Comments (see Section III of the FOA). EERE will review and consider each eligible Full Application, even if no Reply is submitted or if the Reply is found to be ineligible.

Replies to Reviewer Comments must conform to the following content and form requirements, including maximum page lengths, described below. If a Reply to Reviewer Comments is more than three pages in length, EERE will review only the first three (3) pages and disregard any additional pages.

SECTION	PAGE LIMIT	DESCRIPTION
Text	3 pages max	Applicants may respond to one or more reviewer comments or supplement their Full Application. Text, graphs, charts, or other data to respond to reviewer comments or supplement their Full Application are acceptable, and count toward the 3-page limit.

F. Post Selection Information Requests

If selected for award, EERE reserves the right to request additional or clarifying information regarding the following (non-exhaustive list):

- Indirect cost information;
- Other budget information;
- Commitment Letters from Third Parties Contributing to Cost Share, if applicable;
- Name and phone number of the Designated Responsible Employee for complying with national policies prohibiting discrimination (See 10 CFR 1040.5);

- Representation of Limited Rights Data and Restricted Software, if applicable; and
- Environmental Questionnaire.
- Data Management Plan – see Section IV.I
- Non-disclosure agreements (NDAs) and/or cooperative research and development agreements (CRADAs) – see Section IV.K.x

G. Dun and Bradstreet Universal Numbering System (DUNS) Number and System for Award Management (SAM)

Each applicant (unless the applicant is an individual or federal awarding agency that is excepted from those requirements under 2 CFR §25.110(b) or (c), or has an exception approved by the federal awarding agency under 2 CFR §25.110(d)) is required to: (1) Be registered in the SAM at https://www.sam.gov before submitting its application; (2) provide a valid DUNS number in its application; and (3) continue to maintain an active SAM registration with current information at all times during which it has an active federal award or an application or plan under consideration by a federal awarding agency. DOE may not make a federal award to an applicant until the applicant has complied with all applicable DUNS and SAM requirements and, if an applicant has not fully complied with the requirements by the time DOE is ready to make a federal award, the DOE will determine that the applicant is not qualified to receive a federal award and use that determination as a basis for making a federal award to another applicant.

H. Submission Dates and Times

Concept Papers, Full Applications, and Replies to Reviewer Comments must be submitted in EERE Exchange no later than 5 p.m. Eastern Time on the dates provided on the cover page of this FOA.

I. Data Management Plan (DMP)

Applicants whose full applications are selected for award negotiations will be required to submit a DMP during the award negotiations phase.

An applicant may select one of the template Data Management Plans (DMP) listed below. Alternatively, instead of selecting one of the template Data Management Plans below, an applicant may submit another DMP provided that the DMP, at a minimum, (1) describes how data sharing and preservation will enable validation of the results from the proposed work, how the results could be validated if data are not shared or preserved and (2) has a plan for making all research data displayed in publications resulting from the proposed work digitally accessible at the time of publications. DOE Public Access Plan dated July 24, 2014 provides additional guidance and information on Data Management Plans.

Option 1 (when protected data is allowed): For the deliverables under the award, the recipient does not plan on making the underlying research data supporting the findings in the deliverables publicly-available for up to 5 years after the data were first produced because such data will be considered protected under the award. The results from the DOE deliverables can be validated by DOE who will have access, upon request, to the research data. Other than providing deliverables as specified in the award, the recipient does not intend to publish the results from the project. However, in an instance where a publication includes results of the project, the underlying research data will be made available according to the policies of the publishing media. Where no such policy exists, the recipient must indicate on the publication a means for requesting and digitally obtaining the underlying research data. This includes the research data necessary to validate any results, conclusions, charts, figures, images in the publications.

Option 2: For any publication that includes results of the project, the underlying research data will be made available according to the policies of the publishing media. Where no such policy exists, the recipient must indicate on the publication a means for requesting and digitally obtaining the underlying research data. This includes the research data necessary to validate any results, conclusions, charts, figures, images in the publications.

Save the DMP in a single Microsoft Word file using the following convention for the title "ControlNumber_LeadOrganization_DMP".

J. Intergovernmental Review

This FOA is not subject to Executive Order 12372 – Intergovernmental Review of Federal Programs.

K. Funding Restrictions

i. Allowable Costs

All expenditures must be allowable, allocable, and reasonable in accordance with the applicable federal cost principles.

Refer to the following applicable federal cost principles for more information:

- Federal Acquisition Regulation (FAR) Part 31 for For-Profit entities; and
- 2 CFR Part 200 Subpart E - Cost Principles for all other non-federal entities.

ii. Pre-Award Costs

Selectees must request prior written approval to charge pre-award costs. Pre-award costs are those incurred prior to the effective date of the federal award directly pursuant to the negotiation and in anticipation of the federal award

where such costs are necessary for efficient and timely performance of the scope of work. Such costs are allowable only to the extent that they would have been allowable if incurred after the date of the federal award and **only** with the written approval of the federal awarding agency, through the Contracting Officer assigned to the award.

Pre-award costs cannot be incurred prior to the Selection Official signing the Selection Statement and Analysis. Pre-award costs can only be incurred if such costs would be reimbursable under the agreement if incurred after award.

Pre-award expenditures are made at the Selectee's risk. EERE is not obligated to reimburse costs: (1) in the absence of appropriations; (2) if an award is not made; or (3) if an award is made for a lesser amount than the Selectee anticipated.

1. **Pre-Award Costs Related to National Environmental Policy Act (NEPA) Requirements**
   EERE's decision whether and how to distribute federal funds under this FOA is subject to NEPA. Applicants should carefully consider and should seek legal counsel or other expert advice before taking any action related to the proposed project that would have an adverse effect on the environment or limit the choice of reasonable alternatives prior to EERE completing the NEPA review process.

   EERE does not guarantee or assume any obligation to reimburse costs where the prime recipient incurred the costs prior to receiving written authorization from the Contracting Officer. If the applicant elects to undertake activities that may have an adverse effect on the environment or limit the choice of reasonable alternatives prior to receiving such written authorization from the Contracting Officer, the applicant is doing so at risk of not receiving federal funding and such costs may not be recognized as allowable cost share. Likewise, if an application is selected for negotiation of award, and the prime recipient elects to undertake activities that are not authorized for federal funding by the Contracting Officer in advance of EERE completing a NEPA review, the prime recipient is doing so at risk of not receiving federal funding and such costs may not be recognized as allowable cost share. Nothing contained in the pre-award cost reimbursement regulations or any pre-award costs approval letter from the Contracting Officer override these NEPA requirements to obtain the written authorization from the Contracting Officer prior to taking any action that may have an adverse effect on the environment or limit the choice of reasonable alternatives.

iii. Performance of Work in the United States

1. **Requirement**
   All work performed under EERE awards must be performed in the United States. This requirement does not apply to the purchase of supplies and equipment; however, the prime recipient should make every effort to purchase supplies and equipment within the United States. The prime recipient must flow down this requirement to its subrecipients.

2. **Failure to Comply**
   If the prime recipient fails to comply with the Performance of Work in the United States requirement, EERE may deny reimbursement for the work conducted outside the United States and such costs may not be recognized as allowable recipient cost share. The prime recipient is responsible should any work under this award be performed outside the United States, absent a waiver, regardless of if the work is performed by the prime recipient, subrecipients, contractors or other project partners.

3. **Waiver**
   There may be limited circumstances where it is in the interest of the Project to perform a portion of the work outside the United States. To seek a waiver of the Performance of Work in the United States requirement, the applicant must submit a written waiver request to EERE. Appendix B lists the necessary information that must be included in a request to waive the Performance of Work in the United States requirement.

   The applicant must demonstrate to the satisfaction of EERE that a waiver would further the purposes of the FOA and is in the economic interests of the United States. EERE may require additional information before considering a waiver request. Save the waiver request(s) in a single PDF file titled "ControlNumber_LeadOrganization_Waiver". The applicant does not have the right to appeal EERE's decision concerning a waiver request.

iv. Construction

Recipients are required to obtain written authorization from the Contracting Officer before incurring any major construction costs.

v. Foreign Travel

If international travel is proposed for your project, please note that your organization must comply with the International Air Transportation Fair Competitive Practices Act of 1974 (49 USC 40118), commonly referred to as the "Fly America Act," and implementing regulations at 41 CFR 301-10.131 through

301-10.143. The law and regulations require air transport of people or property to, from, between, or within a country other than the United States, the cost of which is supported under this award, to be performed by or under a cost-sharing arrangement with a U.S. flag carrier, if service is available. Foreign travel costs are allowable only with the written prior approval of the Contracting Officer assigned to the award.

vi. Equipment and Supplies

To the greatest extent practicable, all equipment and products purchased with funds made available under this FOA should be American-made. This requirement does not apply to used or leased equipment.

Property disposition will be required at the end of a project if the current fair market value of property exceeds $5,000. The rules for property disposition are set forth in 2 CFR 200.310 – 200.316 as amended by 2 CFR 910.360.

vii. Lobbying

Recipients and subrecipients may not use any federal funds to influence or attempt to influence, directly or indirectly, congressional action on any legislative or appropriation matters.

Recipients and subrecipients are required to complete and submit SF-LLL, "Disclosure of Lobbying Activities" (https://www.grants.gov/web/grants/forms/sf-424-individual-family.html) to ensure that non-federal funds have not been paid and will not be paid to any person for influencing or attempting to influence any of the following in connection with the 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.

viii. Risk Assessment

Prior to making a federal award, the DOE is required by 31 U.S.C. 3321 and 41 U.S.C. 2313 to review information available through any Office of Management and Budget (OMB)-designated repositories of government-wide eligibility qualification or financial integrity information, such as SAM Exclusions and "Do Not Pay."

In addition, DOE evaluates the risk(s) posed by applicants before they receive federal awards. This evaluation may consider: results of the evaluation of the

applicant's eligibility; the quality of the application; financial stability; quality of management systems and ability to meet the management standards prescribed in this part; history of performance; reports and findings from audits; and the applicant's ability to effectively implement statutory, regulatory, or other requirements imposed on non-federal entities.
In addition to this review, DOE must comply with the guidelines on government-wide suspension and debarment in 2 CFR 180, and must require non-federal entities to comply with these provisions. These provisions restrict federal awards, subawards and contracts with certain parties that are debarred, suspended or otherwise excluded from or ineligible for participation in federal programs or activities.

ix. Invoice Review and Approval

DOE employs a risk-based approach to determine the level of supporting documentation required for approving invoice payments. Recipients may be required to provide some or all of the following items with their requests for reimbursement:

- Summary of costs by cost categories;
- Timesheets or personnel hours report;
- Invoices/receipts for all travel, equipment, supplies, contractual, and other costs;
- UCC filing proof for equipment acquired with project funds by for-profit recipients and subrecipients;
- Explanation of cost share for invoicing period;
- Analogous information for some subrecipients; and
- Other items as required by DOE.

x. Additional Requirements

Each of the consortia being leveraged in this FOA have established standard non-disclosure agreements (NDAs) that applicants will be required to sign prior to receiving an award. This applies to Topics 1A, 1B, and 2A only.

V. Application Review Information

A. Technical Review Criteria

i. Concept Papers

Concept Papers are evaluated based on consideration the following factors. All sub-criteria are of equal weight.

Concept Paper Criterion: Overall FOA Responsiveness and Viability of the Project (Weight: 100%)
This criterion involves consideration of the following factors:

- The applicant clearly describes the proposed technology, describes how the technology is unique and innovative, and how the technology will advance the current state-of-the-art;
- The applicant has identified risks and challenges, including possible mitigation strategies, and has shown the impact that EERE funding and the proposed project would have on the relevant field and application;
- The applicant has the qualifications, experience, capabilities and other resources necessary to complete the proposed project; and
- The proposed work, if successfully accomplished, would clearly meet the objectives as stated in the FOA.

ii. Full Applications

Applications will be evaluated against the merit review criteria shown below. All sub-criteria are of equal weight.

Criterion 1: Technical Merit, Innovation, and Impact (50%)
This criterion involves consideration of the following factors:

Technical Merit and Innovation

- Extent to which the proposed technology or process is innovative;
- Degree to which the current state of the technology and the proposed advancement are clearly described;
- Extent to which the application specifically and convincingly demonstrates how the applicant will move the state-of-the-art to the proposed advancement; and
- Sufficiency of technical detail in the application to assess whether the proposed work is scientifically meritorious and revolutionary, including relevant data, calculations and discussion of prior work in the literature with analyses that support the viability of the proposed work.

Impact of Technology Advancement

- How the project supports the topic area objectives and target specifications and metrics; and
- The potential impact of the project on advancing the state-of-the-art.

Criterion 2: Project Research and Market Transformation Plan (30%)
This criterion involves consideration of the following factors:

Research Approach, Workplan and SOPO

- Degree to which the approach and critical path have been clearly described and thoughtfully considered; and
- Degree to which the task descriptions are clear, detailed, timely, and reasonable, resulting in a high likelihood that the proposed Workplan and SOPO will succeed in meeting the project goals.

Identification of Technical Risks

- Discussion and demonstrated understanding of the key technical risk areas involved in the proposed work and the quality of the mitigation strategies to address them.

Baseline, Metrics, and Deliverables

- The level of clarity in the definition of the baseline, metrics, and milestones; and
- Relative to a clearly defined experimental baseline, the strength of the quantifiable metrics, milestones, and a mid-point deliverables defined in the application, such that meaningful interim progress will be made.

Market Transformation Plan

- Identification of target market, competitors, and distribution channels for proposed technology along with known or perceived barriers to market penetration, including mitigation plan; and
- Comprehensiveness of market transformation plan including but not limited to product development and/or service plan, commercialization timeline, financing, product marketing, legal/regulatory considerations including intellectual property, infrastructure requirements, U.S. manufacturing plan, and product distribution.

Criterion 3: Team and Resources (20%)

This criterion involves consideration of the following factors:

- The capability of the Principal Investigator(s) and the proposed team to address all aspects of the proposed work with a high probability of success. The qualifications, relevant expertise, and time commitment of the individuals on the team;
- The sufficiency of the facilities to support the work;
- The degree to which the proposed consortia/team demonstrates the ability to facilitate and expedite further development and commercial deployment of the proposed technologies;
- The level of participation by project participants as evidenced by letter(s) of commitment and how well they are integrated into the Workplan; and

- The reasonableness of the budget and spend plan for the proposed project and objectives.
- The degree to which the applicant is leveraging capabilities/nodes within the respective consortium to facilitate and expedite the proposed materials discovery/development (only applies to Topics 1A, 1B, and 2A).

iii. Criteria for Replies to Reviewer Comments

EERE has not established separate criteria to evaluate Replies to Reviewer Comments. Instead, Replies to Reviewer Comments are attached to the original applications and evaluated as an extension of the Full Application.

B. Standards for Application Evaluation

Applications that are determined to be eligible will be evaluated in accordance with this FOA, by the standards set forth in EERE's Notice of Objective Merit Review Procedure (76 Fed. Reg. 17846, March 31, 2011) and the guidance provided in the "DOE Merit Review Guide for Financial Assistance," effective April 14, 2017, which is available at: https://energy.gov/management/downloads/merit-review-guide-financial-assistance-and-unsolicited-proposals-current.

C. Other Selection Factors

i. Program Policy Factors

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

- The degree to which the proposed project exhibits technological diversity when compared to the existing DOE project portfolio and other projects selected from the subject FOA;
- The degree to which the proposed project, including proposed cost share, optimizes the use of available EERE funding to achieve programmatic objectives;
- The level of industry involvement and demonstrated ability to accelerate commercialization and overcome key market barriers;
- The degree to which the proposed project is likely to lead to increased employment and manufacturing in the United States;
- The degree to which the proposed project will accelerate transformational technological advances in areas that industry by itself is not likely to undertake because of technical and financial uncertainty; and

- The degree to which the proposed project, or group of projects, represent a desired geographic distribution (considering past awards and current applications).

D. Evaluation and Selection Process

i. Overview

The evaluation process consists of multiple phases; each includes an initial eligibility review and a thorough technical review. Rigorous technical reviews of eligible submissions are conducted by reviewers that are experts in the subject matter of the FOA. Ultimately, the Selection Official considers the recommendations of the reviewers, along with other considerations such as program policy factors, in determining which applications to select.

ii. Pre-Selection Interviews

As part of the evaluation and selection process, EERE may invite one or more applicants to participate in Pre-Selection Interviews. Pre-Selection Interviews are distinct from and more formal than pre-selection clarifications (See Section V.D.iii of the FOA). The invited applicant(s) will meet with EERE representatives to provide clarification on the contents of the Full Applications and to provide EERE an opportunity to ask questions regarding the proposed project. The information provided by applicants to EERE through Pre-Selection Interviews contributes to EERE's selection decisions.

EERE will arrange to meet with the invited applicants in person at EERE's offices or a mutually agreed upon location. EERE may also arrange site visits at certain applicants' facilities. In the alternative, EERE may invite certain applicants to participate in a one-on-one conference with EERE via webinar, videoconference, or conference call.

EERE will not reimburse applicants for travel and other expenses relating to the Pre-Selection Interviews, nor will these costs be eligible for reimbursement as pre-award costs.

EERE may obtain additional information through Pre-Selection Interviews that will be used to make a final selection determination. EERE may select applications for funding and make awards without Pre-Selection Interviews. Participation in Pre-Selection Interviews with EERE does not signify that applicants have been selected for award negotiations.

iii. Pre-Selection Clarification

EERE may determine that pre-selection clarifications are necessary from one or more applicants. Pre-selection clarifications are distinct from and less formal than pre-selection interviews. These pre-selection clarifications will solely be for the purposes of clarifying the application, and will be limited to information already provided in the application documentation. The pre-selection clarifications may occur before, during or after the merit review evaluation process. Information provided by an applicant that is not necessary to address the pre-selection clarification question will not be reviewed or considered. Typically, a pre-selection clarification will be carried out through either written responses to EERE's written clarification questions or video or conference calls with EERE representatives.

The information provided by applicants to EERE through pre-selection clarifications is incorporated in their applications and contributes to the merit review evaluation and EERE's selection decisions. If EERE contacts an applicant for pre-selection clarification purposes, it does not signify that the applicant has been selected for negotiation of award or that the applicant is among the top ranked applications.

EERE will not reimburse applicants for expenses relating to the pre-selection clarifications, nor will these costs be eligible for reimbursement as pre-award costs.

iv. Recipient Integrity and Performance Matters

DOE, prior to making a federal award with a total amount of federal share greater than the simplified acquisition threshold, is required to review and consider any information about the applicant that is in the designated integrity and performance system accessible through SAM (currently FAPIIS) (see 41 U.S.C. 2313).

The applicant, at its option, may review information in the designated integrity and performance systems accessible through SAM and comment on any information about itself that a federal awarding agency previously entered and is currently in the designated integrity and performance system accessible through SAM.

DOE will consider any written comments by the applicant, in addition to the other information in the designated integrity and performance system, in making a judgment about the applicant's integrity, business ethics, and record of performance under federal awards when completing the review of risk posed by applicants as described in 2 C.F.R. § 200.205.

v. Selection

The Selection Official may consider the technical merit, the Federal Consensus Board's recommendations, program policy factors, and the amount of funds available in arriving at selections for this FOA.

E. Anticipated Notice of Selection and Award Negotiation Dates

EERE anticipates notifying applicants selected for negotiation of award and negotiating awards by the dates provided on the cover page of this FOA.

VI. Award Administration Information

A. Award Notices

i. Ineligible Submissions

Ineligible Concept Papers and Full Applications will not be further reviewed or considered for award. The Contracting Officer will send a notification letter by email to the technical and administrative points of contact designated by the applicant in EERE Exchange. The notification letter will state the basis upon which the Concept Paper or the Full Application is ineligible and not considered for further review.

ii. Concept Paper Notifications

EERE will notify applicants of its determination to encourage or discourage the submission of a Full Application. EERE will post these notifications to EERE Exchange.

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, EERE 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 encouraging the submission of a Full Application does not authorize the applicant to commence performance of the project. Please refer to Section IV.K.ii. of the FOA for guidance on pre-award costs.

iii. Full Application Notifications

EERE will notify applicants of its determination via a notification letter by email to the technical and administrative points of contact designated by the applicant

in EERE Exchange. The notification letter will inform the applicant whether or not its Full Application was selected for award negotiations. Alternatively, EERE may notify one or more applicants that a final selection determination on particular Full Applications will be made at a later date, subject to the availability of funds or other factors.

iv. Successful Applicants

Receipt of a notification letter selecting a Full Application for award negotiations does not authorize the applicant to commence performance of the project. If an application is selected for award negotiations, it is not a commitment by EERE to issue an award. Applicants do not receive an award until award negotiations are complete and the Contracting Officer executes the funding agreement, accessible by the prime recipient in FedConnect.

The award negotiation process will take approximately 60 days. Applicants must designate a primary and a backup point-of-contact in EERE Exchange with whom EERE will communicate to conduct award negotiations. The applicant must be responsive during award negotiations (i.e., provide requested documentation) and meet the negotiation deadlines. If the applicant fails to do so or if award negotiations are otherwise unsuccessful, EERE will cancel the award negotiations and rescind the Selection. EERE reserves the right to terminate award negotiations at any time for any reason.

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

v. Alternate Selection Determinations

In some instances, an applicant may receive a notification that its application was not selected for award and EERE designated the application to be an alternate. As an alternate, EERE may consider the Full Application for federal funding in the future. A notification letter stating the Full Application is designated as an alternate does not authorize the applicant to commence performance of the project. EERE may ultimately determine to select or not select the Full Application for award negotiations.

vi. Unsuccessful Applicants

EERE shall promptly notify in writing each applicant whose application has not been selected for award or whose application cannot be funded because of the unavailability of appropriated funds.

B. Administrative and National Policy Requirements

i. Registration Requirements

There are several one-time actions before submitting an application in response to this FOA, and it is vital that applicants address these items as soon as possible. Some may take several weeks, and failure to complete them could interfere with an applicant's ability to apply to this FOA, or to meet the negotiation deadlines and receive an award if the application is selected. These requirements are as follows:

1. **EERE Exchange**
   Register and create an account on EERE Exchange at https://eere-Exchange.energy.gov.
   This account will then allow the user to register for any open EERE FOAs that are currently in EERE Exchange. It is recommended that each organization or business unit, whether acting as a team or a single entity, use only one account as the contact point for each submission. Applicants should also designate backup points of contact so they may be easily contacted if deemed necessary. **This step is required to apply to this FOA.**

   The EERE Exchange registration does not have a delay; however, **the remaining registration requirements below could take several weeks to process and are necessary for a potential applicant to receive an award under this FOA**.

2. **DUNS Number**
   Obtain a DUNS number (including the plus 4 extension, if applicable) at http://fedgov.dnb.com/webform.

3. **System for Award Management**
   Register with the SAM at https://www.sam.gov. Designating an Electronic Business Point of Contact (EBiz POC) and obtaining a special password called an Marketing Partner ID Number (MPIN) are important steps in SAM registration. Please update your SAM registration annually.

4. **FedConnect**
   Register in FedConnect at https://www.fedconnect.net. To create an organization account, your organization's SAM MPIN is required. For more information about the SAM MPIN or other registration requirements, review the FedConnect Ready, Set, Go! Guide at https://www.fedconnect.net/FedConnect/Marketing/Documents/FedConnect_Ready_Set_Go.pdf.

5. **Grants.gov**
   Register in Grants.gov (http://www.grants.gov) to receive automatic updates when Amendments to this FOA are posted. However, please note that Concept Papers and Full Applications will not be accepted through Grants.gov.

6. **Electronic Authorization of Applications and Award Documents**
   Submission of an application and supplemental information under this FOA through electronic systems used by the DOE, including EERE Exchange and FedConnect.net, constitutes the authorized representative's approval and electronic signature.

ii. Award Administrative Requirements

The administrative requirements for DOE grants and cooperative agreements are contained in 2 CFR Part 200 as amended by 2 CFR Part 910.

iii. Foreign National Access to DOE Sites

All applicants that ultimately enter into an award resulting from this FOA will be subject to the following requirement concerning foreign national involvement. Upon DOE's request, prime recipients must provide information to facilitate DOE's responsibilities associated with foreign national access to DOE sites, information, technologies, and equipment. A foreign national is defined as any person who was born outside the jurisdiction of the United States, is a citizen of a foreign government, and has not been naturalized under U.S. law. If the prime recipient or subrecipients, contractors or vendors under the award, anticipate utilizing a foreign national person in the performance of an award, the prime recipient is responsible for providing to the Contracting Officer specific information of the foreign national(s) to satisfy compliance with all of the requirements for access approval.

iv. Subaward and Executive Reporting

Additional administrative requirements necessary for DOE grants and cooperative agreements to comply with the Federal Funding and Transparency Act of 2006 (FFATA) are contained in 2 CFR Part 170. Prime recipients must register with the new FFATA Subaward Reporting System database and report the required data on their first tier subrecipients. Prime recipients must report the executive compensation for their own executives as part of their registration profile in SAM.

v. National Policy Requirements

The National Policy Assurances that are incorporated as a term and condition of award are located at: http://www.nsf.gov/awards/managing/rtc.jsp.

vi. Environmental Review in Accordance with National Environmental Policy Act (NEPA)

EERE's decision whether and how to distribute federal funds under this FOA is subject to NEPA (42 USC 4321, *et seq.*). NEPA requires federal agencies to integrate environmental values into their decision-making processes by considering the potential environmental impacts of their proposed actions. For additional background on NEPA, please see DOE's NEPA website, at http://nepa.energy.gov/.

While NEPA compliance is a federal agency responsibility and the ultimate decisions remain with the federal agency, all recipients selected for an award will be required to assist in the timely and effective completion of the NEPA process in the manner most pertinent to their proposed project. If DOE determines certain records must be prepared to complete the NEPA review process (e.g., biological evaluations or environmental assessments), the costs to prepare the necessary records may be included as part of the project costs.

vii. Applicant Representations and Certifications

1. **Lobbying Restrictions**
   By accepting funds under this award, the prime recipient agrees that none of the funds obligated on the award shall be expended, directly or indirectly, to influence Congressional action on any legislation 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.
2. **Corporate Felony Conviction and Federal Tax Liability Representations**
   In submitting an application in response to this FOA, the applicant represents that:
   a. It is **not** a corporation that has been convicted of a felony criminal violation under any federal law within the preceding 24 months, and

   b. 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.

3. **Nondisclosure and Confidentiality Agreements Representations**
In submitting an application in response to this FOA the applicant represents that:

a. 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 contactors 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.

b. 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:

(1) *''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.''*

(2) The limitation above shall not contravene requirements applicable to Standard Form 312 Classified Information Nondisclosure Agreement (https://fas.org/sgp/othergov/sf312.pdf), Form 4414 Sensitive Compartmented Information Disclosure Agreement (https://fas.org/sgp/othergov/intel/sf4414.pdf), or any other form issued by a federal department or agency governing the nondisclosure of classified information.

(3) Notwithstanding the provision listed in paragraph (a), a nondisclosure or 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 disclosures 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.

viii. Statement of Federal Stewardship

EERE will exercise normal federal stewardship in overseeing the project activities performed under EERE awards. Stewardship Activities include, but are not limited to, conducting site visits; reviewing performance and financial reports; providing assistance and/or temporary intervention in unusual circumstances to correct deficiencies that develop during the project; assuring compliance with terms and conditions; and reviewing technical performance after project completion to ensure that the project objectives have been accomplished.

ix. Statement of Substantial Involvement

EERE has substantial involvement in work performed under awards made as a result of this FOA. EERE does not limit its involvement to the administrative requirements of the award. Instead, EERE has substantial involvement in the direction and redirection of the technical aspects of the project as a whole. Substantial involvement includes, but is not limited to, the following:

1. EERE shares responsibility with the recipient for the management, control, direction, and performance of the project.
2. EERE may intervene in the conduct or performance of work under this award for programmatic reasons. Intervention includes the interruption or modification of the conduct or performance of project activities.
3. EERE may redirect or discontinue funding the project based on the outcome of EERE's evaluation of the project at the Go/No-Go decision point(s).
4. EERE participates in major project decision-making processes.

x. Subject Invention Utilization Reporting

In order to ensure that prime recipients and subrecipients holding title to subject inventions are taking the appropriate steps to commercialize subject inventions, EERE may require that each prime recipient holding title to a subject invention submit annual reports for 10 years from the date the subject invention was disclosed to EERE on the utilization of the subject invention and efforts made by prime recipient or their licensees or assignees to stimulate such utilization. The reports must include information regarding the status of development, date of

first commercial sale or use, gross royalties received by the prime recipient, and such other data and information as EERE may specify.

xi. Intellectual Property Provisions

The standard DOE financial assistance intellectual property provisions applicable to the various types of recipients are located at http://energy.gov/gc/standard-intellectual-property-ip-provisions-financial-assistance-awards.

xii. Reporting

Reporting requirements are identified on the Federal Assistance Reporting Checklist, attached to the award agreement. This helpful EERE checklist can be accessed at https://www.energy.gov/eere/funding/eere-funding-application-and-management-forms. See Attachment 2 Federal Assistance Reporting Checklist, after clicking on "Model Cooperative Agreement" under the Award Package section.

Specific reporting and meeting attendance requirements for projects selected from this FOA will include, but are not limited to:

- Quarterly Financial and Technical Reports
- Final Technical Report
- Yearly participation at the DOE Hydrogen Program Merit Review and Peer Evaluation (AMR) meeting, typically held in Washington, D.C.
- Yearly participation in one U.S. DRIVE Technical Team Meeting
- DOE may request that material samples, components, and/or prototype systems resulting from the R&D effort be sent for independent, standardized testing at a facility specified by DOE, as appropriate
- Work with independent system and/or cost analysis projects within DOE portfolio for independent performance and model validation as appropriate
- Consortium (EMN and other lab-based consortia) projects (Topics 1A, 1B, and 2A) will be required to submit materials data to consortium data portals as appropriate.
- Project Safety Plan: Safe practices in the production, storage, distribution, and use of hydrogen are essential for the widespread acceptance of hydrogen and fuel cell technologies. The recipient must comply with the following requirements:
  1. The recipient is required to coordinate with the Hydrogen Safety Panel (HSP), a resource of the DOE Hydrogen and Fuel Cells Program, throughout the project life cycle. Examples of opportunities for HSP involvement include participation in post-award project kickoff meetings, project design and document reviews, risk assessments, and pre-startup reviews prior to beginning field demonstrations. To

minimize project impacts, these engagements should be coordinated with regularly scheduled project activities rather than be unique efforts, and should be based on discussions with HSP.

2. All projects require safety plan, due to DOE 90 days after the award is signed. Guidance for the creation of the Safety Plan can be found at https://h2tools.org/sites/default/files/Safety_Planning_for_Hydrogen_and_Fuel_Cell_Projects-November2017_0.pdf. The Safety Plan should cover the full scope of the project, including work by the prime as well as any subrecipients. The Hydrogen Safety Panel will review the Safety Plan and provide feedback to the Recipient (through DOE). The Recipient will then have 30 days to respond to the HSP's feedback (e.g., either by incorporating comments into the Plan or by providing rationale for not incorporating comments) and resubmit a revised Safety Plan to DOE.
3. DOE may request HSP involvement in site visits or via teleconferences. If a safety-focused site visit/teleconference is requested, the HSP will provide a written site visit report to the recipient for review and comment, and may conduct a follow-up interview with the recipient and their project team. All such HSP reports are also provided to DOE.

For all of the items noted above, please ensure that estimated costs associated with the requirements are included within the proposed budget.

xiii. Go/No-Go Review

Each project selected under this FOA will be subject to a periodic project evaluation referred to as a Go/No-Go Review. At the Go/No-Go decision points, EERE will evaluate project performance, project schedule adherence, meeting milestone objectives, compliance with reporting requirements, and overall contribution to the EERE program goals and objectives. Federal funding beyond the Go/No-Go decision point (continuation funding) is contingent upon (1) availability of federal funds appropriated by Congress for the purpose of this program; (2) the availability of future-year budget authority; (3) recipient's technical progress compared to the Milestone Summary Table stated in Attachment 1 of the award; (4) recipient's submittal of required reports; (5) recipient's compliance with the terms and conditions of the award; (6) EERE's Go/No-Go decision; (7) the recipient's submission of a continuation application; and (8) written approval of the continuation application by the Contracting Officer.

As a result of the Go/No-Go Review, DOE may, at its discretion, authorize the following actions: (1) continue to fund the project, contingent upon the availability of funds appropriated by Congress for the purpose of this program

and the availability of future-year budget authority; (2) recommend redirection of work under the project; (3) place a hold on federal funding for the project, pending further supporting data or funding; or (4) discontinue funding the project because of insufficient progress, change in strategic direction, or lack of funding.

The Go/No-Go decision is distinct from a non-compliance determination. In the event a recipient fails to comply with the requirements of an award, EERE may take appropriate action, including but not limited to, redirecting, suspending or terminating the award.

xiv. Conference Spending

The recipient shall not expend any funds on a conference not directly and programmatically related to the purpose for which the grant or cooperative agreement was awarded that would defray the cost to the United States Government of a conference held by any Executive branch department, agency, board, commission, or office for which the cost to the United States Government would otherwise exceed $20,000, thereby circumventing 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 conference.

xv. Uniform Commercial Code (UCC) Financing Statements

Per 2 CFR 910.360 (Real Property and Equipment) when a piece of equipment is purchased by a for-profit recipient or subrecipient with federal funds, and when the federal share of the financial assistance agreement is more than $1,000,000, the recipient or subrecipient must:

Properly record, and consent to the Department's ability to properly record if the recipient fails to do so, UCC financing statement(s) for all equipment in excess of $5,000 purchased with project funds. These financing statement(s) must be approved in writing by the Contracting Officer prior to the recording, and they shall provide notice that the recipient's title to all equipment (not real property) purchased with federal funds under the financial assistance agreement is conditional pursuant to the terms of this section, and that the Government retains an undivided reversionary interest in the equipment. The UCC financing statement(s) must be filed before the Contracting Officer may reimburse the recipient for the federal share of the equipment unless otherwise provided for in the relevant financial assistance agreement. The recipient shall further make any amendments to the financing statements or additional recordings, including

appropriate continuation statements, as necessary or as the Contracting Officer may direct.

VII. Questions/Agency Contacts

Upon the issuance of a FOA, EERE personnel are prohibited from communicating (in writing or otherwise) with applicants regarding the FOA except through the established question and answer process as described below. Specifically, questions regarding the content of this FOA must be submitted to: *FCTOFOA@ee.doe.gov*. Questions must be submitted not later than 3 business days prior to the application due date and time. Please note, feedback on individual concepts will not be provided through Q&A.

All questions and answers related to this FOA will be posted on EERE Exchange at: https://eere-exchange.energy.gov. **Please note that you must first select this specific FOA Number in order to view the questions and answers specific to this FOA**. EERE will attempt to respond to a question within 3 business days, unless a similar question and answer has already been posted on the website.

Questions related to the registration process and use of the EERE Exchange website should be submitted to: EERE-ExchangeSupport@hq.doe.gov.

VIII. Other Information

A. FOA Modifications

Amendments to this FOA will be posted on the EERE Exchange website and the Grants.gov system. However, you will only receive an email when an amendment or a FOA is posted on these sites if you register for email notifications for this FOA in Grants.gov. EERE recommends that you register as soon after the release of the FOA as possible to ensure you receive timely notice of any amendments or other FOAs.

B. Government Right to Reject or Negotiate

EERE reserves the right, without qualification, to reject any or all applications received in response to this FOA and to select any application, in whole or in part, as a basis for negotiation and/or award.

C. Commitment of Public Funds

The Contracting Officer is the only individual who can make awards or commit the Government to the expenditure of public funds. A commitment by anyone other than the Contracting Officer, either express or implied, is invalid.

D. Treatment of Application Information

In general, EERE will only use data and other information contained in applications for evaluation purposes, unless such information is generally available to the public or is already the property of the Government.

Applicants should not include trade secrets or commercial or financial information that is privileged or confidential in their application unless such information is necessary to convey an understanding of the proposed project or to comply with a requirement in the FOA.

The use of protective markings such as "Do Not Publicly Release – Trade Secret" or "Do Not Publicly Release – Confidential Business Information" is encouraged. However, applicants should be aware that the use of protective markings is not dispositive as to whether information will be publicly released pursuant to the Freedom of Information Act, 5 U.S.C. §552, et. seq., as amended by the OPEN Government Act of 2007, Pub. L. No. 110-175. (See Section I of this document, "Notice of Potential Disclosure Under the Freedom of Information Act (FOIA)" for additional information regarding the public release of information under FOIA.

Applicants are encouraged to employ protective markings in the following manner:

The cover sheet of the application must be marked as follows and identify the specific pages containing trade secrets or commercial or financial information that is privileged or confidential:

Notice of Restriction on Disclosure and Use of Data:
Pages [list applicable pages] of this document may contain trade secrets or commercial or financial information that is privileged or confidential, and 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. [End of Notice]

The header and footer of every page that contains trade secrets or commercial or financial information that is privileged must be marked as follows: "May contain trade secrets or commercial or financial information that is privileged or confidential and exempt from public disclosure."

In addition, each line or paragraph containing trade secrets or commercial or financial information that is privileged or confidential must be enclosed in brackets.

E. Evaluation and Administration by Non-Federal Personnel

In conducting the merit review evaluation, the Go/No-Go Review and Peer Review, the Government may seek the advice of qualified non-federal personnel as reviewers. The Government may also use non-federal personnel to conduct routine, nondiscretionary administrative activities, including EERE contractors. The applicant, by submitting its application, consents to the use of non-federal reviewers/administrators. Non-federal reviewers must sign conflict of interest (COI) and non-disclosure acknowledgements (NDA) prior to reviewing an application. Non-federal personnel conducting administrative activities must sign an NDA.

F. Notice Regarding Eligible/Ineligible Activities

Eligible activities under this FOA include those which describe and promote the understanding of scientific and technical aspects of specific energy technologies, but not those which encourage or support political activities such as the collection and dissemination of information related to potential, planned or pending legislation.

G. Notice of Right to Conduct a Review of Financial Capability

EERE reserves the right to conduct an independent third party review of financial capability for applicants that are selected for negotiation of award (including personal credit information of principal(s) of a small business if there is insufficient information to determine financial capability of the organization).

H. Notice of Potential Disclosure Under Freedom of Information Act (FOIA)

Under the FOIA, 5 U.S.C. §552, et. seq., as amended by the OPEN Government Act of 2007, Pub. L. No. 110-175, any information received from the applicant is considered to be an agency record, and as such, subject to public release under FOIA. The purpose of the FOIA is to afford the public the right to request and receive agency records unless those agency records are protected from disclosure under one or more of the nine FOIA exemptions. Decisions to disclose or withhold information received from the applicant are based upon the applicability of one or more of the nine FOIA exemptions, not on the existence or nonexistence of protective markings or designations. Only the agency's designated FOIA Officer may determine if information received from the applicant may be withheld pursuant to one of the nine FOIA exemptions. All FOIA requests received by DOE are processed in accordance with 10 C.F.R. Part 1004.

I. Requirement for Full and Complete Disclosure

Applicants are required to make a full and complete disclosure of all information requested. Any failure to make a full and complete disclosure of the requested information may result in:

- 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.

J. Retention of Submissions

EERE 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 EERE for funding, applicants consent to EERE's retention of their submissions.

K. 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 inventions unless a waiver is granted (see below);
- Class Patent Waiver: DOE has issued a class waiver that applies to this FOA. Under this class 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 waiver, a domestic large business must agree that any products embodying or produced through the use of a subject invention first created or reduced to practice under this program will be substantially manufactured in the United States, unless DOE agrees that the commitments proposed in the U.S. Manufacturing Plan are sufficient.
- Advance and Identified Waivers: Applicants may request a patent waiver that will cover subject inventions that may be invented 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 EERE within the timeframes 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; and

- DEC: Each applicant is required to submit a U.S. Manufacturing Plan as part of its application. If selected, the U.S. Manufacturing Plan shall be incorporated into the award terms and conditions for domestic small businesses and nonprofit organizations. DOE has determined that exceptional circumstances exist that warrants the modification of the standard patent rights clause for small businesses and non-profit awardees under Bayh-Dole to the extent necessary to implement and enforce the U.S. Manufacturing Plan. Any Bayh-Dole entity (domestic small business or nonprofit organization) affected by this DEC has the right to appeal it.

L. Government Rights in Subject Inventions

Where prime recipients and subrecipients retain title to subject inventions, the U.S. Government retains certain rights.

1. Government Use License

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

2. March-In Rights

The U.S. Government retains march-in rights with respect to all subject inventions. Through "march-in rights," the Government may require a prime recipient or subrecipient who has elected to retain title to a subject invention (or their assignees or exclusive licensees), to grant a license for use of the invention to a third party. In addition, the Government may grant licenses for use of the subject invention when a prime recipient, subrecipient, or their assignees and exclusive licensees refuse to do so.

DOE may exercise its march-in rights only 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 satisfied manner;
- The owner has not met public use requirements specified by federal statutes in a reasonably satisfied manner; or
- The U.S. Manufacturing requirement has not been met.

Any determination that march-in rights are warranted must follow a fact-finding process in which the recipient has certain rights to present evidence and witnesses, confront witnesses and appear with counsel and appeal any adverse

decision. To date, DOE has never exercised its march-in rights to any subject inventions.

M. 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.

"Limited Rights Data": The U.S. Government will not normally require delivery of confidential or trade secret-type 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.

Government Rights in Technical Data Produced Under Awards: The U.S. Government normally retains unlimited 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 EERE awards may be protected from public disclosure for up to five years after the data is generated ("Protected Data"). For awards permitting Protected Data, the protected data must be marked as set forth in the awards intellectual property terms and conditions and a listing of unlimited rights data (i.e., non-protected data) must be inserted into the data clause in the award. In addition, invention disclosures may be protected from public disclosure for a reasonable time in order to allow for filing a patent application.

N. Copyright

The prime recipient and subrecipients may assert copyright in copyrightable works, such as software, first produced under the award without EERE approval. When copyright is asserted, the Government retains a paid-up nonexclusive, irrevocable worldwide license to reproduce, prepare derivative works, distribute copies to the public, and to perform publicly and display publicly the copyrighted work. This license extends to contractors and others doing work on behalf of the Government.

O. Personally Identifiable Information (PII)

All information provided by the applicant must to the greatest extent possible exclude PII. The term "PII" refers to information which can be used to distinguish or trace an individual's identity, such as their name, social security number, biometric records, alone, or when combined with other personal or identifying information which is linked or linkable to a specific individual, such as date and place of birth, mother's maiden name. (See OMB Memorandum M-07-16 dated May 22, 2007, found at:

https://www.whitehouse.gov/sites/whitehouse.gov/files/omb/memoranda/2007/m07-16.pdf

By way of example, applicants must screen resumes to ensure that they do not contain PII such as personal addresses, personal landline/cell phone numbers, and personal emails. **Under no circumstances should Social Security Numbers (SSNs) be included in the application**. Federal Agencies are prohibited from the collecting, using, and displaying unnecessary SSNs. (See, the Federal Information Security Modernization Act of 2014 (Pub. L. No. 113-283, Dec 18, 2014; 44 U.S.C. §3551).

P. Annual Independent Audits

If a for-profit entity is a prime recipient and has expended $750,000 or more of DOE awards during the entity's fiscal year, an annual compliance audit performed by an independent auditor is required. For additional information, please refer to 2 C.F.R. § 910.501 and Subpart F.

If an educational institution, non-profit organization, or state/local government is a prime recipient or subrecipient and has expended $750,000 or more of federal awards during the non-federal entity's fiscal year, then a Single or Program-Specific Audit is required. For additional information, please refer to 2 C.F.R. § 200.501 and Subpart F.

Applicants and subrecipients (if applicable) should propose sufficient costs in the project budget to cover the costs associated with the audit. EERE will share in the cost of the audit at its applicable cost share ratio.

APPENDIX A – COST SHARE INFORMATION

Cost Sharing or Cost Matching

The terms "cost sharing" and "cost matching" are often used synonymously. Even the DOE Financial Assistance Regulations, 2 CFR 200.306, use both of the terms in the titles specific to regulations applicable to cost sharing. EERE almost always uses the term "cost sharing," as it conveys the concept that non-federal share is calculated as a percentage of the Total Project Cost. An exception is the State Energy Program Regulation, 10 CFR 420.12, State Matching Contribution. Here "cost matching" for the non-federal share is calculated as a percentage of the federal funds only, rather than the Total Project Cost.

How Cost Sharing Is Calculated

As stated above, cost sharing is calculated as a percentage of the Total Project Cost. FFRDC costs must be included in Total Project Costs. The following is an example of how to calculate cost sharing amounts for a project with $1,000,000 in federal funds with a minimum 20% non-federal cost sharing requirement:

- Formula: Federal share ($) divided by federal share (%) = Total Project Cost
  Example: $1,000,000 divided by 80% = $1,250,000

- Formula: Total Project Cost ($) minus federal share ($) = Non-federal share ($)
  Example: $1,250,000 minus $1,000,000 = $250,000

- Formula: Non-federal share ($) divided by Total Project Cost ($) = Non-federal share (%)
  Example: $250,000 divided by $1,250,000 = 20%

What Qualifies For Cost Sharing

While it is not possible to explain what specifically qualifies for cost sharing in one or even a couple of sentences, in general, if a cost is allowable under the cost principles applicable to the organization incurring the cost and is eligible for reimbursement under an EERE grant or cooperative agreement, then it is allowable as cost share. Conversely, if the cost is not allowable under the cost principles and not eligible for reimbursement, then it is not allowable as cost share. In addition, costs may not be counted as cost share if they are paid by the federal Government under another award unless authorized by federal statute to be used for cost sharing.

The rules associated with what is allowable as cost share are specific to the type of organization that is receiving funds under the grant or cooperative agreement, though are generally the same for all types of entities. The specific rules applicable to:

- FAR Part 31 for For-Profit entities, (48 CFR Part 31); and
- 2 CFR Part 200 Subpart E - Cost Principles for all other non-federal entities.

In addition to the regulations referenced above, other factors may also come into play such as timing of donations and length of the project period. For example, the value of ten years of donated maintenance on a project that has a project period of five years would not be fully allowable as cost share. Only the value for the five years of donated maintenance that corresponds to the project period is allowable and may be counted as cost share.

Additionally, EERE generally does not allow pre-award costs for either cost share or reimbursement when these costs precede the signing of the appropriation bill that funds the award. In the case of a competitive award, EERE generally does not allow pre-award costs prior to the signing of the Selection Statement by the EERE Selection Official.

General Cost Sharing Rules on a DOE Award

1. Cash Cost Share - encompasses all contributions to the project made by the recipient or subrecipeint(s), for costs incurred and paid for during the project. This includes when an organization pays for personnel, supplies, equipment for their own company with organizational resources. If the item or service is reimbursed for, it is cash cost share. All cost share items must be necessary to the performance of the project.

2. In-Kind Cost Share - encompasses all contributions to the project made by the recipient or subrecipient(s) that do not involve a payment or reimbursement and represent donated items or services. In-Kind cost share items include volunteer personnel hours, donated existing equipment, donated existing supplies. The cash value and calculations thereof for all In-Kind cost share items must be justified and explained in the Cost Share section of the project Budget Justification. All cost share items must be necessary to the performance of the project. If questions exist, consult your DOE contact before filling out the In-Kind cost share section of the Budget Justification.

3. Funds from other federal sources MAY NOT be counted as cost share. This prohibition includes FFRDC subrecipients. Non-federal sources include any source not originally derived from federal funds. Cost sharing commitment letters from subrecipients must be provided with the original application.

4. Fee or profit, including foregone fee or profit, are not allowable as project costs (including cost share) under any resulting award. The project may only incur those costs that are allowable and allocable to the project (including cost share) as determined in accordance with the applicable cost principles prescribed in FAR Part 31 for For-Profit entities and 2 CFR Part 200 Subpart E - Cost Principles for all other non-federal entities.

DOE Financial Assistance Rules 2 CFR Part 200 as amended by 2 CFR Part 910

As stated above, the rules associated with what is allowable cost share are generally the same for all types of organizations. Following are the rules found to be common, but again, the specifics are contained in the regulations and cost principles specific to the type of entity:

(A) Acceptable contributions. All contributions, including cash contributions and third party in-kind contributions, must be accepted as part of the prime recipient's cost sharing if such contributions meet all of the following criteria:

(1) They are verifiable from the recipient's records.

(2) They are not included as contributions for any other federally-assisted project or program.

(3) They are necessary and reasonable for the proper and efficient accomplishment of project or program objectives.

(4) They are allowable under the cost principles applicable to the type of entity incurring the cost as follows:

a. For-profit organizations. Allowability of costs incurred by for-profit organizations and those nonprofit organizations listed in Attachment C to OMB Circular A–122 is determined in accordance with the for-profit cost principles in 48 CFR Part 31 in the FAR, except that patent prosecution costs are not allowable unless specifically authorized in the award document. (v) Commercial Organizations. FAR Subpart 31.2—Contracts with Commercial Organizations; and

b. Other types of organizations. For all other non-federal entities, allowability of costs is determined in accordance with 2 CFR Part 200 Subpart E.

(5) They are not paid by the federal government under another award unless authorized by federal statute to be used for cost sharing or matching.

(6) They are provided for in the approved budget.

(B) Valuing and documenting contributions

(1) Valuing recipient's property or services of recipient's employees. Values are established in accordance with the applicable cost principles, which mean that amounts chargeable to the project are determined on the basis of costs incurred. For real property or equipment used on the project, the cost principles authorize depreciation or use charges. The full value of the item may be applied when the item

will be consumed in the performance of the award or fully depreciated by the end of the award. In cases where the full value of a donated capital asset is to be applied as cost sharing or matching, that full value must be the lesser or the following:

a. The certified value of the remaining life of the property recorded in the recipient's accounting records at the time of donation; or

b. The current fair market value. If there is sufficient justification, the Contracting Officer may approve the use of the current fair market value of the donated property, even if it exceeds the certified value at the time of donation to the project. The Contracting Officer may accept the use of any reasonable basis for determining the fair market value of the property.

(2) Valuing services of others' employees. If an employer other than the recipient furnishes the services of an employee, those services are valued at the employee's regular rate of pay, provided these services are for the same skill level for which the employee is normally paid.

(3) Valuing volunteer services. Volunteer services furnished by professional and technical personnel, consultants, and other skilled and unskilled labor may be counted as cost sharing or matching if the service is an integral and necessary part of an approved project or program. Rates for volunteer services must be consistent with those paid for similar work in the recipient's organization. In those markets in which the required skills are not found in the recipient organization, rates must be consistent with those paid for similar work in the labor market in which the recipient competes for the kind of services involved. In either case, paid fringe benefits that are reasonable, allowable, and allocable may be included in the valuation.

(4) Valuing property donated by third parties.

a. Donated supplies may include such items as office supplies or laboratory supplies. Value assessed to donated supplies included in the cost sharing or matching share must be reasonable and must not exceed the fair market value of the property at the time of the donation.

b. Normally only depreciation or use charges for equipment and buildings may be applied. However, the fair rental charges for land and the full value of equipment or other capital assets may be allowed, when they will be consumed in the performance of the award or fully depreciated by the end of the award, provided that the Contracting Officer has approved the charges. When use charges are applied, values must be determined in accordance with the usual accounting policies of the recipient, with the following qualifications:

i. The value of donated space must not exceed the fair rental value of comparable space as established by an independent appraisal of comparable space and facilities in a privately-owned building in the same locality.

ii. The value of loaned equipment must not exceed its fair rental value.

(5) Documentation. The following requirements pertain to the recipient's supporting records for in-kind contributions from third parties:

a. Volunteer services must be documented and, to the extent feasible, supported by the same methods used by the recipient for its own employees.

b. The basis for determining the valuation for personal services and property must be documented.

APPENDIX B – WAIVER REQUESTS AND APPROVAL PROCESSES: 1. FOREIGN ENTITY PARTICIPATION AS THE PRIME RECIPIENT; AND 2. PERFORMANCE OF WORK IN THE UNITED STATES (FOREIGN WORK WAIVER)

1. Waiver for Foreign Entity Participation as the Prime Recipient

As set forth in Section III.A.iii., all prime recipients receiving funding under this FOA must be incorporated (or otherwise formed) under the laws of a State or territory of the United States and have a physical location for business operations in the United States. To request a waiver of this requirement, an applicant must submit an explicit waiver request in the Full Application.

Overall, the applicant must demonstrate to the satisfaction of EERE that it would further the purposes of this FOA and is otherwise in the economic interests of the United States to have a foreign entity serve as the prime recipient. A request to waive the *Foreign Entity Participation as the prime recipient* requirement must include the following:

- Entity name;
- The rationale for proposing a foreign entity to serve as the prime recipient;
- Country of incorporation;
- A description of the project's anticipated contributions to the US economy;
- How the project will benefit U.S. research, development and manufacturing, including contributions to employment in the U.S. and growth in new markets and jobs in the U.S.;
- How the project will promote domestic American manufacturing of products and/or services;
- A description of how the foreign entity's participation as the prime recipient is essential to the project;
- A description of the likelihood of Intellectual Property (IP) being created from the work and the treatment of any such IP; and
- Countries where the work will be performed (Note: if any work is proposed to be conducted outside the U.S., the applicant must also complete a separate request for waiver of the Performance of Work in the United States requirement).

EERE may require additional information before considering the waiver request.

The applicant does not have the right to appeal EERE's decision concerning a waiver request.

2. Waiver for Performance of Work in the United States (Foreign Work Waiver)

As set forth in Section IV.J.iii., all work under EERE funding agreements must be performed in the United States. This requirement does not apply to the purchase of supplies and equipment, so a waiver is not required for foreign purchases of these items. However, the prime recipient should make every effort to purchase supplies and equipment within the United States. There may be limited circumstances where it is in the interest of the project to perform a portion of the work outside the United States. To seek a waiver of the Performance of Work in the United States requirement, the applicant must submit an explicit waiver request in the Full Application. A separate waiver request must be submitted for each entity proposing performance of work outside of the United States.

Overall, a waiver request must demonstrate to the satisfaction of EERE that it would further the purposes of this FOA and is otherwise in the economic interests of the United States to perform work outside of the United States. A request to waive the *Performance of Work in the United States* requirement must include the following:

- The rationale for performing the work outside the U.S. ("foreign work");
- A description of the work proposed to be performed outside the U.S.;
- An explanation as to how the foreign work is essential to the project;
- A description of the anticipated benefits to be realized by the proposed foreign work and the anticipated contributions to the US economy;
- The associated benefits to be realized and the contribution to the project from the foreign work;
- How the foreign work will benefit U.S. research, development and manufacturing, including contributions to employment in the U.S. and growth in new markets and jobs in the U.S.;
- How the foreign work will promote domestic American manufacturing of products and/or services;
- A description of the likelihood of Intellectual Property (IP) being created from the foreign work and the treatment of any such IP;
- The total estimated cost (DOE and recipient cost share) of the proposed foreign work;
- The countries in which the foreign work is proposed to be performed; and
- The name of the entity that would perform the foreign work.

EERE may require additional information before considering the waiver request.

The applicant does not have the right to appeal EERE's decision concerning a waiver request.

APPENDIX C – GLOSSARY

Applicant – The lead organization submitting an application under the FOA.

Continuation application – A non-competitive application for an additional budget period within a previously approved project period. At least ninety (90) days before the end of each budget period, the Recipient must submit to EERE its continuation application, which includes the following information:

i. A report on the Recipient's progress towards meeting the objectives of the project, including any significant findings, conclusions, or developments, and an estimate of any unobligated balances remaining at the end of the budget period. If the remaining unobligated balance is estimated to exceed 20 percent of the funds available for the budget period, explain why the excess funds have not been obligated and how they will be used in the next budget period.

ii. A detailed budget and supporting justification if there are changes to the negotiated budget, or a budget for the upcoming budget period was not approved at the time of award.

iii. A description of any planned changes from the negotiated Statement of Project Objectives and/or Milestone Summary Table.

Cooperative Research and Development Agreement (CRADA) – a contractual agreement between a national laboratory contractor and a private company or university to work together on research and development. For more information, see https://www.energy.gov/gc/downloads/doe-cooperative-research-and-development-agreements

Federally Funded Research and Development Centers (FFRDC) - FFRDCs are public-private partnerships which conduct research for the United States Government. A listing of FFRDCs can be found at http://www.nsf.gov/statistics/ffrdclist/.

Go/No-Go Decision Points: – A decision point at the end of a budget period that defines the overall objectives, milestones and deliverables to be achieved by the recipient in that budget period. As of a result of EERE's review, EERE may take one of the following actions: 1) authorize federal funding for the next budget period; 2) recommend redirection of work; 3) discontinue providing federal funding beyond the current budget period; or 4) place a hold on federal funding pending further supporting data.

Project – The entire scope of the cooperative agreement which is contained in the recipient's Statement of Project Objectives.

Recipient or "Prime Recipient"– A non-Federal entity that receives a Federal award directly from a Federal awarding agency to carry out an activity under a Federal program. The term recipient does not include subrecipients.

Subrecipient – A non-Federal entity that receives a subaward from a pass-through entity to carry out part of a Federal program; but does not include an individual that is a beneficiary of such program. A subrecipient may also be a recipient of other Federal awards directly from a Federal awarding agency. Also, a DOE/NNSA and non-DOE/NNSA FFRDC may be proposed as a subrecipient on another entity's application. See section III.E.ii.

APPENDIX D – DEFINITION OF TECHNOLOGY READINESS LEVELS

TRL 1:	Basic principles observed and reported
TRL 2:	Technology concept and/or application formulated
TRL 3:	Analytical and experimental critical function and/or characteristic proof of concept
TRL 4:	Component and/or breadboard validation in a laboratory environment
TRL 5:	Component and/or breadboard validation in a relevant environment
TRL 6:	System/subsystem model or prototype demonstration in a relevant environment
TRL 7:	System prototype demonstration in an operational environment
TRL 8:	Actual system completed and qualified through test and demonstrated
TRL 9:	Actual system proven through successful mission operations

APPENDIX E – LIST OF ACRONYMS

AEM	Alkaline Exchange Membrane
AMO	Advanced Manufacturing Office
AMR	Annual Merit Review
ANL	Argonne National Laboratory
ANSI/CSA	American National Standards Institute (ANSI)/CSA Group (CSA)
ARPA-E	Advanced Research Projects Agency – Energy
BOP	Balance of Plant
CFR	Code of Federal Regulation
COI	Conflict of Interest
CRADA	Cooperative Research and Development Agreement
DEC	Determination of Exceptional Circumstances
DMP	Data Management Plan
DOE	Department of Energy
DOI	Digital Object Identifier
EERE	Energy Efficiency and Renewable Energy
EMN	Energy Materials Network
EPAct	Energy Policy Act of 2005
FAR	Federal Acquisition Regulation
FCTO	Fuel Cell Technologies Office
FFATA	Federal Funding and Transparency Act of 2006
FOA	Funding Opportunity Announcement
FOIA	Freedom of Information Act
FFRDC	Federally Funded Research and Development Center
GGE	Gallon Gasoline Equivalent
GMI	Grid Modernization Initiative
H-Mat	Hydrogen Materials consortia
HSP	Hydrogen Safety Panel
HTE	High Temperature Electrolysis
HydroGEN	HydroGEN Advanced Water Splitting Materials consortium
HyMARC	Hydrogen Materials – Advanced Research Consortium
INL	Idaho National Laboratory
LBNL	Lawrence Berkeley National Laboratory
LLNL	Lawrence Livermore National Laboratory
LTE	Low Temperature Electrolysis
MPIN	Marketing Partner ID Number
MTA	Materials Transfer Agreement
MYRD&D	Multi-year Research, Development, and Demonstration plan
NDA	Non-Disclosure Acknowledgement / Non-Disclosure Agreement
NE	Office of Nuclear Energy
NEPA	National Environmental Policy Act
NNSA	National Nuclear Security Agency
NREL	National Renewable Energy Laboratory

OEM	Original Equipment Manufacturer
OMB	Office of Management and Budget
ORNL	Oak Ridge National Laboratory
PEC	Photoelectrochemical
PEM	Proton Exchange Membrane
PGM	Platinum Group Metal
PII	Personal Identifiable Information
PNNL	Pacific Northwest National Laboratory
QTR	Quadrennial Technology Review
R&D	Research and Development
RFC	Reversible Fuel Cell
SAM	System for Award Management
SETO	Solar Energy Technologies Office
SMART	Specific, Measurable, Achievable, Relevant, and Timely
SNL	Sandia National Laboratories
SOPO	Statement of Project Objectives
SPOC	Single Point of Contact
SRNL	Savannah River National Laboratory
STH	Solar-to-Hydrogen
STCH	Solar Thermochemical Hydrogen
TRL	Technology Readiness Level
UCC	Uniform Commercial Code
WBS	Work Breakdown Structure
WETO	Wind Energy Technologies Office
WP	Work Proposal