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

H2@Scale New Markets FOA

Funding Opportunity Announcement (FOA) Number: DE-FOA-0002229
FOA Type: Mod 0002
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FOA Issue Date:	January 23, 2020
Submission Deadline for Concept Papers:	February 25, 2020 5:00pm ET
Submission Deadline for Full Applications:	May 4, 2020 5:00pm ET
Expected Submission Deadline for Replies to Reviewer Comments:	June 5, 2020 5:00pm ET
Expected Date for EERE Selection Notifications:	July 2020
Expected Timeframe for Award Negotiations:	July to September 2020

- 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.

Modifications

All modifications to the FOA are [HIGHLIGHTED] in the body of the FOA.

Mod. No.	Date	Description of Modification
0001	1/27/2020	A correction was made to the funding level per award, max funding, and number of awards for Topic Area 3b. The funding level per award is now $2M to 3M, the max per award is changed to $3M, and the number of awards is now 2 to 3.
0002	3/25/2020	Updated Submission Deadline for Full Applications to May 4, 2020 and updated Expected Submission Deadline for Replies to Reviewer Comments to June 5, 2020.

Table of Contents

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-0002229 entitled "H2@Scale New Markets FOA." The activities supported by this FOA are authorized under the Energy Policy Act of 2005 (EPACT 2005) Public Law 109-58 (Aug. 5, 2005), Title VIII - HYDROGEN, Sections 801 to 816. These provisions are found in the United States Code at 42 U.S.C. §§ 16151 to 16165. Title VIII authorizes the Secretary of Energy to conduct a program of research, development and demonstration on technologies relating to the production, purification, distribution, storage, and use of hydrogen energy, fuel cells, and related infrastructure.

i. Background and Purpose

Hydrogen and fuel cells represent a growing industry with potential across sectors and applications to enable resiliency, energy security, emission reductions and economic growth. In recent years, the industry has delivered thousands of fuel cells across the U.S. for use in limited stationary and transportation applications;[1] today, an expansion to heavy-duty applications is taking shape. These potential new hydrogen-use markets include trucks, marine vessels, rail, data centers, and the expanded industrial use of hydrogen.

At the same time, hydrogen is also emerging as an option for large-scale energy storage, enabling renewable or other baseload energy sources. Renewable electricity can be used during peak production times to produce hydrogen using large-scale electrolysis and store it to be used when the renewable resource is not available. Also, baseload power sources, such as nuclear power plants, can produce hydrogen to store excess energy depending on grid demands. This hydrogen can be used for power generation at a later time, injected into the gas grid, or used for an additional revenue stream in applications such as vehicle refueling, steel manufacturing, or with CO_2 for synthetic fuel production. In some cases, hydrogen or chemical hydrogen carriers can be used to transport energy instead of building new electric transmission lines.

[1] https://www.hydrogen.energy.gov/pdfs/review19/plenary_overview_satyapal_2019.pdf

With these increasing opportunities for hydrogen, there is potential for large increases in hydrogen demand.[2-4] However, key challenges around production scale-up, affordability, durability and reliability still must be addressed to jumpstart new markets across heavy-duty applications, new industrial uses and grid integration. More R&D is needed to realize DOE's "H2@Scale" vision and develop these opportunities.

H2@Scale is a DOE initiative[5] that supports innovations to produce, store, transport, and utilize hydrogen across multiple sectors. H2@Scale also covers collaborations between various industry stakeholders and national laboratories. EERE's three core priorities of energy affordability, integration and storage guide H2@Scale R&D activities.

The overall vision of H2@Scale (Figure 1) recognizes hydrogen's versatility as a flexible energy carrier. ***H2@Scale enables—rather than competes with—energy pathways across many industrial sectors.*** Hydrogen can be produced from a variety of domestic sources and used in numerous industrial and consumer applications. While much of the hydrogen used in the United States today comes from low-cost natural gas, adding other production sources can make industries more resilient to potential price volatility.

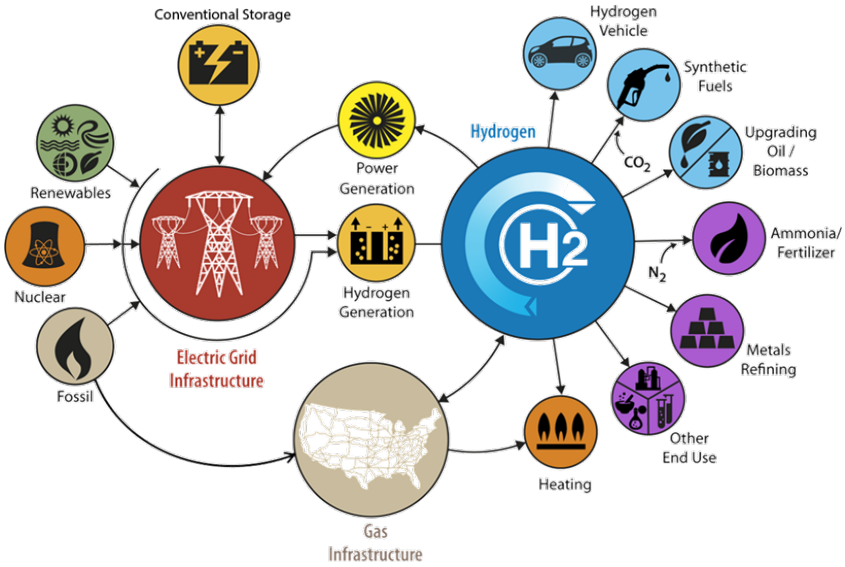

Figure 1: The H2@Scale vision: hydrogen can be produced from diverse domestic resources and is a central input to many important end uses in the industrial, chemical, and transportation sectors

[2] Road Map to a US Hydrogen Economy, http://www.fchea.org/us-hydrogen-study
[3] International Energy Agency, "The Future of Hydrogen" https://webstore.iea.org/download/summary/2803?fileName=English-Future-Hydrogen-ES.pdf
[4] Hydrogen Council, "Hydrogen: Scaling Up", https://hydrogencouncil.com/wp-content/uploads/2017/11/Hydrogen-scaling-up-Hydrogen-Council.pdf
[5] https://www.energy.gov/eere/fuelcells/h2-scale

The technology improvements necessary to advance H2@Scale encompass four main focus areas—better ways to MAKE, MOVE, USE, and STORE hydrogen. The initial H2@Scale FOA, released by EERE in FY19, focused on enabling R&D in these areas—and also funded first-of-kind pilot demonstrations of integrated systems with on-site nuclear power and multiple renewable energy sources. The key to continued advancement of H2@Scale is scaling up affordable hydrogen and fuel cell technology options for expanded supply and demand, enabled in part by continued R&D.

This "H2@Scale New Markets FOA" will provide more than $64M in Federal funding to advance the focus areas of H2@Scale and support EERE's core priorities. Highlighting the importance of *scaling up* hydrogen use across sectors, this FOA will include more novel demonstration projects for several emerging new markets and applications. Specific focus areas include:

- Expanding into new markets for hydrogen in steel manufacturing, maritime applications, and data centers
- Enabling of large-scale manufacturing of electrolyzers to provide further reduction to the cost of hydrogen production at scale
- Reducing the cost of carbon fiber for lower cost compressed hydrogen and natural gas storage
- The development of improved fuel cell stack and membrane technologies for emerging heavy-duty applications
- Workforce development and training to support the growing hydrogen and fuel cell market

ii. Technology Space and Strategic Goals

FCTO focuses on research, development, and demonstration (RD&D) projects to advance emerging hydrogen and fuel cell technologies for transportation and diverse applications enabling energy security, resiliency, and a strong domestic economy.[6] To focus the RD&D it sponsors, FCTO has developed cost targets for specific hydrogen fuel cell, storage, production and delivery technologies. These targets are application-specific and will be further developed in the coming year. As one example, the office has recently published new targets specifically for emerging applications in heavy-duty long haul trucking.[7]

Over the past 40 years, fuel cell technologies have transitioned from highly specialized space applications to commercially available products, including stationary and backup power units, forklifts, and vehicles. Much of this transition

[6] https://energy.gov/eere/fuelcells/about-fuel-cell-technologies-office
[7] Heavy-duty Vehicle Targets, https://www.hydrogen.energy.gov/pdfs/19006_hydrogen_class8_long_haul_truck_targets.pdf

has been enabled by R&D advances from DOE's Hydrogen and Fuel Cells Program,[8] which helped reduce automotive fuel cell costs by 60% since 2006, reduced platinum content by more than 80%, and quadrupled fuel cell durability.[9] Figure 2 shows historical cost reductions along with increased deployments.

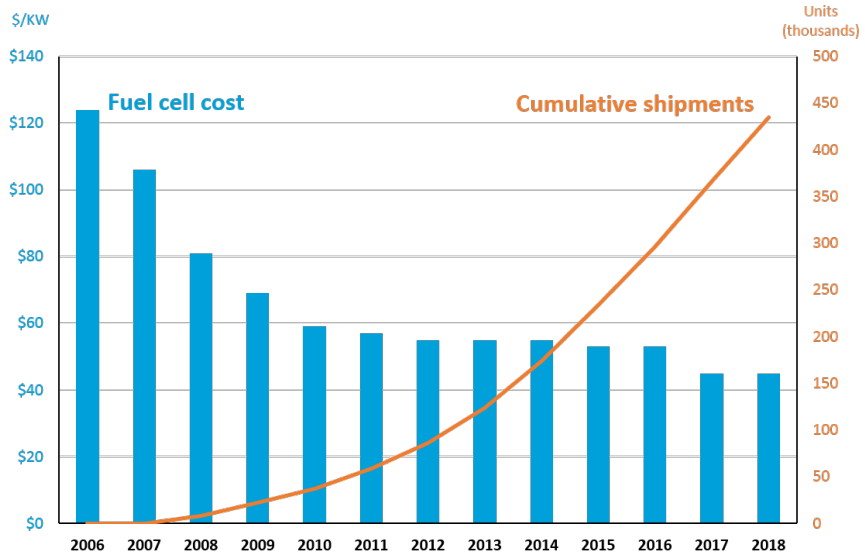

Figure 2: Fuel cell cost reductions are based on modeled cost at high volume in nominal dollars and cumulative global fuel cell shipments for stationary, portable, and transportation applications.[10]

Research and development led by FCTO has also accelerated technologies for producing, delivering, and storing hydrogen:

- Reduced electrolyzer costs by 80% since 2002
- Reduced the cost of tube trailers for hydrogen delivery by over 20% using innovative materials and vessel designs[11,12]
- Reduced the projected cost of onboard compressed hydrogen storage systems by ~30% since 2013[13]

As FCTO works to advance the overall H2@Scale vision, it will support the United States in many strategic goals and areas:

[8] 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.
[9] https://www.energy.gov/eere/fuelcells/fuel-cell-technologies-office-accomplishments-and-progress
[10] https://www.hydrogen.energy.gov/pdfs/17007_fuel_cell_system_cost_2017.pdf
[11] https://www.energy.gov/sites/prod/files/2015/08/f25/fcto_myrdd_delivery.pdf
[12] https://www.osti.gov/biblio/1373926-final-report-development-high-pressure-hydrogen-storage-tank-storage-gaseous-truck-delivery
[13] https://www.hydrogen.energy.gov/pdfs/19008_onboard_storage_cost_performance_status.pdf

- Innovating as a leader in hydrogen manufacturing and export
- Creating domestic jobs in emerging industries and a qualified workforce
- Making the most of available domestic energy resources, such as remote wind and solar resources
- Using the full output of wind and solar energy, as well as baseload generators, that might be curtailed or not profitable depending on grid demands
- Meeting growing domestic demands for advanced transportation technologies, stationary power, and low-emission industrial processes

This FOA advances the H2@Scale vision through six areas of RD&D:

Area 1: Electrolyzer Manufacturing R&D
This area will advance large-scale electrolyzer manufacturing in the U.S., focusing on manufacturing R&D to produce advanced components and systems for multi-MW-scale electrolyzers at high production volumes to lower hydrogen production costs.

Area 2: Advanced Carbon Fiber for Compressed Hydrogen and Natural Gas Storage Tanks
This area will focus on R&D to reduce the cost of compressed gas storage tanks through development of low-cost, high-strength carbon fiber (CF). Projects will seek to achieve targeted high-strength CF properties progressing from small, lab-scale to industry relevant scales.

Area 3: Fuel Cell R&D for Heavy-Duty Applications
This area will advance fuel cells for emerging heavy-duty applications relevant to marine, truck, rail, and data center applications, as well as enable competitive domestic fuel cell system development. Subtopics will include both membrane R&D and fuel cell stack integration.

Area 4: H2@Scale New Markets R&D—HySteel
This area will advance R&D to enable the use of hydrogen in steel manufacturing/iron refining applications, aligned with H2@Scale priorities for fostering new markets for hydrogen.

Area 5: H2@Scale New Markets Demonstrations
This area will jumpstart emerging market opportunities in maritime and data center applications through first-of-a-kind demonstration projects addressing hydrogen production, storage, transport/dispensing/delivery, and utilization at relevant scales.

Area 6: Training and Workforce Development for Emerging Hydrogen Technologies
This area will create cohesive, strategic, and well-coordinated regional efforts to

develop the skills necessary for supporting the growing hydrogen and fuel cell market.

H2@Scale-enabling R&D projects selected through this FOA will address key technology advancements needed to better MAKE, MOVE, USE, and STORE hydrogen. The 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.

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

This FOA includes the following Topic Areas:

Topic Number	Topic Area
Topic 1	**Electrolyzer Manufacturing R&D**
Topic 2	**Advanced Carbon Fiber for Compressed Hydrogen and Natural Gas Storage Tanks**
Topic 3	**Fuel Cell R&D for Heavy Duty Applications**
3a	Membranes for Heavy-Duty Applications
3b	Domestically Manufactured Fuel Cells for Heavy-Duty Applications
Topic 4	**H2@Scale New Markets R&D—HySteel**
Topic 5	**H2@Scale New Markets Demonstrations**
5a	Maritime Demonstrations
5b	Data Center Demonstrations
Topic 6	**Training and Workforce Development for Emerging Hydrogen Technologies**

Topic Area 1: Electrolyzer Manufacturing R&D

Topic 1 Introduction/Background:

Electrolyzers use electricity produced from diverse domestic resources to electrochemically split water into hydrogen and oxygen. The large-scale production of hydrogen from water by electrolysis is viewed as a core enabler to multiple end uses in H2@Scale, such as chemical synthesis and combined heat and power (including tri-generation of heat, power, and hydrogen). As another example,

power-to-gas methods that use electricity to generate hydrogen molecules for energy storage and other applications are rapidly emerging as viable options to help mitigate curtailed renewable resources and contribute to grid stability and resilience. Large, multi-MW scale electrolyzers are needed for these applications, but the high cost of these systems remains a critical challenge impeding widespread adoption. Polymer electrolyte membrane (PEM) electrolyzers currently produced at volumes less than 5 MW/year can cost more than $1000/kilowatt (kW).

Part of this cost comes from the low production volume of manufacturing electrolyzer components and systems, leading to high processing expenses. While electrolyzer costs have been dropping in recent years due to the component- and system-level cost reductions enabled by ongoing FCTO-supported R&D,[14] significant additional cost reductions will require achieving manufacturing economies-of-scale. Cost-effective scale up and high-throughput manufacturing processes are among the necessary innovations.[15] For electrolyzers to produce affordable hydrogen at the DOE cost target of <$2/kg, such innovations will be critical.

A recent analysis using DOE's H2A model[16] shows that H_2 production costs of <$2/kg can potentially be achieved at electricity prices of 3¢/kWh (which is becoming increasingly common with wind and solar installations), when the electrolyzer system capital cost is less than $400/kW.[17] Manufacturing cost analysis supports the concept that these capital costs can be achieved by increasing manufacturing volumes. For example, one study, which assumes technological advances beyond current commercial electrolyzers, shows that increasing the annual production volume from 10 MW to 1,000 MW could potentially decrease PEM electrolyzer system costs down to ~$250/kW.[18] Achieving needed scales of manufacturing will require leveraging lessons learned to date from the hydrogen and fuel cell R&D communities along with the implementation of state-of-the-art manufacturing innovations.

Manufacturers of PEM electrolyzers have historically leveraged work carried out by fuel cell developers. There may therefore be opportunities to adapt state-of-the-art

[14] In the last decade, research has enabled an 80% reduction in capital costs of water electrolyzers for large-scale hydrogen production

[15] K. Ayers, "High Efficiency PEM Water Electrolysis Enabled by Advanced Catalysts, Membranes and Processes", 2019 DOE FCTO Annual Merit Review and Peer Evaluation, https://www.hydrogen.energy.gov/pdfs/review19/p155_ayers_2019_o.pdf.

[16] H2A is a discounted cash-flow model providing transparent reporting of process design assumptions and a consistent cost analysis methodology for H_2 production at central and distributed facilities: http://www.hydrogen.energy.gov/h2a_production.html

[17] DOE Hydrogen and Fuel Cells Program Record, Hydrogen Production Cost from PEM Electrolysis – 2019, publication TBD; https://www.hydrogen.energy.gov/program_records.html.

[18] A. Mayyas, M. Ruth, B. Pivovar, G. Bender, and K. Wipke, NREL/TP-6A20-72740, https://www.nrel.gov/docs/fy19osti/72740.pdf, 2018.

methods used for the manufacture of fuel cells to the specific needs of electrolyzers, capitalizing on some common requirements. Both technologies, for example, require membranes with low cost, high proton conductivity, high electrical insulation, low hydrogen permeation, and high mechanical stability. In practice, roll-to-roll processing (an approach that enables two-dimensional processing of materials in a continuous manner at high process rates) developed specifically for fuel cells could potentially be applied in the manufacture of electrolyzers.

In addition to leveraging fuel cell manufacturing techniques, electrolyzer manufacturing cost could also be lowered by reducing the number of parts in a cell unit and reducing the total number of processing steps.[18,19] Other innovative manufacturing approaches such as additive manufacturing, process automation, and advanced real-time metrology techniques for QC/QA also have potential to enable overall system cost reductions. Standardization in electrolyzer manufacturing processes and in the design/optimization of components, stacks and systems offers another important pathway for the promotion of a more effective and robust domestic supply chain, with significant cost saving potential. A combination of manufacturing and related supply chain innovations may be needed to enable commercialization of large-scale electrolyzers that can produce affordable hydrogen at the target of <$2/kg.[20]

Topic 1 Description/Objective:

EERE seeks applications in R&D of manufacturing techniques to produce advanced components, sub-systems, and systems for multi-MW-scale electrolyzers at high production volumes, leveraging one or more of the innovations/approaches such as those described above. As one example, applicants could address the development of high-performance, lower-cost membrane electrode assemblies (MEAs) with lower amounts of precious metal catalysts (such as Iridium) that can be qualified to meet demanding operating conditions (including dynamic response needed in grid applications) while maintaining performance and durability. State-of-the-art metrics that should be considered, where relevant, are, for example, electrolyzer stack performance of 2 A/cm^2 at 1.9 V with a degradation rate of <1.5 mV/khr.[17] In all proposals, applicants will be expected to address the impact of their manufacturing innovations on projected cost reductions (while maintaining life and other metrics) for large-scale electrolyzers.[20] Some specific areas of interest for this topic include but are not limited to:

[19] M. Hamdan, https://www.energy.gov/sites/prod/files/2014/03/f12/webinarslides052311_pemelectrolysis_hamdan.pdf.

[20] K. Ayers, Technology Roadmap and Development Strategy for Large Scale PEM Electrolysis, "Hydrogen Fuel and Infrastructure Research and Development Workshop Report", Washington D.C., August 2019. https://static1.squarespace.com/static/53ab1feee4b0bef0179a1563/t/5d5c24ea694fb700019ca5b1/1566319851623/FCHEA+DOE+H2+Workshop+Summary+Report+Final.pdf.

- Manufacturing innovations to enable the scale-up of lower catalyst loading technologies and other advances that can reduce cost while meeting performance and durability targets
- Innovations for increasing the rate of catalyst layer deposition during high-volume manufacturing
- Manufacturing techniques that lower the cost, optimize performance, and improve the durability of porous transport layers while maintaining required functionality (e.g., maintain pressure differential) within the electrolyzer (especially on the anode side which poses greater technical challenges)
- Approaches to decrease the stack part count, including integrating multiple components into one and decreasing the number of assembly steps required for stack fabrication
- Innovations in bipolar plate manufacturing for electrolyzers (including improved coating processes at high production volumes), especially for large cell areas >1000 cm^2
- Developing best practices for material/component handling, roll-to-roll techniques, automated component and stack assembly as appropriate, quality control, in situ diagnostics/inspection (at required production rates, in-line), reducing reject rates, addressing non-uniformities, conditioning, and other required steps in the manufacturing process, including approaches that minimize service requirements and enable ease of servicing.

Applications should be more focused on taking proven or commercially viable materials and scaling to high volume manufacturing processes rather than developing new, higher risk materials or manufacturing methods that end with only a small-scale demonstration. Deliverables include new, high-speed, high-volume manufacturing processes that generate cell components, cells, stacks, balance-of-plant, or systems sized for multi-MW or gigawatt electrolyzers.

Applicants must clearly identify the status of their proposed electrolyzer technology as it relates to the state-of-the-art. They should provide sufficient justification, supported by a cost analysis, that the approach proposed has the potential to lead to a competitive modular, scaleable manufacturing solution suitable for low cost, efficient, durable and reliable multi-MW scale electrolyzer deployments. The project must include production of electrolyzers using the manufacturing technology on a scale relevant to high volume manufacturing. For example, a project might include production of electrolyzers using the manufacturing technology on roll-to-roll production machinery (e.g., for MEA manufacturing), or fabricating parts (e.g., porous transport layers of >1000 cm^2) to be relevant to MW-scale electrolyzer stacks. High-throughput manufacturing approaches with appropriate quality inspection (including uniformity and tolerances) are

encouraged. While the focus is on MW-scale stack technology, applicants may propose limited critical BOP activities as long as they are not "one-off" and emphasize/enable manufacturability and scale-up. If components and subsystems can benefit from standardization to help develop a supply chain with higher economies of scale, particularly among electrolyzer manufacturers, such standardization approaches may be proposed.

Topic 1 Project Structure:

Applicants should propose 2-3 year projects for total DOE funding amounts between $3,000,000 and $5,000,000. The funding request should be commensurate with the level of work proposed. Projects should be planned as 2-3 multi-phase efforts (depending on the duration of the project) with a Go/No-Go decision point separating each phase (budget period). Applicants should provide project work plans with strong quantitative Go/No-Go decision points including clear metrics that demonstrate lower cost manufacturability while maintaining the state-of-the-art in performance and durability, targeting the metrics given in the previous section, as applicable. Projects must include at least 20% cost share consistent with R&D activities.

Topic 1 Teaming Arrangements:

Collaborative projects comprising appropriate industrial and manufacturing expertise are strongly encouraged. Applicants should describe succinctly the qualifications, experience, and capabilities of the proposed project team to execute the project plan successfully. If the project lead does not have the facilities/capabilities to carry out the electrolyzer production on a high volume relevant manufacturing scale, it will be necessary to include a project partner or partners who can perform that role. Applicants are highly encouraged to develop teaming arrangements between stack/system integrator and stack and component suppliers. For example, rather than only including suppliers as vendors, domestic component suppliers (e.g., both stack and BOP components) are encouraged as partners/subrecipients, where appropriate. Applicants are encouraged to coordinate and leverage activities funded by the Advanced Manufacturing Office and other relevant DOE Offices, but to avoid duplicative efforts. Strong preference is given to applicants with domestic manufacturing capabilities and intent to manufacture in the United States.

Topic 1 Applications Specifically Not of Interest:

EERE is not interested in projects specifically addressing solid oxide electrolyzers or alkaline (including both liquid KOH and alkaline exchange membrane) electrolyzers.

Topic Area 2: Advanced Carbon Fiber for Compressed Hydrogen and Natural Gas Storage Tanks

Topic 2 Introduction/Background:

The cost of the fuel storage tanks is a major barrier to the mass deployment of hydrogen or compressed natural gas (CNG) fueled vehicles. For instance, the fuel storage system can add up to $50,000[21] to the cost of a CNG-fueled truck compared to a diesel truck. While gaseous fuels such as NG and hydrogen have very high energy densities per unit mass, they have very low energy densities per unit volume, and thus are stored at very high pressures to reduce the size required for the storage system. Hydrogen and CNG are typically stored onboard vehicles at pressures of 350 or 700 bar (5,000 or 10,000 psi) for hydrogen and 250 bar (3,600 psi) for CNG.

While some CNG-fueled vehicles have used all metal tanks, in the U.S. the tanks are usually comprised of either a metal or polymer liner overwrapped by carbon fiber (CF) reinforced composite to reduce weight. The CF composite can contribute over half of the cost of the tank. A recent analysis of the costs for 700 bar hydrogen storage systems for light-duty vehicles indicated that at an annual manufacturing rate of 100,000 systems per year, the CF accounts for approximately 52% of the total system cost of $16/kWh of hydrogen.[22] The DOE ultimate cost target for onboard hydrogen storage in transportation applications is $8/kWh.[23]

The cost of the high-pressure tanks used for gaseous fuel storage must therefore be significantly lowered. Tanks are constructed using a filament winding process with continuous tow fiber. For lower pressure CNG and 350 bar hydrogen tanks, both Type 3 (metal lined) and Type 4 (polymer lined) tanks are in common use. For higher pressure 700 bar hydrogen tanks, Type 4 are more dominant. The amount of CF required for the overwrap depends on a number of factors, such as the nominal service pressure, CF properties (e.g., tensile strength and failure strain), and translation or load-transfer efficiency within the composite. An optimized balance is therefore required between the amount of CF required and the cost of the CF to reduce the overall cost of the tank.

[21] https://afdc.energy.gov/files/u/publication/ng_regional_transport_trucks.pdf

[22] Adams, J., C. Houchins, and R. Ahluwalia. 2019. "Onboard Type IV Compressed Hydrogen Storage System - Cost and Performance Status 2019," *DOE Hydrogen and Fuel Cells Program Record 19008*, https://www.hydrogen.energy.gov/pdfs/19008_onboard_storage_cost_performance_status.pdf

[23] Light-duty Vehicle targets: https://www.energy.gov/eere/fuelcells/doe-technical-targets-onboard-hydrogen-storage-light-duty-vehicles; Heavy-duty Vehicle targets: https://www.hydrogen.energy.gov/pdfs/19006_hydrogen_class8_long_haul_truck_targets.pdf

Toray T700S[24] has been used as the baseline commercial fiber in the DOE cost analyses.[22] Based on input from tank and automotive manufacturers, the price for Toray T700S in 2019 ranged from $26-30/kg CF, depending on the annual CF demand.[22] Assuming CF cost accounts for approximately 50% of total system cost, then to meet the DOE ultimate target of $8/kWh for hydrogen storage onboard vehicles, CF cost would need to be reduced to approximately $13-15/kg CF.

The cost of CF is approximately evenly split between the cost of the precursor fiber and the cost of converting the precursor fiber to CF.[25] DOE has previously supported R&D on novel, low-cost precursors and advanced conversion processes with potential to lead to low-cost, high-strength CF[26- 31] and reduce energy use.[32] Today, high-tensile strength CF is almost exclusively produced from polyacrylonitrile (PAN) precursor fibers. PAN fiber precursors are typically produced by a solution spinning process that requires extensive capital investment for the fiber formation and solvent recovery processes. The conversion of PAN precursor fiber to CF includes several moderate- to high-temperature processing steps to stabilize and partially oxidize the material, followed by high-temperature, inert atmosphere carbonization steps to drive off most non-carbon elements and leave essentially pure carbon. The mass yield of the PAN fiber to CF conversion process is approximately 50%, meaning that approximately two kg of PAN fiber is required to produce one kg of CF. To reduce the cost of high-tensile strength CF, cost reductions will be required in both the precursor and conversion processes.

[24] TorayCA T700S data sheet: https://www.toraycma.com/file_viewer.php?id=4459, accessed 22 Nov. 2019.
[25] Warren, C. D., "Carbon Fiber Precursors and Conversion", *Oak Ridge National Laboratory*, Department of Energy Physical-Based Storage Workshop: Identifying Potential Pathways for Lower Cost 700 Bar Storage Vessels, https://www.energy.gov/sites/prod/files/2016/09/f33/fcto_h2_storage_700bar_workshop_3_warren.pdf, November 22, 2019.
[26] Warren, C.D. and F.L. Paulauskas. 2014. "Development of Low-Cost, High-Strength Commercial Textile Precursor (PAN-MA)," DOE FCTO Annual Progress Report, https://www.hydrogen.energy.gov/pdfs/progress14/iv_f_2_warren_2014.pdf
[27] Paulauskas, F.L., B. Norris, K. Yarborough, F. Xiong, 2016, "Melt Processable PAN Precursor for High Strength, Low-Cost Carbon Fibers", DOE FCTO Annual Progress Report.
[28] Weisenberger, M.C., E. A. Morris, 2018, "Precursor Development for Low-Cost, High-Strength Carbon Fiber for Composite Overwrapped Pressure Vessel Applications," DOE FCTO Annual Progress Report.
[29] Chung, T.C.M., 2018, "Developing a New Polyolefin Precursor for Low-Cost, High-Strength Carbon Fiber," DOE FCTO Annual Progress Report.
[30] Dai, S., H. Martin, H. Luo, R. Mayes, A. Naskar, 2018, "Novel Plasticized Melt-Spinning Process of Polyacrylonitrile Fibers Based on Task Specific Ionic Liquids," DOE FCTO Annual Progress Report.
[31] DOE Vehicles Technologies Office, "Lightweight Materials R&D," 2015 Annual Report: https://www.energy.gov/sites/prod/files/2016/09/f33/Lightweight%20Materials%20-%202015%20Annual%20Report.pdf
[32] DOE Advanced Manufacturing Office, "Bandwidth Study on Energy Use and Potential Energy Saving Opportunities in U.S. Carbon Fiber Reinforced Polymer Manufacturing," September 2017: https://www.energy.gov/sites/prod/files/2019/05/f62/CFRP_bandwidth_study_2017_0.pdf

Topic 2 Description/Objective:

EERE seeks applications to significantly reduce the cost of high-pressure compressed hydrogen and natural gas storage tanks through the development and demonstration of low-cost, high-tensile strength CF production and consideration of end-of-life materials reuse and recycling. In order to produce low-cost carbon fibers, projects are expected to utilize novel low-cost precursors and/or advanced high-efficiency, low-cost conversion processes. The resulting CF needs to be suitable for use in fiber-winding processes, and meet the requirements for use in high-pressure compressed hydrogen and natural gas storage tanks.

While proposed work is to be focused on demonstrating low-cost, high-performance CF, the ultimate objective of the projects should be to lower the cost of compressed gas storage tanks. Applications will be therefore evaluated and progress tracked by both the projected cost and demonstrated performance of the produced CF, and the projected cost and performance of compressed gas storage tanks constructed using the produced CF.

Applications will be expected to include projections for 250 and 700 bar compressed gas storage tanks, comparing projected tank cost and performance (e.g., weight, total volume) between those constructed with Toray T700S CF at $28/kg and those constructed with the proposed CF. The tanks should be designed to comply with American National Standards Institute (ANSI) NGV2/HGV2 standards as appropriate. An ultimate target for this topic is at least a 10% reduction in modeled cost of a 250 bar CNG tank using the developed CF compared to Toray T700S.

Topic 2 Project Structure:

Applicants should propose projects planned as two phase efforts, with each phase divided into multiple budget periods of approximately 12 months each. Phase I should be planned for 24 months (2 budget periods). At the end of Phase I, EERE expects to conduct a down-select to a single award to continue into Phase II. Phase II should be planned for 24-36 months (2-3 budget periods). Applicants should propose projects for a maximum total DOE funding of $9,000,000, with a maximum of $3,000,000 for Phase I and $6,000,000 for Phase II. The funding request should be commensurate with the level of work proposed. Applicants should provide project work plans with strong quantitative Go/No-Go decision points separating each budget period that include targeted CF and tank properties described in more detail below. Projects must include at least 20% cost share consistent with R&D activities.

During Phase I, the projects should demonstrate the ability to produce their proposed precursor fiber in sufficient quantity to demonstrate the conversion into CF and carry out cost analyses to project costs at annual production volumes to

meet onboard tank manufacturing demands. By the end of Phase I, projects will be expected to demonstrate conversion to carbon fiber of at least 100 continuous meters of a fiber tow with a minimum of 100 filaments. Additionally, projects will be required to provide projected tank cost and performance constructed with the CF. Projects will be evaluated based on the projected tank cost and performance as well as the properties (e.g., tensile strength, tensile modulus, failure strain) of the resulting carbon fiber.

Phase II of the project should demonstrate scale-up to a minimum of 12,000 filament tows, with optimization of the precursor spinning and conversion processing to CF. Sufficient quantities of CF should be produced to enable the manufacture of prototype tanks. Three prototype tanks should be designed and built to either ANSI NGV2 or HGV2 standards with nominal working pressure of 250 or 700 bar, respectively, and with an internal volume of at least 5 L. At least two tanks must be burst tested to determine their minimum burst pressure.

Additionally, as part of Phase II, consideration is to be given to end-of-life reuse and recyclability of the CF composites used in the tank construction.

Final Phase II deliverables include performance results of the optimized CF produced (e.g., mass yield, tensile strength, tensile modulus, failure strain); results from manufacture and testing of the tanks (tank mass, overall dimensions, burst pressure); a comparison of the prototype tank cost and performance to tanks manufactured with Toray T700S; cost analysis for volume production of the CF; and potential concepts for end-of-life reuse and recycling of the CF composites. DOE may require data and sample materials be provided to third parties for independent characterization and analyses. DOE expects to use the provided data to have independent modeling and analyses performed by Oak Ridge National Laboratory (ORNL) to project CF costs, Argonne National Laboratory to predict tank performance, and Strategic Analysis to model storage system cost for comparison with baseline systems.

Topic 2 Teaming Arrangements:

Applicants should describe a research partnership or consortium, consisting of at least three team members, that must include partners and/or suppliers capable of carrying out the proposed effort and comply with U.S. Manufacturing Commitments (Section IV.D.xv). Work on the scale-up optimization and production will be carried out at industry relevant scales. Project teams are therefore expected to include members capable of scaling up the precursor fiber production, with expertise in production of structural composite materials and CF production, as well as partners that can model, manufacture and test the prototype tanks. Budgetary information should be provided at a task level for each performing entity.

Selected applicants will be highly encouraged to work with the Carbon Fiber Technology Facility (CFTF)[33] at ORNL on the conversion optimization of the precursor fibers to CF. If selections are made on projects proposing involvement with CFTF, funding for ORNL support should be included in the project proposal, but will be provided directly by DOE. Strong preference will be given to applicants with domestic manufacturing capabilities and intent to manufacture in the United States.

Topic Area 3: Fuel Cell R&D for Heavy-Duty Applications

Hydrogen fuel cells are an attractive technology to power zero-emissions heavy-duty vehicles, including truck, rail, and marine applications. They can offer several advantages over incumbent diesel engine technologies, including higher efficiency, reduced emissions, higher torque, and no noise pollution. Additionally, they offer fast fueling and adequate fuel storage for applications demanding longer range. These early-market applications can pave the way for expanding hydrogen infrastructure and contribute to greater adoption of hydrogen and fuel cells as part of the H2@Scale vision.

For heavy-duty fuel cell vehicles to be market competitive, it is necessary to improve the performance and durability of polymer electrolyte membrane fuel cells (PEMFCs) currently employed in automotive applications. Heavy-duty applications require significantly longer vehicle lifetimes (>25,000 hours/1,000,000 miles for heavy-duty trucks), and therefore require improved fuel cell durability compared to light-duty vehicles. Furthermore, because of this extended lifetime, hydrogen fuel costs comprise a greater proportion of heavy-duty vehicle lifecycle cost, making increased efficiency a key parameter for economic viability.

The two subtopics under this topic area cover fuel cell R&D for emerging heavy-duty applications relevant to trucks, marine, rail, and data centers. Subtopic 3A focuses on improvement of membrane technologies suitable for high temperature operation in heavy-duty vehicles. Subtopic 3B focuses on the manufacturing of specialized heavy-duty stacks to enable competitive domestic fuel cell system development.

Subtopic 3A: Membranes for Heavy-Duty Applications

Subtopic 3A Background/Introduction:

Enhanced fuel cell performance and durability, beyond what has been achieved for light-duty vehicle applications, is essential for heavy-duty fuel cell vehicles to be commercially competitive. Fuel cells need to be able to handle heavy-duty drive

[33] Oak Ridge National Laboratory Carbon Fiber Technology Facility website: https://www.ornl.gov/facility/cftf

cycles while maintaining their power output over their operational lifetime (e.g., 1,000,000 miles for heavy-duty trucks); fuel cell degradation also reduces efficiency and fuel economy, payload and grade speed.[34] In addition to stringent lifetime requirements, heavy-duty applications would benefit from enhanced fuel cell efficiency to drive low fuel consumption and higher temperature operation to facilitate system heat rejection and enable lower system size and cost.

Membranes and their respective ionomers are a critical fuel cell component. They are likely to degrade; membrane durability is affected by both humidity variations, which cause mechanical stresses from swelling and shrinking, and chemical degradation, which can be accelerated by degradation products from other components (e.g. bipolar plates) in the fuel cell system. Also, membranes need low-hydrogen cross-over to maintain high fuel cell efficiency and performance. Membrane degradation and hydrogen cross-over can be somewhat mitigated by the use of thicker membranes, but this increases cost and membrane resistance which negatively affects fuel cell performance. As for membranes, electrode ionomers must also maintain conductivity under high temperature, low relative humidity conditions and meet more strenuous long-term durability requirements. Hence, the need for inexpensive and, more importantly for heavy-duty applications, durable high-performing membrane alternatives to currently available solutions.

In addition to achieving high membrane performance and durability, a promising approach to meeting the demands of heavy-duty vehicle applications is higher temperature operation of the fuel cell (up to 120 °C), which can improve the stack efficiency and power output. A fuel cell operating at higher temperature can also more effectively reject heat, leading to lower cost radiators and increased efficiency through decreased parasitic power loss from cooling. However, operating the fuel cell at temperatures above 100 °C presents challenges for PEM (e.g., accelerated membrane degradation). Also, higher temperature operation lowers the feasible relative humidity in the fuel cell, resulting in reduced membrane proton conductivity and performance.

State-of-the-art membrane technology is limited in its ability to address the aforementioned issues pertaining to fuel cell heavy-duty applications. While higher membrane cost can be tolerated for heavy-duty applications in relation to what is desired for automotive fuel cells, the stringent durability and performance requirements for heavy-duty applications, as well as the need for sustained high-temperature membrane operation, require innovative approaches. Also, today's membrane suppliers and manufacturing approaches have been mainly targeting light-duty fuel cell applications. Innovative membranes, operating at hotter and

[34] Heavy-Duty Vehicle Targets: https://www.hydrogen.energy.gov/pdfs/19006_hydrogen_class8_long_haul_truck_targets.pdf

drier conditions while meeting heavy-duty durability and performance requirements will enable fuel cell competitiveness and establish a healthy and strong membrane manufacturing base.

Subtopic 3A Description/Objective:

EERE seeks applications for membrane technologies suitable for high temperature operation in heavy-duty vehicle applications. Technologies should demonstrate significant progress toward the 2030 heavy-duty truck targets of 25,000 hour lifetime, 68% peak efficiency, and $80/kW fuel cell system cost (and ultimate targets of 30,000 hour lifetime, 72% peak efficiency, and $60/kW fuel cell system cost). Projects should explore the relationships between operating conditions and the conductivity and durability of the membrane. In particular, operating temperature in the range of 100–120 °C and relative humidity in the range of 20–30% should be investigated.

Applicants should seek to significantly surpass the durability of existing state-of-the-art membranes, and should discuss how they will assess membranes for the durability requirements of heavy duty applications, including the 25,000 hour lifetime target and high temperature operation. Options for durability assessment include extending the duration of the recommended membrane accelerated stress tests (ASTs) or proposing new or modified AST protocols. To ensure efficient operation, applicants should seek to meet the technical targets described in FCTO's multi-year research, development, and demonstration (MYRDD) plan,[35] including:

- area-specific proton resistance (< 0.02 ohm cm^2 under standard and maximum temperature operating conditions; < 0.2 ohm cm^2 at -20 °C for cold start),
- oxygen and hydrogen gas crossover (< 2 mA/cm^2), and
- electrical resistance (> 1000 ohm cm^2).

Meeting these targets will enable additional potential use for light-duty vehicle applications. Applicants should also focus on lowering membrane cost, especially through high volume manufacturing. Consideration of lifecycle concerns is encouraged, including recovery and recycling of platinum and environmental impacts of manufacturing and disposal. Investigation of the impacts of chemical contaminants on membrane durability and conductivity may be included.

Proposed projects may include perfluorosulfonic acid (PFSA) or non-PFSA membranes capable of meeting the specified requirements. Interest is limited to membranes for high-power-density PEMFCs suitable for vehicle applications. In

[35] Technical performance and durability targets listed in Table 3.4.6 of the Fuel Cells MYRDD: http://energy.gov/sites/prod/files/2016/06/f32/fcto_myrdd_fuel_cells_0.pdf.

particular, proposed membranes must be capable of providing sufficient low temperature conductivity to meet vehicle cold start requirements. Membrane thickness may increase somewhat relative to state of the art membranes for light duty vehicles to provide improved durability, but increases in thickness must be limited to ensure that all membrane and MEA requirements can be concurrently met. Proposals that rely on increased thickness alone to meet durability requirements will not be considered. The application must encompass work up to, and including, single cell MEA testing at a size of ≥ 50 cm^2.

Development of electrode ionomers for heavy-duty applications is also of interest. Electrode ionomers must also maintain conductivity under high temperature, low relative humidity conditions and meet more strenuous long-term durability requirements. Proposed electrode ionomer development work may include improvements to stability, intrinsic conductivity, and dispersion in electrodes. The focus of proposed projects, however, should not be solely on electrode ionomers.

Deliverables of the proposed work must include a set of MEAs (6 or more, each with active area ≥ 50 cm^2) made available for independent testing and evaluation by the Fuel Cell Performance and Durability (FC-PAD) core lab consortium,[36] and membrane materials in sufficient quantities to enable independent MEA assembly and evaluation.

Subtopic 3A 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. Projects must include at least 20% cost share consistent with R&D activities.

Subtopic 3A Teaming Arrangements:
Multi-disciplinary teams are encouraged but not required. A potential domestic membrane manufacturer as part of the team is encouraged.

Subtopic 3A Applications Specifically Not of Interest:
Proposals for electrolyte materials for solid oxide fuel cells, molten carbonate fuel cells, phosphoric acid, polybenzimidazole-type phosphoric-acid fuel cells, and alkaline anion exchange membranes, will not be considered. Also, proposals that rely on increased thickness alone to meet durability requirements will not be considered.

[36] https://www.fcpad.org/

Subtopic 3B: Domestically Manufactured Fuel Cells for Heavy-Duty Applications

Subtopic 3B Introduction/Background:

To enable commercially viable systems for heavy-duty applications, advances are required for fuel cell stacks, balance-of-plant components, systems integration/system designs and their associated manufacturing technologies and processes. A standardized, modular and scalable PEMFC stack that meets performance, efficiency, durability, and affordability requirements for heavy-duty applications, could enable significant cost reductions and potential for scale up. Stacks designed with modularity and flexibility in mind for use in multiple applications would also offer benefits in potential economies of scale as they are applied in multiple markets. In addition to standardized and modular stack designs, standardized and modular subsystems and even systems (where feasible) could offer benefits in terms of common platforms for more than one application.

Today there are limited suppliers for fuel cell stacks and systems for heavy-duty applications. Typically, stacks and systems designed for light-duty vehicles or other applications are used for heavy-duty markets. However, these do not meet the required performance to be competitive with incumbent or emerging technologies. The supply chain and manufacturing processes are still virtually non-existent. Investment in manufacturing processes is only beginning, and a number of unknowns still exist. For instance, best practices/lessons learned are not available for material/component handling, roll-to-roll techniques, automated component and stack assembly, quality control, in-situ diagnostics/inspection (at required production rates, in line), reducing reject rates, addressing non-uniformities, conditioning, testing/protocols, etc.

Developing a purpose-built stack with manufacturability in mind and applicability across heavy-duty platforms/applications would advance the commercial viability of heavy-duty fuel cell systems. In addition, the need for components with improved durability and efficiency extends to the balance of plant (BOP). For instance, as system developers rely on higher pressure operation, air handling subsystems are of greater importance. Improvements to BOP component durability increase system reliability and decrease maintenance cost, and improvements to BOP component performance decrease parasitic power losses, thereby decreasing fuel use. Based upon the relatively large fraction of cost and failures attributed to the BOP in fuel cell automotive applications, solely stack solutions will not be adequate to meet overall system needs. However, the stack is the core of the fuel cell system and will dictate BOP requirements. Hence the primary focus is on fuel cell stacks, with a secondary focus on BOP, subsystems and systems.

Subtopic 3B Description/Objective:

EERE seeks the development and demonstration of a modular 80-100 kW_{net} PEM fuel cell stack in a system with potential to meet the 2030 system targets that are suitable for multiple heavy-duty applications, including:[37]

- High durability: ≥25,000 hours of operation (30,000 hours ultimate target)
- High efficiency: ≥68% system efficiency (≥72% ultimate)
- System cost: \$80/kW_{net} (≤\$60/kW_{net} ultimate)
- Limited platinum group metal (PGM) loading: nominally about 0.2-0.3 mg_{PGM}/cm^2

The intent is not a project to develop a one-off prototype; applicants should consider manufacturability and scalability. The proposed stack should be modular and applicable to real-world systems, and applicants should highlight the suitability of the stack for multiple system configurations (e.g., multiple stacks using a common BOP sized to meet the needs of various heavy-duty applications). The development and application of advanced manufacturing techniques may be included in the work scope to develop the final stack deliverable.

Applicants should explain how the proposed stack design would be incorporated into a system that has the potential to meet the required targets. The use of advanced manufacturing techniques for scaling and the incorporation of design considerations to facilitate the recovery and recycling of components are also encouraged. Furthermore, demonstration of stacks operating at higher temperature (≥ 100 °C, for heat rejection) and stack designs that would decrease the cost of BOP and power electronics components are desirable.

While the focus of this topic is on the fuel cell stack, applicants may propose additional critical BOP (e.g. air handling, heat rejection) or system level deliverables, *if provided within the available funds.* If any BOP is included, it should at a minimum be sufficient for evaluation in a generic system context; and innovation is encouraged for either improvements of BOP or for scaling and/or standardization across platforms.

In order to build a domestic heavy-duty fuel cell supply chain, this topic prioritizes American manufacturing capability by encouraging the incorporation of domestically sourced, state-of-the-art stack components into a standardized stack suitable for multiple heavy-duty applications. Note that the focus of this topic is not on material and cell component R&D, but on advancing the technology and *manufacturability* at the stack and system level. The results from the stack and

[37] Heavy-duty Vehicle Targets, https://www.hydrogen.energy.gov/pdfs/19006_hydrogen_class8_long_haul_truck_targets.pdf

prototype system development and testing work will provide further insight on critical early stage R&D needs for heavy-duty fuel cell systems and approaches to strengthen the domestic supply chain.

The final deliverable of the proposed project should include validation of an 80-100 kW PEMFC stack prototype. This stack should meet the requirements outlined under this FOA topic description as determined by applicant testing and reported to DOE. This should include a detailed cost analysis. 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 modular fuel cell manufacturing solution suitable for heavy-duty applications (e.g., truck, marine, rail).

Subtopic 3B Project Structure:
Applicants should propose projects for no more than 3 years in length for a maximum total DOE funding of $3,000,000. Awards may range from $2,000,000 to $3,000,000 each. EERE intends to select 2 to 3 projects based on available funds and proposed scope. The funding request should be commensurate with the level of work proposed. The projects should be planned as a two-phase effort with a quantitative Go/No-Go decision point based on demonstrating a 1-5 kW stack prototype separating each phase (budget period). Each budget period should nominally be 12-18 months long. Projects must include at least 20% cost share consistent with R&D activities.

Subtopic 3B Teaming Arrangements:
Applicants are highly encouraged to develop teaming arrangements between stack/system integrator and stack and component suppliers. For example, rather than only including suppliers as vendors, domestic component suppliers (e.g. both stack and BOP components) are encouraged as partners/sub-recipients. Partnering with end user(s) is also encouraged. Applicants should plan to coordinate with the Fuel Cell Systems Modeling and Analysis effort at Argonne National Laboratory for system optimization, assessment and cost analysis.

Subtopic 3B Applications Specifically Not of Interest:
Projects focused on fuel cell component R&D are not of interest. Strong preference is given to domestic sourcing of components and to applicants with domestic manufacturing capabilities and intent to manufacture in the United States. Systems based on fuel cell technologies other than PEMs such as alkaline exchange membrane or solid oxide, are not of interest.

Topic Area 4: H2@Scale New Markets R&D—HySteel

Topic 4 Introduction/Background:

A key objective of the H2@Scale initiative is to enable hydrogen use in emerging industrial applications. One of the most promising of these is in steelmaking, which is an essential segment of the U.S. economy accounting for about 6% of delivered energy in U.S. industry.[38] In current steelmaking processes, hydrogen is used in syngas (a blend of carbon monoxide and hydrogen) to reduce iron ore, and is also used in pure form (100% hydrogen) to anneal steel.

Several R&D and demonstration projects worldwide have recently begun exploring increasing the use of renewable hydrogen in these applications. Examples include the GrinHy project, wherein a prototype 150 kW high-temperature electrolyzer is being demonstrated in Germany to produce hydrogen for metals annealing; the H2FUTURE project, wherein 6 MW of electrolysis are being installed in Austria to produce hydrogen for iron reduction; the SuSteel project wherein an industry team in Austria is conducting foundational research on breakthrough hydrogen plasma-based approaches to iron reduction; and the HYBRIT project that is constructing a pilot project in Sweden for hydrogen-based iron reduction.

The two main approaches to steelmaking are electric arc furnaces (EAFs) and basic oxygen furnaces (BOFs). Both EAFs and BOFs are supplied with iron that has been produced through reduction of iron ore. Today, the reductant used in refining of iron ore is typically either carbon monoxide (CO) or syngas. CO is used when iron is being refined in a blast furnace, which is supplied with coke that is ultimately burned to produce CO and trace amounts of hydrogen. Blast furnaces operate at temperatures up to 1,650°C, and represent the most energy-intensive step in steelmaking.[39,40]

An alternative to blast furnaces is direct reduction of iron (DRI) furnaces, which achieve higher efficiencies. DRI furnaces, which typically operate at temperatures up to 1,090°C,[41] utilize syngas that is produced from reforming of natural gas or gasification of coal. Syngas used in DRI is typically comprised of about 55% hydrogen and 36% CO; it is important to note, however, that in select DRI installations, concentrations of hydrogen in syngas have reached over 75%.[41,42]

[38] https://www.eia.gov/todayinenergy/detail.php?id=27292
[39] https://www.energy.gov/sites/prod/files/2018/08/f54/fcto-h2-scale-kickoff-2018-19-green.pdf
[40] https://www.steel.org/~/media/Files/AISI/Making%20Steel/TechReportResearchProgramFINAL.pdf
[41] https://www.energy.gov/sites/prod/files/2018/08/f54/fcto-h2-scale-kickoff-2018-8-chevrier.pdf
[42] https://issuu.com/quartzbusinessmedia/docs/steel_times_international_january_f/34

Conventional blast furnace technology requires the use of coke to manage gas flow through the furnace, and to maintain the furnace temperature high enough for iron reduction. As a result, the quantity of hydrogen that can be injected, and the associated emission benefit, is limited by the minimum rate of coke injection that the furnace can accept. DRI is also commercial today, but far less common. The use of high concentrations of hydrogen appears to be feasible in DRI in the near-term with some modifications to process and technology. Flash ironmaking technology (FIT) is a less mature process that instead relies on reduction of iron ore as a concentrate in flash furnaces. The advantage of FIT is that it eliminates pelletizing and sintering of iron ore. As a result, the energy consumption of FIT can be over 30% lower than that of blast furnaces, regardless of the reductant used.[40]

Plasma-based approaches are in much earlier stages of development than DRI or FIT, but have the potential for higher efficiencies. Plasma-based approaches reduce the activation energy of iron reduction, and heat iron ore in a localized manner. As a result, these approaches have potential to consume less energy than approaches relying on gaseous hydrogen. Plasma-based approaches have been explored at laboratory scale, but face many substantial R&D challenges to viability.

Many concepts that would enable the use of hydrogen for iron reduction have been explored in recent years. Advancement of such concepts toward commercial viability requires additional R&D and systems engineering to enhance long-term reliability, efficiency, and scalability. It is important to note that use of a small quantity of natural gas may always be essential to the iron reduction processes to optimize the carbon content of the iron product, and to control process temperature.[42]

Topic 4 Description/Objective:

EERE seeks multi-party R&D projects that advance promising concepts for iron reduction in hydrogen gas toward proof-of-concept of commercial viability at a pre-pilot scale. The ultimate goal is to both create new markets for hydrogen at scale and to develop affordable technologies to decrease life cycle emissions in steel manufacturing. Specific iron reduction technologies of interest include but are not limited to DRI in hydrogen, FIT, the use of hydrogen plasmas, and use of hydrogen in other methods of iron reduction, such as injection in existing blast furnaces.

Applicants are encouraged to focus either on advancing critical path R&D challenges in multiple emerging approaches to iron reduction, and/or to focus on achieving a step-change improvement in commercial viability of a specific approach to iron reduction.

Applicants should include bench-scale verification of at least one approach to iron reduction at a scale of 1 tonne/week. If other amounts are proposed, a justification

should be provided. Concepts proposed should be ultimately scalable to capacities of at least 5,000 tonnes/day, to meet the requirements of existing steel mills. Concepts should also target achieving an energy consumption no higher than that of current state-of-the-art DRI plants, which are baselined at approximately 11 gigajoule (GJ)/tonne steel, including energy required to produce hydrogen from steam methane reforming.[43] Applicants should include preliminary estimates of the energy efficiency expected of concepts proposed, detail the assumptions of those estimates and the boundary conditions, and also provide estimates for emissions associated with the process. Concepts should also target achieving capital costs no higher than those of conventional blast furnaces, which are baselined at approximately $210/tonne-pig iron/year.[44]

Examples of key R&D challenges that have been identified in prior work, and could be addressed in applications to this topic include but are not limited to:[45- 49]

- Process flow modeling to optimize key parameters that influence the efficiency and reactor sizes in DRI, and to ensure reliable operation by mitigating "sticking"/fusion of iron ore particles. Modeling should be coupled with experimental validation. Projects should aim to identify a clear path toward reduction in the cost of DRI in hydrogen. Examples of relevant parameters include:
  - Temperature and pressure of hydrogen gas
  - Size, morphology, porosity, and tortuosity of iron oxide pellets.
- Systems engineering of hydrogen-based iron refining processes to optimize the quality of the resulting iron, accounting for the cost of process enhancements (e.g. optimizing the properties of slag) as well as the price of higher purity steel (e.g. with lower amounts of SiO_2 and gangue)
- Comprehensive experimentation and thermodynamic modeling of the kinetics of iron ore reduction under varying conditions (e.g. temperature, water vapor concentration), to identify strategies to improve efficiency of FIT or DRI.
- Energy-efficient synthesis of hydrogen plasmas at high densities at temperatures below the boiling point of iron ore, to enable their use in iron reduction.
- Foundational understanding of the interactions between hydrogen plasmas and iron ore at interfaces.

[43] https://www.osti.gov/servlets/purl/1485414
[44] https://iea-etsap.org/E-TechDS/PDF/I02-Iron&Steel-GS-AD-gct.pdf
[45] https://www.osti.gov/servlets/purl/1485414
[46] https://arxiv.org/ftp/arxiv/papers/1402/1402.1715.pdf
[47] https://www.sciencedirect.com/science/article/pii/S0016236117300753
[48] https://onlinelibrary.wiley.com/doi/pdf/10.1002/srin.201900108
[49] https://www.mdpi.com/2075-4701/8/10/751/pdf

- Materials compatibility challenges, safety issues, and approaches to address them.
- Systems engineering of a reactor compatible with a plasma-based process[50] or other advanced process.

R&D advancements in all established and emerging methods of iron reduction will require a combination of computational modeling of process kinetics to guide system design, experimental verification of new concepts to guide modeling and process improvements, systems engineering, and technoeconomic analysis to assess value proposition of concepts being considered and guide system design. Successful applications will incorporate R&D activities across each of these disciplines. Deliverables should include an assessment of cost (capital and operating) and total emissions reduction expected with various pathways. Based on technoeconomic assessments, potential cost targets for hydrogen (production, storage, and delivery) should be provided.

Topic 4 Project Structure:

Applicants should propose projects up to 3 years in length for a total DOE funding of $4,000,000 to $8,000,000 for each project. EERE intends to select 1 to 2 projects based on available funds and proposed scope, with a preference for one large, cohesive, coordinated project across multiple relevant stakeholders. 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 Go/No-Go decision point with specific criteria and metrics separating each phase (budget period). Projects must include at least 20% cost share consistent with R&D activities.

Topic 4 Teaming Arrangements:

Teaming arrangements that include multiple stakeholders across academia, industry, national laboratories as appropriate, and across technical disciplines are strongly encouraged. For example, teams that include multiple partners are preferred over applications that only include a single organization. The applicant team must include a partner actively involved in steel manufacturing. Domestic manufacturing is strongly preferred.

EERE is compiling a Teaming Partner List to facilitate the widest possible national participation in the formation of applicant teams for Topic 4. 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.

[50] https://www.researchgate.net/publication/315319583_Hydrogen_Plasma_Processing_of_Iron_Ore

The Teaming Partner List will be available on EERE Exchange at https://eere-Exchange.energy.gov under FOA DE-FOA-0002229 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 4 Applications Specifically Not of Interest:

Demonstrations of existing processes, without R&D improvements beyond the state-of-the-art, and without the ultimate potential to *both* enable hydrogen use at scale as well as reduce lifecycle emissions in steel manufacturing, are not of interest.

Topic Area 5: H2@Scale New Markets Demonstrations

The key to continued advancement of H2@Scale is scaling up affordable hydrogen and fuel cell technology options for expanded supply and demand. The initial H2@Scale FOA, released by EERE in FY19, funded first-of-kind pilot demonstrations of integrated systems with on-site nuclear power and multiple renewable energy sources. This topic solicits the demonstration of additional innovative integrated systems in two specific new markets of interest for hydrogen: maritime applications and data centers.

These first of-a-kind U.S. integrated systems demonstrations will help catalyze viable business cases for increasing asset utilization across the entire energy production to end-use value chain. The efforts will serve as real world laboratories with multi-sector industry-led validation of innovative technologies that will help guide future R&D needs. They will also help identify regulatory barriers and codes and standards that need to be addressed for ultimate largescale commercial viability.

Subtopic 5A: Maritime Demonstrations

Subtopic 5A Introduction/Background:

Stakeholders from governments, industry and research communities are increasingly realizing the significant potential for hydrogen options in numerous maritime applications. These include marine vessels, port vehicles, shore power, port-related cargo equipment, and energy transport/export, among others. An international workshop co-organized by DOE in September 2019 found that support of large-scale demonstration projects is needed to establish the at-scale viability of these options, while identifying and addressing remaining research needs.[51]

H2@Scale opportunities in marine and ports applications are gradually emerging in select regions, particularly in Europe. The maritime industry transports over 90% of goods shipped globally, with over 750 million shipping containers being moved annually at major ports worldwide.[52] With the size of this industry and the low quality of today's low-cost heavy fuel oils (HFOs), maritime transportation is the world's largest source of sulfur oxide emissions. In response, the International Maritime Organization (IMO) has set new strict regulations on these emissions. Beginning in January 2020, the limit for sulfur in fuel oil used on board ships operating outside designated emission control areas (ECAs) must be reduced from 3.50 to 0.50% m/m (mass by mass).[53] The limits are further reduced to 0.1% for ships operating in ECAs (e.g., coastal regions of the United States and northern Europe).

Enormous volumes of alternative low-sulfur fuels are needed, which could include large-scale, low-cost clean hydrogen or various synthetic fuels enabled by hydrogen. As one example, a preliminary assessment conducted by Oak Ridge National Laboratory suggests that replacing HFO with biofuels in maritime applications could significantly reduce sulfur and criteria emissions in the near term.[54] Hydrogen carriers, including synthetic ammonia and methanol, among others could be even more promising in the long term.

With imperatives to reduce maritime emissions both at sea[55] and at ports,[56] a number of low- and zero-emission options are being assessed, including promising options enabled by the H2@Scale vision. Several international projects are already

[51] https://www.energy.gov/eere/fuelcells/h2ports-workshop
[52] https://unctad.org/en/PublicationsLibrary/rmt2018_en.pdf, Port Traffic Volumes
[53] https://www.maritime-executive.com/article/imo-answers-questions-on-the-2020-sox-regulation
[54] https://info.ornl.gov/sites/publications/Files/Pub120597.pdf
[55] http://www.imo.org/en/MediaCentre/HotTopics/Documents/IMO%20ACTION%20TO%20REDUCE%20GHG%20EMISSIONS%20FROM%20INTERNATIONAL%20SHIPPING.pdf
[56] https://www.itf-oecd.org/sites/default/files/docs/dp201420.pdf

underway focused on the research, development and deployment of clean hydrogen in maritime applications. For example, in government-supported projects at Scotland's Orkney Islands,[57] remote tidal and wind energy is being converted through electrolysis into hydrogen for storage and distribution to coastal population centers. There, infrastructure is being developed to convert the hydrogen into heat and power for buildings and vessels, as well as fuel for operating hydrogen fuel cell vehicles. As another example, the Port of Valencia in Spain is setting into motion plans for reducing nitrogen oxides and other emissions using hydrogen fuel cell power for cranes, yard tractors, reach stackers and forklifts (these account for nearly 90% of the fuel consumed at that port). In the U.S., the Port of Los Angeles, with industry partners Toyota and Kenworth, is developing a renewable hydrogen refueling station for fuel cell powered drayage trucks at the port.[58]

Other regions are starting to develop concepts for cluster demonstrations at ports, aligned with the recent report issued by the International Energy Agency (IEA) for the G20 Summit in 2019.[59] This report documented a number of specific recommendations for scaling up hydrogen, including the following charge: "Make industrial ports the nerve centres for scaling up the use of clean hydrogen." Coastal industrial clusters that are co-located near ports offer the opportunity for utilization of hydrogen both for nearby industrial applications, and for fueling ships, ferries, pier-side generators, and heavy-duty vehicles such as drayage trucks.

Subtopic 5A Description/Objective:

EERE seeks applications for industry-led efforts to demonstrate H2@scale-based solutions for maritime applications. Demonstration projects are sought which address maritime needs to jumpstart a new market, particularly those that will deal with challenges needed to enable scale. Projects should include optimization and performance characterization of technologies related to maritime applications and ports that may encompass production, storage, distribution, and hydrogen uses.

Because there are very limited examples of demonstrations involving marine vessels, and infrastructure for fueling such vessels is virtually nonexistent, proposals are sought to operate such a prototype system, collect data and analyze results. This information would help determine key information such as total cost of ownership and maintenance needs compared to incumbent technologies. Examples could include, but are not limited to, hydrogen fuel cell powered harbor support vessels such as tugs and related novel applications such as pier cranes and shore

[57] Including Scotland's 'Surf N Turf' project as well as the follow-on "BIG HIT" project funded by EU's Fuel Cell and Hydrogen Joint Undertaking; http://www.surfnturf.org.uk/; https://www.bighit.eu/

[58] https://pressroom.toyota.com/the-future-of-zero-emission-trucking-takes-another-leap-forward/

[59] The Future of Hydrogen, IEA, 2019, https://www.iea.org/hydrogen2019/

power for marine vessels. In addition, further challenges that may be addressed through the proposed project include siting, codes, standards, fueling protocols, and component reliability and availability.

Figure 3 below includes examples of energy technologies of interest and pathways that meet the intent of the H2@Scale-based approach. The incorporation of innovative, emerging approaches and concepts that enhance the reliability, lower the cost, and lower the footprint of hydrogen and fuel cell technologies and systems is strongly encouraged.

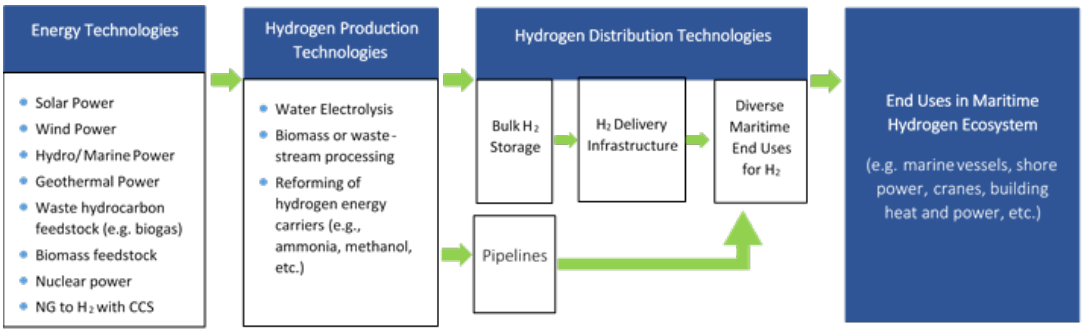

Figure 3. Integrated hydrogen ecosystem for maritime applications

Projects may include the use of multiple advanced technologies while focusing on innovative, efficient and viable integration of these technologies within the hydrogen-based ecosystem. EERE encourages the demonstration of advanced technologies with potential for commercial viability, including affordability and reliability, across relevant aspects of hydrogen production, distribution, and utilization pathways.

An area of particular interest is the leveraging of underutilized local energy resources (e.g. resources with low capacity factors or high rates of curtailment), such as solar, wind, geothermal, hydro/marine-power, bio/waste-streams, and nuclear. Applications that leverage these energy resources directly or indirectly to supply affordable hydrogen at large-scale to support existing and emerging demands for maritime-related applications are encouraged.

Large marine vessels may provide a pathway for alternative storage methods, including the use of liquid hydrogen or hydrogen carriers, as an alternative to compressed gas. Regardless of the method of hydrogen production, transport and storage used in the proposed concept, applications should present the technical and economic potential of the entire approach. Techno-economic viability, including total cost of ownership, for the proposed maritime hydrogen ecosystem demonstration is a priority for the work scope.

Examples of relevant hydrogen technologies include, but are not limited to:

- Low-cost electrolyzers for hydrogen production comprising local clean energy inputs such as solar and wind;
- Novel refueling processes and hydrogen delivery approaches for refueling of marine vessels, as well as potentially additional port equipment/vehicles;
- Multiple regional end users in one demonstration to generate economies of scale that reduce overall cost of hydrogen use;
- Approaches to optimize the generation, storage, delivery and utilization of hydrogen to ensure reliability and availability of fuel for all applications, as well as optimal revenue streams from diverse end-uses for commercial viability.

Applicants may also propose other innovative concepts aligned with the subtopic that enable clear advantages such as lower cost, improved performance, reliability, and efficiency for maritime applications.

As part of the submission to demonstrate an integrated maritime hydrogen ecosystem on a pilot scale, applicants should include infrastructure specifications such as siting plans and fueling needs/protocols for each application (e.g., vessels, cranes, pier-side power, etc.). Specific refueling details including proposed processes, distribution and fuel dispensing equipment for compression, storage, and dispensing for each application should be described.

Planned infrastructure activities should describe:

- Hydrogen use of at least 500 kg per day,[60] preferably leveraging hydrogen produced on- or off-site from local energy resources (preferably co-located or nearby);
- Hydrogen storage and distribution systems commensurate with proposed hydrogen production and utilization levels;
- Detailed process engineering and sub-system/component integration;
- Systems integration and on-site validation of the pilot-scale processes;
- Pilot operations tests;
- Compilation and dissemination of operational data;
- Hydrogen demand profiles for demonstrated end-uses including hydrogen powered equipment and marine vessels (if applicable);
- Rigorous hydrogen safety strategy, including safety plan; and
- Techno-economic analysis of the specific scenario with design details.

Refueling infrastructure specifications should include (as applicable):

[60] https://www.energy.gov/sites/prod/files/2015/06/f23/fcto_myrdd_production.pdf, 3.1.1 Technical Goal and Objectives; https://www.energy.gov/sites/prod/files/2015/08/f25/fcto_myrdd_delivery.pdf, 3.2.1 Technical Goal and Objectives

- Engineering and construction plans—an engineering package with a site map, drawings and calculations, a schedule, and the budget required for permitting and construction of the hydrogen infrastructure facilities;
- Operations start up plans—a training and operation startup plan including hydrogen production/delivery, hydrogen storage, refueling, and other requirements/facilities;
- Operation and maintenance—testing plan including data collection (See Section IV.D.xvi. and Section VIII.L for data management requirements) to measure and evaluate performance, durability, and reliability characteristics of the hydrogen production (if applicable), transport, storage, and refueling subsystems; and
- Infrastructure codes and standards—codes and standards plan for the design, engineering, installation, permitting, certification, and operation of hydrogen infrastructure including coordination with appropriate standards development organizations, regulators and other pertinent participants.

Planned vessel demonstration activities should describe, at a minimum:[61]

- Vessel specifications (e.g., length, beam, dead weight, draught (max), speed (max), amount of onboard hydrogen required)
- Operating routes and range
- Propulsion system(s)—power levels in kWs
- Towing power in tons (if applicable)
- Service speed
- Refueling specifications including liquid or gaseous fuel parameters

Applications should detail:

- Unique or first-of-its-kind aspects of the demonstration proposed and how they can advance the H2@Scale concept;
- The 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 engineering advancements to cost-competitively enhance the performance and capabilities of maritime-related hydrogen systems and components; 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).

[61] Vessels to be demonstrated should adhere to guidance found in the American Bureau of Shipping "Fuel Cell Power Systems for Marine and Offshore Applications November 2019"

In their proposals, applicants should clearly describe targeted performance and verification testing processes for the integrated systems within the demonstrated ecosystem,[62] and include techno-economic analysis to assess the business case for the proposed approaches and resource availability. 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. Applications are strongly encouraged that propose innovative methods to remove regulatory barriers along the hydrogen production, storage and distribution, dispensing, and usage pathways in maritime environments. In addition, applicants may include activities to assess the status of relevant domestic vs. global hydrogen and fuel cell markets in the maritime space, including opportunities for hydrogen exports.

Work scope should also be included to ensure safety, assess potential cybersecurity threats or vulnerabilities, and address cybersecurity challenges.

Subtopic 5A Project Structure:

Applicants should propose projects up to approximately 3 years in length for a maximum total DOE funding of $8,000,000. Awards may range from $4,000,000 to $8,000,000 each. EERE intends to select 1 to 2 projects based on available funds and proposed scope. The funding requested should be commensurate with the level of work proposed. Projects must include a 50% cost share consistent with demonstration activities. Efforts should be planned as two or three multi-phase efforts with a quantitative annual Go/No-Go decision point separating each phase (budget period). Specific criteria with metrics should be included for each decision point. As with all DOE Hydrogen and Fuel Cells Program demonstration projects, a safety plan must be provided[63] and a site visit by the Hydrogen Safety Panel will likely be conducted.

Subtopic 5A Teaming Arrangements:

FCTO encourages teams to leverage diverse resources (equipment, infrastructure and expertise) as appropriate, accomplishments from other ongoing projects, and funding from external stakeholders. The industry team must include a partner actively involved in maritime operations or marine technology development. Successful applicant teams would ideally include stakeholders from diverse industries (and encompass all relevant parties such as maritime industry partners, hydrogen providers, end-users, infrastructure developers, and other experts as required), and leverage existing demonstration capabilities (while avoiding duplication) where they add value in developing and implementing the proposed technologies. The prime applicant should be from industry.

[62] Components, subsystems and integrated processes for the hydrogen ports project

[63] https://h2tools.org/hsp

EERE is compiling a Teaming Partner List to facilitate the widest possible national participation in the formation of applicant teams for Subtopic 5a. 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-0002229 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.

Subtopic 5A Applications Specifically Not of Interest:
Concepts that can only generate incremental improvements in existing commercial processes, or that propose commercial applications that do not provide improvements to systems integration, or scalability of hydrogen fuel in maritime/port operations, are not of interest. Also, applications that focus primarily on drayage trucks at a port are not of interest.

Subtopic 5B: Data Center Demonstrations

Subtopic 5B Introduction/Background:
Data centers have become integral to modern life, providing data and services such as website hosting, financial services, and computing global weather forecast models. The capacity of installations can range from server closets to 100 MW hyperscale data centers and higher. Worldwide, data center energy consumption amounted to about 416 terawatts annually, or roughly two percent of all electricity

generated on the planet.[64] Global connectivity trends are driving an increasing need for new data centers and network services. Worldwide internet traffic has tripled since 2015 and is expected to grow to 4.2 zettabytes per year by 2022.[65]

While new computer technologies are becoming more energy efficient, hyperscale data centers still require significant power. Therefore, additional electricity supply and backup power alternatives have been used to minimize operational risks, maximize resiliency, and supply the increased energy demand of data centers.

The incumbent technologies that support power needs in data centers are primarily electricity from the grid (for prime power) and diesel generators (for backup power). Alternatively, fuel cells can be used to support critical loads for energy reliability, security, sustainability, and economic benefit. They offer potential for prime or backup power, microgrids, grid support, and combined heat and power applications in a data center. One practical reason that end users are pursuing fuel cell technologies is the challenge and cost of obtaining permits for diesel generators to power extremely large-scale data centers. Retrofitting old data centers to incorporate fuel cells might require high capital investments, but potential long-term benefits of performance and reliability could outweigh the initial costs. Uptime is a particularly high priority because downtime can mean substantial financial losses. Reliability and redundancy are extremely important.

Hydrogen fuel cells may provide additional benefits by reducing operating costs of data centers associated with electrical distribution inside the facility, lower maintenance and operation costs of the backup units, reduction of energy footprint and building shell cost, and electricity cost optimization since demand spikes are not subject to market-driven electricity costs. On-site electricity generation also improves the ability of data centers to respond to electricity demand changes and improve energy efficiency by integrating heat recovery from the fuel cell with the data center's heating and potential cooling needs. Further fuel cell benefits include a simplified mechanical system and independent and resilient operation, which allow individual racks to continue operation while others are offline during maintenance.[66]

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 volumetric energy density is roughly four times lower than conventional liquid fuels and it is difficult to store. Hydrogen is currently transported and stored as either a compressed gas or a cryogenic liquid.

[64] https://www.vxchnge.com/blog/power-hungry-the-growing-energy-demands-of-data-centers
[65] https://www.iea.org/tcep/buildings/datacentres/
[66] Hydrogen and Fuel Cells for Data Center Applications Project Meeting: Workshop Report https://www.nrel.gov/docs/fy20osti/75355.pdf

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, or by pipeline for large volumes. Liquefied hydrogen is transported in trailers equipped with multi-layer vacuum insulated dewars, with payloads that can exceed 4,000 kg of hydrogen.[67]

Other options include materials-based storage such as hydrogen carriers or solid state materials such as metal hydrides and sorbents. In some cases, a hydrogen carrier that can easily transport hydrogen to the point of use and store it at ambient conditions allows for less expensive storage compared to high pressure tanks. In that case, a dehydrogenation reactor is required to release the hydrogen upon demand. Regardless, the optimum storage method is application-specific and depends on various factors such as cost and operating requirements.

Although early demonstrations of hydrogen fuel cells for data centers have taken place at the laboratory scale, hydrogen infrastructure is a challenge for real-world data center applications. The project(s) from this subtopic would be *the first of its kind, large-scale* (potentially multi-MW) demonstration that integrates all relevant components onsite, including hydrogen infrastructure.

Subtopic 5B Description/Objective:

EERE seeks applicants to demonstrate the feasibility of coupling hydrogen and fuel cell technologies to data centers for primary and/or backup power applications as a part of an overall integrated system demonstration. This topic seeks applications to demonstrate hydrogen fuel cell-powered data centers on a small pilot scale with potential for scale up—at least 100 kW to 2 MW hydrogen PEM fuel cell power system—with preference for the higher end of this power range. Projects over 2 MW are also eligible if proposed within available funds and if other criteria are met.

FCTO's vision is for very large-scale use of hydrogen to support hyper-scale data centers and address their integration with the grid. This project, although smaller in scale, should demonstrate the ability to use hydrogen to support this scope if scaled up. Projects that also show how hydrogen can be used to help manage grid impacts of this size data center would be of particular interest.

Based on workshop and industry feedback,[66] the following characteristics are of interest and should be addressed in the proposed project(s):

- Robust, modular systems that are scalable for ultimate buildup and economies of scale;
- Innovative but commercially viable approaches for hydrogen infrastructure including storage, dispensing/delivery, and potential on-site or co-located

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

production (with preference given to low/zero emissions hydrogen production technologies);
- Systems and subsystems/components that allow for high dynamic response reliability/durability, low maintenance, and ease of serviceability;
- Approaches for optimized thermal management and both capital cost and operating expense reduction;
- Systems and components appropriate for relevant IT load characteristics; and
- Overall cost and performance with the potential to meet specifications of incumbent technologies.

Specific work areas to be addressed in proposals include planned activities and specifications for:
- Hydrogen PEM fuel cell power system and relevant subsystems;
- Hydrogen demand requirements for the data center system;
- Hydrogen infrastructure including storage system;
- Detailed process engineering and integration;
- Unit integration and on-site validation of the pilot-scale performance;
- Pilot operations tests;
- The compilation and dissemination of operational data (e.g. response time, reliability, power usage effectiveness (PUE) measurements, and other parameters to help guide future R&D);
- Techno-economic analysis of specific scenarios with design details and estimates for capital costs and operating expenses, as well as reliability and availability; and
- Estimation of overall emissions reduction analysis for the entire pathway (production, delivery, dispensing, storage, utilization).

EERE encourages innovative concepts in system and subsystem designs across the value chain (i.e. hydrogen infrastructure and utilization) with potential for commercial viability, such as fuel cell power-plant architectures that incorporate novel, low-cost, highly durable materials and components, in-situ gas distribution and storage schemes, system designs with DC power (as appropriate), and possibly the use of hydrogen carriers or other low cost storage approaches. Novel approaches to conventional compressed and liquefied hydrogen fuel may include the use of hydrogen carriers that have potential to provide advantages over bulk storage and transport through higher energy efficiency or lower capital costs. Regardless of storage approach, cost estimates should be provided in the proposal.

In addition, work scope should be included to ensure safety, assess potential cybersecurity threats or vulnerabilities, and address cybersecurity challenges.

Subtopic 5B Project Structure:

Applicants should propose projects no more than 3 years in length for a total DOE funding of $3,000,000 to $6,000,000 for each award. EERE intends to select 1 to 2 projects based on available funds and proposed scope. The funding requested should be commensurate with the level of work proposed. Projects must include a 50% cost share consistent with demonstration activities. A Go/No-Go decision point must be included before the demonstration is initiated. Criteria must be provided based on economic and performance parameters, including volumes of hydrogen required, throughput, infrastructure plans, as well as requirements for power, reliability, uptime, transient response, efficiency, safety, heating/cooling loads, and other key characteristics. As with all DOE Hydrogen and Fuel Cells Program demonstration projects, a safety plan must be provided[68] and a site visit by the Hydrogen Safety Panel will likely be conducted.

Subtopic 5B Teaming Arrangements:

An effective application will include multi-disciplinary teams across the entire energy production to end-use value chain and should include a data center operator. Commercial end users and developers are strongly encouraged to participate, demonstrating commercial interest and the potential for market viability. Preference is given to systems developers and integrators that are manufacturing and/or integrating systems in the U.S.

EERE is compiling a Teaming Partner List to facilitate the widest possible national participation in the formation of applicant teams for Subtopic 5b. 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-0002229 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

[68] https://h2tools.org/hsp

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.

Subtopic 5B Applications Specifically Not of Interest:
EERE is not interested in the demonstration of solid oxide fuel cells, molten carbonate fuel cells, phosphoric acid fuel cells, or alkaline anion exchange membrane fuel cells. Aligned with the intent of the H2@Scale vision, this topic focuses on hydrogen as a fuel.

Topic Area 6: Training and Workforce Development for Emerging Hydrogen Technologies

Topic 6 Introduction/Background:
Demand for hydrogen and hydrogen-related technologies (including fuel cells) is expected to increase in the coming years for emerging and varied end-use applications, such as fuel cell material handling equipment, fuel cell vehicles, industrial applications (e.g. steel manufacturing, fertilizer production, petroleum refining), energy storage (supporting both renewable and nuclear energy resources), synthetic fuels, heating applications, and more. As of December 2018, global shipments for fuel cell power for transportation and stationary applications had an average annual growth rate of 40% from 2015 through 2018,[69] demonstrating an increasing interest in hydrogen-related technologies. Moreover, the H2@Scale initiative, which envisions technologies for large-scale production, storage, transport and utilization of hydrogen in the United States, can enable growth in the use of hydrogen and hydrogen-related technologies.

Increasing use of hydrogen creates the need to develop a talent pool with the appropriate skills and training to safely and effectively deploy, use and maintain hydrogen-related technologies (and fuel cell systems) across various applications (e.g., transportation, energy storage, industrial purposes). Also, establishing an integrated training and workforce development program early on will be critical to effectively respond to the expected growth in hydrogen-supported industries and to develop and maintain a national competitive advantage in an advanced energy technology field. Establishing such programs through coordination with land-grant universities, community colleges, or technical schools can also provide the benefit of expanding a specialized and high-technology skillset across a more diverse talent

[69] Annual Merit Review and Peer Review Hydrogen and Fuel Cell Program Plenary https://www.hydrogen.energy.gov/pdfs/review19/plenary_overview_satyapal_2019.pdf

pool including, for instance, veterans that are transitioning in the civilian life and minority groups that are underrepresented in science, technology, engineering, and math (STEM).

With increased interest in hydrogen, a number of state and regional groups or coalitions are beginning to develop and disseminate information related to hydrogen and fuel cells to raise awareness and educate relevant stakeholders such as policymakers and the public. However, these efforts are often uncoordinated and information is outdated or inaccurate. A more cohesive and coordinated effort that includes targeted regional activities would create a robust foundational framework to build upon, and offer a launchpad from which other efforts can grow over time. Training materials can support regional hydrogen and fuel cell end users, assist small companies and entrepreneurs interested in business opportunities, facilitate growth of supply chain workers, and promote adoption of the technologies through stakeholder engagement and various other outreach efforts. A coordinated approach to education and training would benefit these stakeholder groups, and the industry as a whole.

The operation, handling and maintenance of hydrogen-related technologies can be sufficiently different when compared to incumbent technologies to require a tailored and customized workforce development and training program. Examples of these differences include but are not limited to the following:

- While hydrogen is a flammable gas, it has properties that are distinct from more commonly encountered flammable gases like natural gas or propane. General flammable gas training is not completely sufficient for safe hydrogen system operations and maintenance activities.
- Gaseous hydrogen applications, for uses like vehicle fueling and energy storage, benefit from storage at high pressure—typically at pressures not normally encountered in other gas storage environments. These elevated pressures often require specialized hardware and operational/maintenance procedures.
- Increased hydrogen demand is expected to increase the need for transportation, handling, and storage of hydrogen as a cryogenic liquid (to increase shipping density). As cryogenic hydrogen is at a lower temperature than more common cryogens (like nitrogen and oxygen), specific precautions and procedures are needed.

Since hydrogen and fuel cell technologies and markets are still developing, building upon the lessons learned and best practices from other clean energy industries will be valuable as this first-of-its-kind training and workforce development network is put into place. Examples of workforce development programs for solar energy, natural gas and electric vehicles, and other emerging energy technologies should be reviewed to propose the most appropriate approach for hydrogen and fuel cells.

The solar industry, for instance, developed an indispensable resource that provides actionable solutions for industry-led workforce development initiatives, such as the Solar Training Network's toolkit demonstrating how teaming and learning programs can benefit the user.[70,71]

Topic 6 Description/Objective:

EERE seeks applications to establish a training and workforce development program in support of the deployment of emerging hydrogen and fuel cell technologies. Applications should clearly describe plans to develop a cohesive training and workforce program, reaching specific high-priority regions, coordinating with regional centers (as well as state and local efforts), and ultimately expanded nationwide, prioritizing the rollout based on markets and needs. Training programs that address the needs for emerging hydrogen and fuel cell applications beyond light-duty vehicles are of particular interest.

Given that the prime applicant is expected to work across regions and with many partners, including academia, industry and government, the term "**H2 Training Network (H2N) coordinator**" or coordinator will be used in describing the prime applicant for this FOA topic.

Applicants should describe how data-driven identification of workforce training gaps and skills shortfalls will be conducted to inform the alignment of trainers, tools, and curricula. The coordinator should determine when and where a targeted expansion or increased deployment of resources in the existing network is necessary. For example, in areas such as new and emerging hydrogen and fuel cell applications (e.g., heavy-duty trucks or electrolyzer deployments for different applications), the coordinator should work with relevant stakeholders to determine and prioritize workplans, and to avoid duplication.

Partnerships with land-grant universities, community colleges, or technical schools are strongly encouraged. Examples of feasible partnerships could include but are not limited to: 1) leveraging STEM resources within land-grant universities, community colleges, or technical schools that have existing hydrogen activities, or 2) development of internship, fellowship, or co-op programs that enable training of participants in operations, maintenance, and handling of hydrogen technologies.

EERE also encourages programs that incorporate participation of under-represented groups, as well as programs that have the potential to be replicable in other regions in the U.S. Other examples of coordination could include DOE's Office

[70] https://www.energy.gov/eere/solar/solar-training-network
[71] https://www.americansolarworkforce.org/

of Indian Energy Policy and Programs[72] and Historically Black Colleges and Universities (HBCUs). EERE is also committed to supporting the advancement of our nation's veterans in the hydrogen and fuel cell technology workforce. Applicants are encouraged to identify means of incorporating veterans into proposed workforce training initiatives, including through established nationwide veterans' programs such as "Hiring Our Heroes."[73]

EERE supports the deployment of hydrogen and fuel cell technologies in a timely manner while placing a high priority on safety. As such, applicants should address training on best safety practices within the scope of the proposed programs. Areas of interest include, but are not limited to:

- Best safety practices for maintenance procedures and operations;
- Fuel cell and hydrogen storage system maintenance of light-, medium-, and heavy-duty fuel cell electric vehicles and other specialty vehicles, such as forklifts;
- Training related to operations, maintenance, and handling of both gaseous and cryogenic hydrogen systems;
- Operations and maintenance training for both industrial applications and fueling stations;
- Operations and maintenance training for technologies in emerging applications within the H2@Scale concept, including marine, rail, and stationary power (e.g. stationary hydrogen fuel cells or hydrogen combustion turbines); and
- Training of technicians at R&D facilities for work with gaseous or cryogenic hydrogen.

Any existing tools and resources to help set up a training program should be utilized as appropriate and updated as necessary, including relevant international resources. Duplication or re-creation of resources should be avoided and the team is expected to coordinate with other relevant entities such as the Center for Hydrogen Safety,[74] the Hydrogen Safety Panel,[75] and other relevant programs. Maintenance training programs should incorporate close coordination structures between technology providers, technology users, and training outlets. In addition to training programs for the workforce, the coordinator should include train-the-trainer approaches and materials for diverse stakeholders, including state and local officials. The plan for specific training and outreach events should be data driven and prioritized based on impact potential, and the coordinator should provide a

[72] https://www.energy.gov/indianenergy/about-us
[73] https://www.hiringourheroes.org/
[74] www.aiche.org/chs
[75] https://h2tools.org/hsp

detailed plan for each region, along with specific goals and targeted results (e.g. addressing challenges that may be region-specific).

The coordinator should develop and implement a plan to improve the industry-relevance, visibility, and employment impact of the network. The coordinator should connect training instructors and institutions directly with hydrogen and fuel cell industry employers—e.g., through career fairs or industry days—fostering industry relationships, ensuring local trainee supply meets local needs, and maintaining alignment with the industry workforce training needs.

Applications should include components that allow the tracking of the workforce development program's effectiveness such as job placement and retention and the number of personnel in the workforce. Benchmarking against other relevant programs in similar industries is encouraged. The H2 Training Network should link to other resources such as FCTO's hydrogen and fuel cell career map.[76]

Establishing industry recognized workforce personnel credentials

Applicants should evaluate the need for certification or other formal credentialing and should describe the value of any specific proposed credentials. Several years ago, the solar industry was in a similar position to the hydrogen and fuel cell industry today. The Solar Foundation's Jobs Census of 2014 concluded that the solar industry had not developed a "consistent framework for training and evaluating talent."[77] Subsequently, the DOE's Solar Energy Technologies Office (SETO) issued a FOA that included the creation of relevant credentials.[78] While still early for hydrogen and fuel cells, this technology area is sufficiently comprehensive that it would benefit from the identification and development of relevant credential requirements.

Workforce credentials, such as those supported by the U.S. Department of Labor, allow workers to demonstrate measured competencies, provide workers strength in wage negotiations and mobility in employment locations, support employers in acquiring known proficiency when hiring employees, and protect consumers with some level of quality assurance in the work performed.

H2 Training Network Sustainability

In the later phases of the program, applicants should propose approaches for enabling a sustainable pathway forward, leveraging private sector and other funds

[76] https://www.energy.gov/eere/fuelcells/hydrogen-and-fuel-cells-career-map
[77] The Solar Foundation, *National Solar Jobs Census 2014*. 2015. p. 53
[78] https://www.energy.gov/eere/solar/funding-opportunity-announcement-fy-2018-solar-energy-technologies-office

outside FCTO. Examples from other programs that can provide a starting point for innovative funding mechanisms should be proposed to provide adequate private-sector funding for workforce training programs in out-years.[79] However, basic information should be made available to the public. Training and workforce programs should also be accessible to under-represented populations in relevant markets.

Finally, deliverables from this topic should be made available to other DOE-funded training and workforce development programs as they emerge. For instance, as generic energy workforce training programs are established, modules for hydrogen and fuel cell technologies should be included by sharing programs developed from this FOA.

Topic 6 Project Structure:
EERE seeks a single project for a maximum total DOE funding of $2,000,000. Applicants should propose projects 4-5 years in length. EERE intends to select 1 project based on available funds and proposed scope. The funding request should be commensurate with the level of work proposed. Applicants should plan projects as three to four 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.

Awardees must also develop relevant metrics and an evaluation plan to track progress and measure impact. Applicant project descriptions must describe how they will develop relevant metrics and an evaluation plan explaining how progress will be measured and project goals and expected outcomes.

Among other criteria, applicants will be judged on the degree to which their program would be self-sustaining after the award period. Budget may be allocated for independent program evaluation.

Topic 6 Teaming Arrangements:
Teaming arrangements that include regional coalitions or partnerships as well as relevant academic institutions (e.g. land-grant universities) and industry are strongly encouraged. Teams should include industry representatives from diverse applications, across stationary, transportation, and industrial sectors, and should cover the complete value chain from hydrogen production, delivery, storage, dispensing, and utilization.

[79] Financing the Next Generation of Solar Workers https://www.thesolarfoundation.org/financing-the-next-generation-of-solar-workers/

Preference will be given to a non-profit or third-party institute rather than a single company to serve as the H2 Training Network coordinator. Teaming to include multiple regions across the U.S. is strongly encouraged.

Coordination with other federal and state agencies, such as the Department of Defense, Department of Labor, and state jobs programs, is also strongly encouraged to leverage resources and expertise.

EERE is compiling a Teaming Partner List to facilitate the widest possible national participation in the formation of applicant teams for Topic 6. 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-0002229 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 6 Applications Specifically Not of Interest:

Applications seeking to develop training materials that are already available (i.e., first responder training or training for authorities having jurisdiction) are not of interest for this topic area.[80] Applications that are focused on only one market or region, such as only light-duty fuel cell cars, or one region would not be considered responsive. Given the focus on enabling deployment, curriculum development for K through 12 is not solicited in this topic.

[80] Training resources available at https://h2tools.org/

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

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 Area 1: EERE is not interested in projects specifically addressing solid oxide electrolyzers or alkaline (including both liquid KOH and alkaline exchange membrane) electrolyzers.
- Subtopic 3A: Proposals for electrolyte materials for solid oxide fuel cells, molten carbonate fuel cells, phosphoric acid, polybenzimidazole-type phosphoric-acid fuel cells, and alkaline anion exchange membranes, will not be considered. Also, proposals that rely on increased thickness alone to meet durability requirements will not be considered.
- Subtopic 3B: Projects focused on fuel cell component R&D are not of interest. Systems based on fuel cell technologies other than polymer electrolyte membranes, for example, alkaline exchange membrane or solid oxide, are not of interest.
- Topic Area 4: Demonstrations of existing processes, without R&D improvements beyond the state-of-the-art, and without the ultimate potential to *both* enable hydrogen use at scale as well as reduce lifecycle emissions in steel manufacturing, are not of interest.
- Subtopic 5A: Concepts that can only generate incremental improvements in existing commercial processes, or that propose commercial applications that do not provide improvements to systems integration, or scalability of hydrogen fuel in maritime/port operations, are not of interest. Also, applications that focus primarily on drayage trucks at a port are not of interest.
- Subtopic 5B: EERE is not interested in the demonstration of solid oxide fuel cells, molten carbonate fuel cells, phosphoric acid fuel cells, or alkaline anion exchange membrane fuel cells.
- Topic Area 6: Applications seeking to develop training materials that are already available (i.e., first responder training or training for authorities having jurisdiction) are not of interest for this topic area.[81] Applications that are focused on only one market or region, such as light duty fuel cell cars in

[81] Training resources available at https://h2tools.org/

one state would not be considered responsive. Given the focus on enabling deployment, curriculum development for K through 12 is not solicited in this topic.

D. Authorizing Statutes

FCTO's programmatic statutory authority is contained in the following legislation:

Energy Policy Act of 2005 (EPACT 2005) Public Law 109-58 (Aug. 8, 2005), Title VIII, Sections 801 to 816; 42 U.S.C. §§ 16151 to 16165.

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 $64,000,000 of federal funding available for new awards under this FOA, subject to the availability of appropriated funds. EERE anticipates making approximately 21 awards under this FOA. EERE may issue one, multiple, or no awards. Individual awards may vary between $1 and $9 million.

EERE may issue awards in one, multiple, or none of the following topic areas:

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 1: Electrolyzer Manufacturing R&D	**$15M**	**Up to 4**	**$5M**	**3**	**20%**
Topic 2: Advanced Carbon Fiber for Compressed Gas Storage Tanks	**$15M**	**Up to 3**	**$9M**	**5**	**20%**
Topic 3A: Fuel Cell R&D for Heavy-Duty Applications - Membranes for Heavy-Duty Applications	**$4M**	**Up to 4**	**$1M**	**3**	**20%**
Topic 3B: Fuel Cell R&D for Heavy-Duty Applications -	**$6M**	**2 to 3**	**$3M**	**3**	**20%**

Domestically Manufactured Fuel Cells for Heavy-Duty Applications					
Topic 4: H2@Scale New Markets R&D-HySteel	**$8M**	**1 to 2**	**$8M**	**3**	**20%**
Topic 5A: H2@Scale New Markets Demonstrations - Maritime Demonstrations	**$8M**	**1 to 2**	**$8M**	**3**	**50%**
Topic 5B: H2@Scale New Markets Demonstrations - Data Center Demonstrations	**$6M**	**1 to 2**	**$6M**	**3**	**50%**
Topic 6: Training and Workforce Development for Emerging Hydrogen Technologies	**Up to $2M**	**1**	**$2M**	**5**	**0%**
Total:	**Up to $64M**	**Up to 21**			

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. Before the expiration of the initial budget period(s), EERE may perform a down-select (for Topic 2) among different recipients and provide additional funding only to a subset of recipients.

ii. Period of Performance

EERE anticipates making awards that will run up to 5 years in length, comprised of one or more budget periods. Project continuation will be contingent upon several elements, including satisfactory performance and Go/No-Go decision review. For a complete list, see Section VI.B.xiv. At the Go/No-Go decision points, EERE will evaluate project performance, project schedule adherence, the extent milestone objectives are met, compliance with reporting requirements, and overall contribution to the program goals and objectives. As a result of this evaluation, EERE 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.

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 apply for funding as a subrecipient, but are not eligible to apply as a prime recipient.

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

Federal agencies and instrumentalities (other than DOE) are eligible to apply for funding 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 C 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.

ii. Non-Industry Applicants

Only industry (for-profit) applicants are eligible to apply as prime recipients to Topic 5 under this FOA; however, all entities are eligible to participate as subrecipients.

C. Cost Sharing

Cost Share 20% and 50%

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.)

Topic Area	Minimum Required Non-Federal Cost Share %
Topic 1,2,3, & 4	20%
Topic 5	50%
Topic 6	0%

To assist applicants in calculating proper cost share amounts, EERE has included a cost share information sheet and sample cost share calculation as Appendices A and B 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 obligations 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.i. 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 cost sharing requirements.

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 by the applicable deadline 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 FFRDC effort, in aggregate, shall not exceed 50% of the total estimated cost of the project for Topic Area 2, and 25% of the total estimated cost of the project for all other Topic Areas, including the applicant's and the FFRDC's portions of the effort.

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.

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, 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 pages 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
	Resumes (PDF format. 1 page maximum per person)	ControlNumber_LeadOrganization_Resumes
	Letters of Commitment, if applicable (PDF format. 1 page maximum per letter)	ControlNumber_LeadOrganization_LOCs
	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 (PDF format)	ControlNumber_LeadOrganization_SF-LLL
	Foreign Entity and Foreign Work waiver requests, if applicable (PDF format)	ControlNumber_LeadOrganization_Waiver

	U.S. Manufacturing Plan (PDF format)	ControlNumber_LeadOrganization_USMP
	Data Management Plan (Microsoft Word format)	ControlNumber_LeadOrganization_DMP

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, 2, 3, 4 and 6; 25 pages for Topic 5, 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, process, or training program 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, training program, or process, 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 feasibility of the proposed technology, training program, or process, 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, process, or training program; the benefits of proposed advancement, 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	The Workplan should include a summary of the Project Objectives, Technical Scope, Work Breakdown Structure (WBS), Milestones, Go/No-Go

constitute approximately 40% of the Technical Volume)	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. • 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. At a minimum, 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. See Section VI.B.xiv. The applicant should also provide the specific technical criteria to be used to evaluate the project at the Go/No-Go decision point. 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). At a minimum, 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 (**NOT** applicable to Topic Area 6): 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

	• Impact Assessment (applicable **ONLY** to Topic Area 6): The applicant should provide an impact assessment including the following:
	  ○ Identification of target audience and distribution channels for the proposed program along with known or perceived barriers to deployment, including mitigation plan;
	  ○ Plan to improve the industry relevance, visibility, and employment impact of the proposed network and to track the effectiveness of the program; and
	  ○ Description of how the proposed program will be self-sustaining upon completion of the award period.

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.
	• Describe the technical services to be provided by DOE/NNSA FFRDCs, if applicable.
	• 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
	  ○ Communication plans

iii. Resumes

Applicants are required to submit one-page resumes for key participating team members. Multi-page resumes are not allowed. Save the resumes in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_Resumes".

iv. Letters of Commitment

Submit letters of commitment from all subrecipient and third party cost share providers. If applicable, also include any letters of commitment from partners/end users (1 page maximum per letter). Save the letters of commitment in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_LOCs".

v. 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".

vi. 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".

vii. 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".

viii. 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".

ix. 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.

x. 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".

xi. 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".

xii. 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".

xiii. 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".

xiv. Waiver Requests: Foreign Entities and Foreign Work (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 C lists the necessary information that must be included in a request to waive this requirement.

2. **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. Appendix C lists the necessary information that must be included in a foreign work waiver request.

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

xv. 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".

xvi. Data Management Plan (DMP)

Applicants are required to submit a DMP with their Full Application.

An applicant may select one of the template Data Management Plans (DMP) listed below. Alternatively, instead of selecting one of the template DPMs 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 DPMs.

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 five (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".

E. Content and Form of Replies to Reviewer Comments

EERE will provide applicants with reviewer comments following the 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 the 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 (3) 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.

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. Intergovernmental Review

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

J. 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 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. **National Environmental Policy Act (NEPA) Requirements Related to Pre-Award Costs**
   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 pre-award costs incurred prior to receiving written authorization from the Contracting Officer. If the applicant elects to undertake activities that DOE determines 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 for their project 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. 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.

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

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 whether 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 foreign work waiver, the applicant must submit a written waiver request to EERE. Appendix C lists the necessary information that must be included in a request for a foreign work waiver.

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. For-profit entity disposition requirements are set forth at 2 CFR 910.360. Property disposition requirements for other non-federal entities are set forth in 2 CFR 200.310 – 200.316.

vii. Domestic Preference – Infrastructure Projects

As appropriate and to the extent consistent with law, Applicants shall ensure that, to the greatest extent practicable, iron and aluminum as well as steel, cement, and other manufactured products (items and construction materials composed in whole or in part of non-ferrous metals such as aluminum; plastics and polymer-based products such as polyvinyl chloride pipe; aggregates such as concrete; glass, including optical fiber; and lumber) used in the proposed project shall be produced in the United States. This requirement shall flow down to all sub-awards including all contracts, subcontracts and purchase orders for work performed under the proposed project.

viii. 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.

ix. 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.

x. 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.

V. Application Review Information

A. Technical Review Criteria

i. Concept Papers

Concept Papers are evaluated based on consideration of 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 sub-criteria:

- 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: Merit, Innovation, and Impact (50%)
This criterion involves consideration of the following sub-criteria:

Merit and Innovation

- Extent to which the proposed technology, training program, or process is innovative;
- Degree to which the current state of the technology, training program, or process 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 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 sub-criteria:

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 Risks

- Discussion and demonstrated understanding of the key 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 baseline, the strength of the quantifiable metrics, milestones, and mid-point deliverables defined in the application, such that meaningful interim progress will be made.

Market Transformation Plan (**NOT** applicable to Topic Area 6)

- Identification of target market, competitors, and distribution channels for proposed technology along with known or perceived barriers to market penetration, including mitigation plan;
- 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; and
- Degree to which the commitments made in the U.S. Manufacturing Plan will strengthen the competitiveness of domestic manufacturing and translate into increased long-term manufacturing and employment in the United States.

Impact Assessment (applicable **ONLY** to Topic Area 6)

- Identification of target audience and distribution channels for proposed program along with known or perceived barriers to deployment, including mitigation plan;
- Comprehensiveness of plan to improve the industry-relevance, visibility, and employment impact of the proposed network and to track the effectiveness of the program; and
- Degree to which the proposed program will be self-sustaining upon completion of the award period.

Criterion 3: Team and Resources (20%)

This criterion involves consideration of the following sub-criteria:

- 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 team demonstrates the ability to facilitate and expedite further development and commercial deployment of the proposed project deliverables;
- 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.

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;
- The degree to which the proposed project, or group of projects, represent a desired geographic distribution (considering past awards and current applications); and
- Whether the proposed project with occur in a Qualified Opportunity Zone or otherwise advance the goals of Qualified Opportunity Zones.[82] The goals include spurring economic development and job creation in distressed communities throughout the United States.

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.

[82] Opportunity zones were added to the Internal Revenue Code by section 13823 of the Tax Cuts and Jobs Act of 2017, codified at 26 U.S.C. 1400Z-1. The list of designated Qualified Opportunity Zones can be found in IRS Notices 2018-48 (PDF) and 2019-42 (PDF). Further, a visual map of the census tracts designated as Qualified Opportunity Zones may also be found at Opportunity Zones Resources. Also see, frequently asked questions about Qualified Opportunity Zones.

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.J.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.J.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 a 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 Under DOE Order 142.3A, "Unclassified Foreign Visits and Assignments Program"

All applicants selected for an award under this FOA may be required to provide information to DOE in order to satisfy requirements for foreign nationals' access to DOE sites, information, technologies, equipment, programs or personnel. A foreign national is defined as any person who is not a U.S. citizen by birth or naturalization. If a selected applicant (including any of its subrecipients, contractors or vendors) anticipates involving foreign nationals in the

performance of its award, the selected applicant may be required to provide DOE with specific information about each foreign national to ensure compliance with the requirements for access approval. National laboratory personnel already cleared for site access may be excluded. Access approval for foreign nationals from countries identified on the U.S. Department of State's list of State Sponsors of Terrorism must receive final approval authority from the Secretary of Energy or the Secretary's assignee before they commence any work under the award.

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 U.S.C. 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 https://www.energy.gov/nepa.

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 recipient may be required to prepare the records and 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 ten (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
- 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 are required to submit safety plans. 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.pdf. The Safety Plan should cover the full scope of the project, including work by the prime as well as any subrecipients, and should be complete before the work is started. The Safety Plan is due to DOE within 90 days after the award is signed unless alternative timing is approved due to project constraints. The HSP will review the Safety Plan and provide feedback to the Recipient (through DOE) within approximately 30 days of receipt. 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.

C. Program Down-Select

In addition to the Go/No-Go Reviews required for each project, EERE intends to conduct a competitive project review (down-selection process) upon the completion of the Phase I down-selection decision point for projects awarded under Topic Area 2, “Advanced Carbon Fiber for Compressed Gas Hydrogen and Natural Gas Storage Tanks”. Recipients will present their projects to EERE individually (not to other recipients). Subject matter experts from academia, national laboratories, and industry may be used as reviewers, subject to conflict of interest and non-disclosure considerations. Projects will be evaluated based on the

following criteria:

1) Demonstrated conversion of novel precursor and/or demonstrated low-cost conversion process to carbon fiber of at least 100 continuous meters of a fiber tow with a minimum of 100 filaments.
2) Performance properties of the resulting carbon fiber (e.g. tensile strength, tensile modulus, failure strain).
3) Projected cost and performance of tanks based on CF produced

Upon completion of the competitive project review (down-selection process), EERE will select which projects will receive federal funding beyond the Phase I Down-Selection Decision Point. Due to the availability of funding and program considerations, only a portion of the recipients will be selected to receive funding for project continuation. As a result of this down-select process, certain projects will not receive federal funding beyond the Phase I Down-Selection Decision Point even if the project is meeting the pre-defined metrics.

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 three (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 three (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

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. Applicants are advised to not include any critically sensitive proprietary detail.

If an application includes trade secrets or information that is commercial or financial, or information that is confidential or privileged, it is furnished to the Government in confidence with the understanding that the information shall be used or disclosed only for evaluation of the application. Such information will be withheld from public disclosure to the extent permitted by law, including the Freedom of Information Act. Without assuming any liability for inadvertent disclosure, EERE will seek to limit disclosure of such information to its employees and to outside reviewers when necessary for merit review of the application or as otherwise authorized by law. This restriction does not limit the Government's right to use the information if it is obtained from another source.

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

The cover sheet of the Concept Paper, Full Application, Reply to Reviewer Comments, or other submission must be marked as follows and identify the specific pages containing trade secrets, confidential, proprietary, or privileged information:

Notice of Restriction on Disclosure and Use of Data:
Pages [list applicable pages] of this document may contain trade secrets, confidential, proprietary, or privileged information that is exempt from public disclosure. Such information shall be used or disclosed only for evaluation purposes or in accordance with a financial assistance or loan agreement between the submitter and the Government. The Government may use or disclose any information that is not appropriately marked or otherwise restricted, regardless of source. [End of Notice]

The header and footer of every page that contains confidential, proprietary, or privileged information must be marked as follows: "Contains Trade Secrets, Confidential, Proprietary, or Privileged Information Exempt from Public Disclosure." In addition, each line or paragraph containing proprietary, privileged, or trade secret information must be clearly marked with double brackets or highlighting.

E. Evaluation and Administration by Non-Federal Personnel

In conducting the merit review evaluation, the Go/No-Go Reviews and Peer Reviews, 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. 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.

I. 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.

J. 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.

K. 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.

L. 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.

M. 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.

N. Export Control

The U.S. government regulates the transfer of information, commodities, technology, and software considered to be strategically important to the U.S. to protect national security, foreign policy, and economic interests without imposing undue regulatory burdens on legitimate international trade. There is a network of federal agencies and regulations that govern exports that are collectively referred to as "Export Controls". To ensure compliance with Export Controls, it is the prime recipient's responsibility to determine when its project activities trigger Export Controls and to ensure compliance.

Export Controls may apply to individual projects, depending on the nature of the tasks. When Export Controls apply, the recipient must take the appropriate steps to obtain any required governmental licenses, monitor and control access to restricted information, and safeguard all controlled materials. Under no circumstances may foreign entities (organizations, companies or persons) receive access to export controlled information unless proper export procedures have been satisfied and such access is authorized pursuant to law or regulation.

Applicants are advised that some of the results of the research conducted under this FOA are expected to be restricted for proprietary reasons and not published or shared broadly within the scientific community.

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 subrecipient(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.

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 and the extent, if any, the entity is state owned or controlled;
- 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
IPMP	Intellectual Property Management Plan
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
M&O	Management and Operating
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
OSTI	Office of Scientific and Technical Information
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
RFI	Request for Information
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