Notice of Intent No. DE-FOA-0001411

Notice of Intent to Issue
Funding Opportunity Announcement No. DE-FOA-0001412

The Office of Energy Efficiency and Renewable Energy (EERE) intends to issue, on behalf of the Fuel Cell Technologies Office (FCTO), a Funding Opportunity Announcement (FOA) entitled "Hydrogen and Fuel Cell Technologies Research, Development, and Demonstrations".

The Fuel Cell Technologies Office (FCTO) is a key component of the Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) portfolio. Fuel cells powered by hydrogen from renewable or low-carbon resources can lead to substantial energy savings and reductions in imported petroleum and carbon emissions. FCTO aims to provide clean, safe, secure, affordable, and reliable energy from diverse domestic resources, providing the benefits of increased energy security and reduced criteria pollutants and greenhouse gas (GHG) emissions. FCTO accomplishes its goals by adopting a technology-neutral approach toward research, development and demonstration (RD&D) to address both key technical challenges for fuel cells and hydrogen fuels (i.e. hydrogen production, delivery and storage) and other barriers such as hydrogen codes and standards. The central mission of FCTO is to enable the widespread commercialization of a portfolio of hydrogen and fuel cell technologies through applied RD&D, and diverse efforts to overcome institutional and market challenges.

Fuel cells can address our critical energy challenges in all sectors: transportation, commercial, residential, and industrial. They can use diverse fuels, including biomass-based fuels, natural gas, and hydrogen produced from renewable resources. FCTO's focus is primarily transportation and light-duty passenger vehicles utilizing hydrogen as an energy carrier. These areas will have the greatest impact in terms of GHG and petroleum reduction and they are aligned with the President's goals and Climate Action Plan. However, FCTO also supports a range of other applications, including near-term markets such as distributed primary and backup power, lift trucks, and portable power; mid-term markets such as residential combined-heat-and-power (CHP) systems, and auxiliary power units; and longer-term markets such as fleet vehicles.

This FOA will provide funding to meet FCTO's goals for Hydrogen Production and Delivery, Hydrogen Storage, Fuel Cell Technologies, Technology Validation, Manufacturing, and Analysis Programs. More detailed descriptions of the FCTO Programs, including technical and cost targets, can be found in the Multi-Year Research, Development and Demonstration Plan (MYRD&D) at http://energy.gov/eere/fuelcells/downloads/fuel-cell-technologies-office-multi-

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year-research-development-and-22. It is anticipated that up to \$35M in DOE funds will be awarded under this FOA, subject to the availability of appropriations.

It is anticipated that the FOA may include the following Areas of Interest (AOI) and Topics:

AOI 1 – Research and Development (R&D)

Topic 1: Hydrogen Production R&D: Advanced High-Temperature Water Splitting (\$1M-\$3M per award; 1-3 awards; 2-3 year duration; maximum \$5M total federal funds; TRL 2-4)

Applications are sought for the development of high-efficiency, advanced high-temperature water splitting (HTWS) technologies for hydrogen production, energy storage, and grid service applications capable of meeting FCTO targets. This Topic is NOT for conventional, low temperature electrolysis. Advanced HTWS, where electricity is the predominant energy source for splitting water, used in conjunction with high-temperature process waste heat offers the potential for cost-effective large-scale hydrogen production. The development of efficient and durable materials and material systems for use in the electrodes, electrolyte and interconnects of HTWS for operational temperatures ≥600°C are needed. To be cost effective, HTWS will need to meet specific technical performance targets (e.g., per-cell area-specific resistance ≤0.3 Ω•cm2 in a stack configuration and stack electrical efficiency >95% LHV H_2), durability targets (e.g., lifetime of 7 years) and overall system efficiency greater than 75% LHV H_2. Innovative materials development and system integration work are needed to simultaneously achieve performance and durability targets at both the stack and system level. Applications must indicate how the targets can be met; demonstrate that the current technology readiness level (TRL) is at least a 2-4; and include a detailed technical description of how the technology can enable large-scale HTWS capable of meeting the FCTO central production cost goal of <\$2/kg H_2. Deliverables for the proposed work must include techno-economic and life-cycle analysis demonstrating projected costs and GHG emissions savings relative to steam methane reforming of natural gas.

Topic 2: Advanced Compression (\$1M-\$3M per award; 1-3 awards; 2-3 years; maximum \$5M total federal funds; TRL 2-4)

Applications are sought for the development of innovative compression systems that can pressurize hydrogen to at least 875 bar. In order to dispense hydrogen to fuel cell electric vehicle (FCEV) tanks quickly (i.e. compliant with SAE J2601 protocol,) the hydrogen must be compressed to a minimum of 875 bar at the fueling station. Conventional compressors can account for over half of the station's cost, have poor reliability, and have insufficient flow rates for a mature FCEV market. Accordingly, FCTO seeks to fund novel compression technologies that are compatible with stations supplied by 120 bar pipelines, liquid tankers, and/or novel forms of hydrogen delivery (e.g. materials-based storage or cryo-compressed tankers). Applicable compressor technologies include, but are not limited to, centrifugal, advanced liquid pumps, screw, ionic liquid, electrochemical compression, and metal hydride compression. Proposed compression systems must be oil-free or include, and sufficiently demonstrate, the ability to perform gas cleanup resulting in hydrogen that is compliant with the quality standards found in Appendix C of the MYRD&D. Proposed compression systems may require integration with additional station components. However, when such an integration is required, the total cost of the delivery pathway utilizing the proposed system (i.e. hydrogen supply mode, compression system, and ancillary components) must be characterized to demonstrate cost reduction. Applications must identify pathways for the compression system to meet the ultimate capital and operating and maintenance (O&M) targets in the Hydrogen Delivery MYRD&D ($170,000 per compressor with an O&M cost of less than $3,400 per year in high volume production based on 750 kg/day station and ~100 kg H_2/hour peak compressor flow). Applications must also demonstrate that the current TRL is at least a 2-4 and include a detailed technical description of a pathway for the technology to achieve a throughput of 100 kg H_2/hr, an energy consumption of 1.4 kWh/kg or less, and a reliability of 80% or greater. Deliverables of the proposed work must include cost analysis of the design including expected maintenance requirements and a lab-scale demonstration of the technology showing an increase in the TRL of at least 2 levels.

Topic 3: Advanced thermal insulation for automotive applications ($1M per award; 1-2 awards; 2-3 years; maximum$2M total federal funds; TRL 2-4)

Applications are sought for the investigation of improved materials and development of accelerated test methods for use with advanced insulation systems for alternative fuel storage applications onboard vehicles. Gaseous alternative fuels, such as hydrogen and natural gas, suffer from low energy density. One way to improve the energy density is to store the fuel at sub-ambient temperatures, either as a cryogenic liquid or as a cold/cryo-compressed gas. To prevent pressure build-up and loss of fuel through venting, the systems need high performance insulation. Proposed metrics for insulation performance that are expected to be needed include the ability to sustain an average heat leakage rate of about 7 watts or less for an approximate 100 L capacity storage vessel. Additionally, for use onboard vehicles, the insulation must be able to maintain its performance for a typical 15 year average lifetime of a vehicle. Current multi-layer vacuum superinsulation has not proven to be sufficiently robust to meet these requirements for onboard vehicle applications. Therefore advancements are needed in areas such as: development of advanced insulation materials, getters to remove volatile components within the vacuum space, accelerated test methods to evaluate performance and new concepts for high-performance, robust insulation. This technology may be applicable for hydrogen delivery and early market applications (e.g., fleets, buses, etc.) as well, and not solely for light-duty vehicles.

AOI 2 – Demonstration and Deployment

Topic 1: Component Manufacturing and Standardization for H_2 Infrastructure (e.g., hose/piping, dispenser/station technologies) ($1M-$2M per award; 2-3 awards; 3-4 years; maximum $6M total federal funds; TRL-2-5)

Applications are sought for innovative component manufacturing and demonstration to support the supply chain necessary for the growing hydrogen fueling infrastructure. As FCEVs begin to enter the market, more and more scrutiny will be placed on the hydrogen refueling infrastructure that is beginning to come online. Infrastructure reliability is essential for the early FCEV adopters. Station cost must also be reduced and part of this challenge involves developing a robust supply chain and promoting competition for station components such as nozzles, hoses, high-pressure valves, chillers, compressor components and metering devices.

Innovative, low-cost manufacturing processes and demonstration of reliable, low-cost forecourt components that can reliably supply hydrogen at a pressure of ≥ 875 bar (e.g., compatible with SAE J2601 protocol) of FCEVs as well as early market applications (e.g., fleets, buses) should be emphasized. Development of potential components include, but are not limited to, nozzles, hoses, high-pressure valves, chillers, compressor components and metering devices. Compatibility of component materials with hydrogen as well as the ability to withstand frequent pressure and temperature (down to -40°C due to the necessity for precooling) cycling and typical weather conditions seen at refueling stations needs to be considered. Collaboration with other suppliers and end developers in the industry is highly encouraged to allow for component standardization and interchangeability. Approaches to streamline designs, use modular systems/subsystems, and enable multiple suppliers and system integrators to reduce cost while ensuring system performance are encouraged.

Applications for this topic should include plans for a 3 year project divided into 3 Budget Periods. Budget Period 1 will be focused on innovative, low cost manufacturing and standardization of hydrogen refueling infrastructure components. Budget Period 2 will constitute initial bench scale testing. Components successfully developed and tested in Budget Periods 1 and 2 would then be transitioned into Budget Period 3, which will encompass real-world, integrated component testing in the field and ideally at the forecourt. Accelerated project schedules are allowed.

Topic 2: FCTO Crosscutting: America's Climate Communities of Excellence ($250K per award; 1 award; 1-3 years; maximum $250K total federal funds; TRL 7-9)

Applications are sought from communities that are in need of technical assistance in implementing hydrogen and fuel cell technologies to reduce GHG emissions and prepare their communities for the impacts of climate change. Funds will be used for technical assistance and for promoting relevant training, outreach, education and other forms of support to supplement deployment activities already planned by the community (such as the deployment of FCEVs in fleet applications or installation of hydrogen infrastructure). Other examples include deployment of zero emission on and off-road transportation technologies such as: ground support equipment for airports; heavy duty vehicles such as drayage trucks at ports; and medium duty vehicles such as parcel delivery vans, or hydrogen generation technologies, including green hydrogen such as converting landfill and sewage treatment plant waste into usable hydrogen for power generation or transportation applications. The intent of this Topic is to provide technical assistance to awardees of the Climate Action Communities program - http://www.energy.gov/epsa/climate-action-champions)

AOI 3 – Consortium Topics

Topics under AOI 3 are specifically for projects that will work with existing lab-led consortia.

Topic 1: Fuel Cell - Performance and Durability (FC-PAD) ($1M-$3M per award; 2-6 awards; 2-4 years; maximum $6M total federal funds; TRL 2-4)

Applications are sought in the areas of fuel cell performance and durability by expanding the existing national laboratory consortium FC-PAD.

Performance: Fuel cell performance at high power defines system size requirements and therefore greatly impacts cost. Performance of polymer electrolyte membrane fuel cells (PEMFCs) at high power is limited by inefficient mass transport, especially for systems with the low catalyst loadings necessary to approach DOE cost targets. Mass transport issues can also limit performance at other points in the operation cycle, such as during cold operation and during some transients. Applications are sought to improve understanding of critical transport issues in the membrane electrode assembly (MEA) and improve transport in and performance of the MEA. This topic will incorporate innovations from other projects and the broader R&D community into the FC-PAD consortium, aiding in the understanding of performance and durability. The focus of this topic is on low platinum group metal (PGM) materials. A future FOA may focus on non-PGM materials.

Durability: Durability of PEMFCs, especially of those with catalyst loadings that have potential to meet the DOE cost and performance targets, is still insufficient to meet the DOE targets of 5,000 hours for transportation and 60,000 - 80,000 hours for stationary applications (under realistic operating conditions). In the most demanding applications, these conditions include operation in the presence of fuel and air impurities, starting and stopping, freezing and thawing, and humidity and load cycling that result in mechanical and chemical stresses on fuel cell materials, components, and interfaces. MEA durability decreases with decreasing PGM loading, making it all the more difficult to meet durability targets while also meeting cost and PGM loading targets. Proposed approaches should increase understanding of degradation in new and state-of-the-art material sets and improve durability of lower-cost fuel cells under realistic conditions. R&D is needed to improve understanding of degradation of advanced fuel cell materials and components. The results are intended to guide component, cell, and stack development efforts to improve durability by identifying degradation mechanisms and developing mitigation strategies.

While applicants are encouraged to simultaneously address performance and durability, applications that have a narrower focus within performance or durability are allowed. R&D on new structures is solicited, including integration of new electrode ionomers and electrode structures with improved performance and durability. The development of catalysts and membranes is not solicited under this topic as DOE funds separate activities in these areas.

Topic 2: Hydrogen Storage Materials – Advanced Research Consortium (HyMARC)
($250k-$1M per award; 5-12 awards; 1-3 years; maximum $7M total federal funds; TRL 2-4)

Applications are sought for innovative and novel rechargeable hydrogen storage material concepts for use in automotive applications. The materials should have potential for reversible capacities and sufficient charge/discharge kinetics within the operating temperature and pressure window to meet PEMFC requirements onboard vehicles. Further information on specific material requirements can be found on the DOE FCTO Hydrogen Storage Program website (http://energy.gov/eere/fuelcells/materials-based-hydrogen-storage). These projects will work collaboratively with the HyMARC national lab core team on the materials' development and characterization. The projects will initially be funded for a 12-18 month Budget Period I (~$250k for Budget Period I) to demonstrate feasibility of the concept. Only concepts that are demonstrated to be feasible and meet agreed upon minimum performance criteria will be funded for additional Budget Periods.

AOI 4 – Analysis

Topic 1: Cost and Performance Analysis for Fuel Cells ($1M-$1.5M per award; 1 award; 3-5 years; maximum; $1.5M total federal funds)

Applications are sought for fuel cell system analyses for transportation applications to envision, define, and determine the cost of reference for state-of-the-art or conceptual fuel cell systems for various sizes, applications, and manufacturing volumes that are optimized for lifecycle cost. A ground-up cost projection will be based on conceptual designs and related costs of fuel cell system and component manufacturing equipment and processes.

To ensure economic success, transportation fuel cell power systems for applications such as light-duty vehicles, and medium and heavy-duty trucks and buses, must be competitive in performance and cost to the internal combustion engine. For a technology like fuel cells that is not yet in the marketplace in large numbers, a credible and referenceable manufacturing cost estimate is required to accurately gauge the status and the potential of the technology through a bottom-up assessment of the projected future costs (2020 and 2025) that are based on scenarios that meet the DOE goals. Generating a rigorous cost estimate requires a thorough understanding of current PEM fuel cell technology as well as a rigorous design/evaluation methodology, which when applied to the technology will yield optimized (on a lifecycle cost basis) components and manufacturing processes.

Topic 2: Cost and Performance Analysis for H_2 Storage ($1M-$1.5M per award; 1 award; 3-5 years; maximum; $1.5M total federal funds)

Applications are sought for techno-economic and life-cycle assessment analyses for advanced hydrogen storage technologies. The techno-economic analyses will include low through high-volume manufacturing of hydrogen storage systems for onboard transportation and early market fuel cell applications, such as portable, and material handling (e.g., forklifts), with comparisons to DOE cost targets and identification of primary contributors in need of further development for cost reduction. The analyses may need to include developing production costs for innovative system components, such as alternative fibers, advanced fiber composites, and novel hydrogen storage materials. The hydrogen storage systems, for which the cost analyses are to be conducted, will be based primarily on the hydrogen storage system process design and specification from a third-party who will perform the process modeling and design. The system specifications and designs will be based on referenceable system models. The cost analysis will also consider and include material disposal/recycling requirements, as well as, validation of spent fuel regeneration and first fill fuel costs.

Topic 3: Cost and Performance Analysis for H_2 Production and Delivery ($1M-$1.5M per award; 1 award; 3-5 years; maximum; $1.5M total federal funds)

Applications are sought for advancing system-level techno-economic and life-cycle-assessment analyses of hydrogen production and delivery technologies. Techno-economic analyses and cases studies will be developed to: evaluate the potential of production and delivery pathways to meet the FCTO projected high-volume cost goal of <$4/gallon gas e equivalent (gge) untaxed, delivered and dispensed hydrogen by 2020; and evaluate the potential of production and delivery pathways to meet the FCTO early market hydrogen cost target of <$7/gge, untaxed and dispensed at the pump. Life-cycle analyses and case studies will be developed to evaluate the greenhouse gas-emissions- and petroleum-reduction potentials associated with the FCTO portfolio of hydrogen production and delivery options. DOE's portfolio of hydrogen production and delivery analysis tools, including H2A, HDSAM and others are expected to be utilized extensively in the analytical work.

EERE intends to award multiple financial assistance awards in the form of cooperative agreements. The estimated period of performance for each award will vary by AOI and topic area and are provided above.

This Notice is issued so that interested parties are aware of the EERE's intention to issue this FOA in the near term. All of the information contained in this Notice is subject to change. EERE will not respond to questions concerning this Notice. Once the FOA has been released, EERE will provide an avenue for potential Applicants to submit questions.

EERE plans to issue the FOA on or about December 10, 2015 via the EERE Exchange website https://eere-exchange.energy.gov/. If Applicants wish to receive official notifications and information from EERE regarding this FOA, they should register in EERE Exchange. When the FOA is released, applications will be accepted only through EERE Exchange.

In anticipation of the FOA being released, Applicants are advised to complete the following steps, which are required for application submission:

- Register and create an account in EERE Exchange at https://eere-exchange.energy.gov/. This account will 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.

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

- Obtain a Dun and Bradstreet Data Universal Numbering System (DUNS) number (including the plus 4 extension, if applicable) at http://fedgov.dnb.com/webform

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

- 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

- Register in Grants.gov to receive automatic updates when Amendments to a FOA are posted. However, please note that applications will not be accepted through Grants.gov. http://www.grants.gov/. All applications must be submitted through EERE Exchange.