Financial Assistance
Notice of Funding Opportunity
Part 1

U.S. Department of ENERGY | Office of Energy Efficiency & Renewable Energy

U.S. Department of Energy
Office of Energy Efficiency and Renewable Energy
Hydrogen and Fuel Cell Technologies Office

Advanced Hydrogen and Fuel Cell Technologies to Drive National Goals
Notice of Funding Opportunity (NOFO) Number: DE-FOA-0003439

Applications Due: January 31, 2025 at 5:00 p.m. ET

Modifications to this NOFO will be posted on eXCHANGE and Grants.gov. Grants.gov will automatically notify applicants when a NOFO modification is processed. Applicants must be registered to this NOFO in Grants.gov to receive email notifications. See Registration Requirements in Part 2 of this NOFO.

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Before You Begin

Navigating the Notice of Funding Opportunity

The OMB Memorandum M-24-11 directs Federal agencies to reduce the burden on applicants in the Notice of Funding Opportunity (NOFO) process and limit the length of the NOFO information requests. With Fiscal Year (FY) 2025 NOFOs, DOE has separated the NOFO into two parts.

The NOFO Part 1 describes the specific DOE programmatic goals and evaluation criteria, eligibility, and other components that are specific to each funding opportunity. The NOFO Part 2 includes all fixed DOE requirements that generally do not change from NOFO to NOFO, including standard information for the application phase, expectations for award negotiations, and post-award requirements. Prior to application submission, applicants must review both the NOFO Part 1 and the NOFO Part 2. To facilitate navigation, you will find links throughout this document to additional information found in Part 2.

There are several required one-time actions applicants must take before applying to this NOFO. Some of these actions may take several weeks, so it is vital applicants build in enough time to complete them. Failure to complete these actions could interfere with application or negotiation deadlines or the ability to receive an award if selected. If you have previously completed the necessary registrations, make sure your registration is active and up to date. All registrations are free. Please refer to NOFO Part 2, Section I. *Get Registered,* for additional information.

This announcement is published in conjunction with NOFO Part 2.

I. Basic Information

A. Key Facts

Issuing Agency	Department of Energy, Office of Energy Efficiency and Renewable Energy, Hydrogen and Fuel Cell Technologies Office
Funding Opportunity Title	Advanced Hydrogen and Fuel Cell Technologies to Drive National Goals
Announcement Type	Initial
Funding Opportunity Number	DE-FOA-0003439
Funding Instrument	Cooperative Agreement
Research and Development or non-Research and Development	Research and Development; Research, Development, and Demonstration
Assistance Listing Number	81.087
Funding Opportunity Description	This Notice of Funding Opportunity (NOFO) seeks to advance EERE's goals and DOE's commitment to pushing the frontiers of science and engineering and catalyzing clean energy jobs through research, development, demonstration, and deployment. Specifically, HFTO's mission is to enable affordable clean hydrogen and fuel cell technologies for a sustainable, resilient, and equitable net-zero emissions economy.
Program Goals & Objective(s)	This NOFO advances EERE and national goals to deliver an equitable, clean energy future, and put the United States on a path to achieve net-zero emissions, economy-wide, by no later than 2050 to the benefit of all Americans. Projects selected in this NOFO will support the goals of DOE's Hydrogen Shot, which targets affordable clean hydrogen production at $1/kg by 2031, and the H2@Scale Initiative, which aims to advance affordable hydrogen production, transport, storage, and utilization to enable decarbonization and revenue opportunities across multiple sectors. Specific goals in addition to clean hydrogen production of $1/kg by 2031 include: $80/kilowatt (kW), 25,000-hour durability for fuel cell systems in heavy-duty transportation and reducing hydrogen storage costs to an ultimate goal of $8/kilowatt-hour (kWh).
Topic Areas	• Topic 1: Photoelectrochemical Water Splitting Device Scale Up • Topic 2: High-Performance Materials for Hydrogen Service, Including Cryogenic and/or High-Pressure Conditions • Topic 3: Sustainable High-Temperature Proton Exchange Membranes and Ionomers for Heavy-Duty Transportation Applications • Topic 4: Domestic Hydrogen Fuel Cell Electric Motorcoach Bus Development and Demonstration

KEY DATES

Notice of Funding Opportunity Issue Date:
October 23, 2024

Concept Paper Deadline:
November 20, 2024, at 5pm ET

Application Deadline:
January 31, 2025, at 5pm ET

Reply to Reviewer Comments Deadline:
March 14, 2025, at 5pm ET

Anticipated Selection Notification Date:
May 2025

Anticipated Award Date:
September 2025

Eligible Applicants	• Domestic Entities (Institutions of higher education; for-profit entities; nonprofit entities; state and local government entities; and Indian Tribes, as defined in section 4 of the Indian Self-Determination and Education Assistance Act, 25 U.S.C. § 5304 • DOE/NNSA FFRDCs are eligible to apply for funding as a subrecipient but are not eligible to apply as a recipient. • Non-DOE/NNSA FFRDCs are eligible to participate as a subrecipient but are not eligible to apply as a recipient. • Federal agencies and instrumentalities (other than DOE) are eligible to participate as a subrecipient but are not eligible to apply as a recipient. • A foreign entity may submit an application to this NOFO, but the application must be accompanied by an explicit written waiver request. Likewise, if the applicant seeks to include a foreign entity as a subrecipient, the applicant must submit a separate explicit written waiver request in the application for each proposed foreign subrecipient.
EERE eXCHANGE URL and Help Desk Contact Info	https://eere-eXCHANGE.energy.gov EERE-ExchangeSupport@hq.doe.gov – include NOFO name and number in the subject line.

1. Funding Details

Multiple Topics

Approximate total available funding including all topics: up to $46,000,000* in FY 2025

*Subject to availability of appropriations

Topic 1: Photoelectrochemical Water Splitting Device Scale Up

Approximate total available funding: up to $10,000,000 in FY 2025
Approximate number of awards: 3 to 4
Approximate dollar amount of individual awards: up to $2,000,000 to $3,000,000
Minimum cost share required: 20% of the total project costs
Approximate award project period: 24 to 36 months
Anticipated length of budget periods: 12 months

Topic 2: High-Performance Materials for Hydrogen Service, Including Cryogenic and/or High-Pressure Conditions

Approximate total available funding: up to $16,000,000 in FY 2025
Approximate number of awards: 6 to 11
Approximate dollar amount of individual awards: up to $1,000,000 to $3,000,000
Minimum cost share required: 20% of total project costs
Approximate award project period: 24 to 36 months
Anticipated length of budget periods: 12 months

Topic 3: Sustainable High-Temperature Proton Exchange Membranes and Ionomers for Heavy-Duty Transportation Applications

Approximate total available funding: up to $10,000,000 in FY 2025
Approximate number of awards: 3 to 5
Approximate dollar amount of individual awards: up to $2,000,000 to $3,000,000
Minimum cost share required: 20% of total project costs
Approximate award project period: 24 to 36 months
Anticipated length of budget periods: 12 months

Topic 4: Domestic Hydrogen Fuel Cell Electric Motorcoach Bus Development and Demonstration

Approximate total available funding: up to $10,000,000 in FY 2025
Approximate number of awards: 1-2
Approximate dollar amount of individual awards: up to $5,000,000 to $10,000,000
Minimum cost share required: 50% of total project costs
Approximate award project period: 36 to 48 months
Anticipated length of budget periods: 12 or 18 months

2. Period of Performance

DOE anticipates making awards, comprised of multiple budget periods. If applicable, project continuation will be contingent upon DOE's Go/No-Go decision. For a complete list and more information on the Go/No-Go review, see the NOFO Part 2, Section VIII. *Award Administration Information*. Funding for all budget periods, including the initial budget period, is not guaranteed.

B. Executive Summary

Hydrogen and fuel cell technologies play a key role in enabling America's leadership in clean energy technology, enhancing energy security and resilience, reducing emissions, and in creating economic value and equitable opportunities for all Americans. Aligned with national goals, the benefits of hydrogen and fuel cell technologies will be significant in hard to decarbonize sectors, and span across transportation, power, and industrial and chemical production applications. As stated in the *U.S. National Clean Hydrogen Strategy and Roadmap,*[1] clean hydrogen has the potential to reduce economy-wide emissions 10% by 2050 and create 100,000 jobs by 2030.

Clean hydrogen has a particularly important role to play in addressing our hardest-to-decarbonize sectors, which include key economic engines that are essential to the modern American economy and quality of life, such as heavy-duty transportation, chemical and industrial processes like steelmaking, and the production of liquid fuels and fertilizers. By enabling diverse, domestic clean energy pathways across multiple sectors of the economy, clean hydrogen will also strengthen American energy independence and resilience while creating good jobs, economic growth, and export opportunities.

The Hydrogen and Fuel Cell Technologies Office's (HFTO) mission is to enable affordable clean hydrogen and fuel cell technologies for a sustainable, resilient, and equitable net-zero emissions economy. Informed by input from diverse stakeholders engaged in relevant private- and public-sector hydrogen activities across multiple sectors of the economy, HFTO strategically deploys funding for research, development, and demonstration (RD&D) activities to achieve the goals that support this mission.

[1] U.S. Department of Energy. U.S. National Clean Hydrogen Strategy and Roadmap. 2023. https://www.hydrogen.energy.gov/library/roadmaps-vision/clean-hydrogen-strategy-roadmap.

This NOFO targets RD&D topics critical to scaling hydrogen infrastructure and enabling increased adoption of clean hydrogen across sectors. Increased adoption of hydrogen technologies will help achieve economies of scale and drive down costs, directly supporting DOE's Regional Clean Hydrogen Hubs (H2Hubs) Program,[2] an $8 billion federal investment to create networks of hydrogen producers, consumers, and local connective infrastructure to accelerate the use of hydrogen. Activities funded under this NOFO align with the H2@Scale Initiative,[3] which aims to advance affordable hydrogen production, transport, storage, and utilization to enable decarbonization and revenue opportunities across sectors and supports DOE's Hydrogen Shot goal,[4] which targets affordable clean hydrogen production at $1/kg within a decade.

HFTO supports a broad portfolio of RD&D projects for materials, components, and systems throughout the clean hydrogen value chain. This NOFO specifically seeks applications in the following four topics:

- Topic 1: Photoelectrochemical Water Splitting Device Scale Up
- Topic 2: High-Performance Materials for Hydrogen Service, Including Cryogenic and/or High-Pressure Conditions
- Topic 3: Sustainable High-Temperature Proton Exchange Membranes and Ionomers for Heavy-Duty Transportation Applications
- Topic 4: Domestic Hydrogen Fuel Cell Electric Motorcoach Bus Development and Demonstration

C. Agency Contact Information

Office of Energy Efficiency and Renewable Energy
Hydrogen and Fuel Cell Technologies Office
U.S. Department of Energy
1000 Independence Ave SW
Washington, D.C. 20585

For questions relating to this specific NOFO, please send emails to H2FCFOA@ee.doe.gov .

DISCLAIMER: Applicants are discouraged from submitting information considered proprietary unless it is deemed essential for proper evaluation of the application. If the application contains information that the applicant organization considers to be trade secrets, information that is commercial or financial, or information that is privileged or confidential, the pages containing that information should be identified as specified in the application instructions. When such information is included in the application, it will be withheld from public disclosure to the extent permitted by law, including the Freedom of Information Act, with the understanding that the information will be used or disclosed only for evaluation of the application. The information contained in the application will be protected by DOE from unauthorized disclosure, consistent with the need for merit review of applications of financial assistance awards to assure the integrity of the competitive process and the accuracy and completeness of the information. If a federal financial assistance award is made as a result of or in connection with an application, the federal government has the right to use or disclose the information to the extent authorized by law. This restriction does not limit the federal government's right to use the information if it is obtained without restriction from another source.

[2] Regional Clean Hydrogen Hubs | Department of Energy
[3] *H2@Scale Initiative*, https://www.energy.gov/eere/fuelcells/h2scale
[4] *Hydrogen Shot*, https://www.energy.gov/eere/fuelcells/hydrogen-shot

II. Eligibility

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 and ineligible for any award. DOE will not make eligibility determinations for potential applicants prior to the date on which applications to this NOFO must be submitted. The decision whether to apply in response to this NOFO lies solely with the applicant. The information included here is specific to eligibility requirements for this NOFO. For eligibility requirements applicable to all NOFOs, please consult the NOFO Part 2, Section II. *Eligibility*.

A. Eligible Applicants

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.

1. Restricted eligibility

In accordance with 2 CFR 910.126, eligibility for this NOFO is restricted because HFTO plans to designate more than 50% of the FY2025 appropriations for ongoing research and development (R&D) at national laboratories. To ensure there are funding opportunities for the private sector, consistent with Congressional and DOE priorities, this NOFO is restricted to exclude DOE/NNSA FFRDCs/National Laboratories from applying for funding as a prime recipient. DOE is restricting eligibility to the entities identified below.

2. Domestic Entities

Domestic entities are eligible to apply as recipients or subrecipients. The following types of domestic entities are eligible to participate as a recipient or subrecipient of this NOFO:

- Institutions of higher education;
- For-profit organizations;
- Nonprofit organizations;
- State and local governmental entities; and
- Indian Tribes, as defined in section 4 of the Indian Self-Determination and Education Assistance Act, 25 U.S.C. § 5304.[5]

To qualify as a domestic entity, the entity must be organized, chartered, or incorporated (or otherwise formed) under the laws of a particular state or territory of the United States or under the laws of the United States; **have majority domestic ownership and control**; and have a physical place of business in the United States.

[5] "**Indian Tribe**," for the purposes of this NOFO and as defined in in section 4 of the Indian Self-Determination and Education Assistance Act (25 U.S.C. § 5304), [1]means any Indian tribe, band, nation, or other organized group or community, including any Alaska Native village or regional or village corporation as defined in or established pursuant to the Alaska Native Claims Settlement Act (85 Stat. 688) [43 U.S.C. § 1601, et seq.], which is recognized as eligible for the special programs and services provided by the United States to Indians because of their status as Indians. Federally Recognized Indian Tribes are also considered disadvantaged communities for the purposes of Justice40 requirements in this NOFO per https://www.whitehouse.gov/wp-content/uploads/2023/01/M-23-09_Signed_CEQ_CPO.pdf.

3. Foreign Entity Participation

In general, foreign entities are not eligible to apply as either a recipient or subrecipient. In limited circumstances, DOE may approve a waiver to allow a foreign entity to participate as a recipient or subrecipient.

A foreign entity may submit an application to this NOFO, but the application must be accompanied by an explicit written waiver request. Likewise, if the applicant seeks to include a foreign entity as a subrecipient, the applicant must submit a separate explicit written waiver request in the application for each proposed foreign subrecipient. Please see NOFO Part 2, Section IV.B. *Application Content Requirements* for the requirements for submission of a foreign entity waiver request. The applicant does not have the right to appeal DOE's decision concerning a waiver request.

Participant Limitations

Participation of the following entities are limited as follows.

- DOE FFRDCs[6] are eligible to apply for funding as a subrecipient but are not eligible to apply as a recipient.
- Non-DOE FFRDCs are eligible to participate as a subrecipient but are not eligible to apply as a recipient.
- Federal agencies and instrumentalities (other than DOE) are eligible to participate as a subrecipient but are typically not eligible to apply as a recipient.

Performance of Work in the United States

All work for the awards under this NOFO must be performed in the United States. To request a waiver of this requirement, the applicant must submit an explicit waiver request in the application. Absent an approved waiver, such costs will not be allowable under the award. The NOFO Part 2, Section IV.B. *Application Content Requirements* lists the requirements for submission of a foreign work waiver request.

Ineligible Participants

The following entities are ineligible for participation in this NOFO as a recipient, subrecipient, or subcontractor:

- In accordance with 2 CFR 200.214, entities banned from doing business with the U.S. government such as entities debarred, suspended, or otherwise excluded from or ineligible for participating in federal programs.
- Entities identified on Department of the Treasury Office of Foreign Assets Control Treasury's Sanctions Program Specially Designated Nationals list are prohibited from doing business with the United States government and are not eligible. See OFAC - Sanctions List Service(treas.gov).
- 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. However, nonprofit organizations described in Section 501(c)(5) of the Internal Revenue Code are eligible to apply for funding.

Entity of Concern Prohibition

Entities of Concern are prohibited from participating in projects selected under this NOFO (see NOFO Part 2, Section II.B.2. *Entity of Concern Prohibition* for details and definitions).

[6] FFRDCs are public-private partnerships that conduct research for the U.S. government. A listing of FFRDCs can be found at http://www.nsf.gov/statistics/ffrdclist/.

B. Limitation on Number of each Paper and Application Eligible for Review

An entity may submit more than one Concept Paper and associated application to this NOFO, provided that each describes a unique, scientifically distinct project concept.

C. Cost Sharing

Applicants are expected to follow through on estimated cost share commitments proposed in their applications if selected for award negotiations. Please refer to the NOFO Part 2, Section II. *Eligibility* for more information on Cost Sharing.

1. Cost Share Requirements

The cost share must be at least 20% of the total project costs[7] for research and development projects and 50% of the total project costs for demonstration projects[8].

Topic Number	Topic Title	Cost Share Requirement
1	Photoelectrochemical Water Splitting Device Scale Up	20%
2	High-Performance Materials for Hydrogen Service, Including Cryogenic and/or High-Pressure Conditions	20%
3	Sustainable High-Temperature Proton Exchange Membranes and Ionomers for Heavy-Duty Transportation Applications	20%
4	Domestic Hydrogen Fuel Cell Electric Motorcoach Bus Development and Demonstration	50%

Applications that do not meet the minimum required cost share may be deemed ineligible during the initial compliance review and will not be further reviewed.

The cost share percentage is calculated by dividing the cost share by the total allowable project costs for the award where the total allowable project costs include government share (including FFRDC costs if applicable) and cost share. To help applicants calculate proper cost share amounts, DOE has included a cost share information sheet and sample cost share calculation in the NOFO Part 2, Section II. A.7. *Cost Share Calculation Examples*.

2. Unallowable Cost Share Sources, NOFO Specific

Refer to NOFO Part 2, Section II.B. *Cost Sharing* for unallowable cost share sources applicable to all NOFOs.

[7] Total project cost is the sum of the government share, including FFRDC costs if applicable, and the recipient share of project costs.

[8] Energy Policy Act of 2005, Pub.L. 109-58, sec. 988. Also see 2 CFR 200.306 and 2 CFR 910.130 for additional cost sharing requirements.

D. FFRDC Eligibility Criteria

1. DOE and Non-DOE FFRDCs as a Subrecipient

As long as there is no conflict of interest present, DOE and non-DOE FFRDCs may be proposed as a subrecipient on another entity's application subject to the following guidelines:

Authorization for non-DOE 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.

Authorization for DOE 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."

Funding, Cost Share, and Subaward with FFRDCs

The value of and funding for the FFRDC portion of the work will not normally be included in the award. DOE FFRDCs participating as a subrecipient on a project will be funded directly through the DOE Work Authorization process in accordance with DOE O 412.1A. Non-DOE FFRDCs participating as a subrecipient will be funded through an interagency agreement with the sponsoring agency.

Although the FFRDC portion of the work is excluded from the award, 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.

All DOE FFRDCs are required to enter into a Cooperative Research and Development Agreement[9] (CRADA) or, if the role of the DOE FFRDC is limited to technical assistance and intellectual property (IP) is not anticipated to be generated from the DOE FFRDC's work, a Technical Assistance Agreement (TAA), with at least the recipient. A fully executed CRADA or TAA must be in place or be compliant with a Master Scope of Work process prior to the FFRDC starting work directly allocable to the financial assistance award.

A CRADA is used to ensure accountability for project work and provide the appropriate management of IP, e.g., data protection and background IP. A Data Management Plan is not suited for this purpose.

Limit on FFRDC Effort

The FFRDC effort, in aggregate, shall not exceed 25% of the total project cost.[10]

[9] A cooperative research and development agreement is 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

[10] Total project cost is the sum of the government share, including FFRDC costs if applicable, and the recipient share of project costs.

III. Program Description

A. Background and Context

The Office of Energy Efficiency and Renewable Energy (EERE) advances applied research, development, demonstration, and deployment projects to support the adoption and commercialization of energy innovations across a range of technologies and sectors. These innovations power our grid with low-carbon renewable energy, enable sustainable transportation and fuels, reduce energy consumption and emissions from our buildings and industries, and drive growth and improvement in domestic manufacturing and supply chains.

EERE is issuing Notice of Funding Opportunity (NOFO) DE-FOA-0003439 on behalf of the Hydrogen and Fuel Cell Technologies Office (HFTO), which coordinates hydrogen activities with offices across the Department of Energy (DOE) as described in the *DOE Hydrogen Program Plan*.[11] These activities align with EERE's mission, the *U.S. National Clean Hydrogen Strategy and Roadmap,*[12] the *U.S. National Blueprint for Transportation Decarbonization*,[13] and other DOE initiatives as described below.

Through this NOFO, HFTO seeks to continue to advance EERE's goals and DOE's commitment to pushing the frontiers of science and engineering and catalyzing clean energy jobs through research, development, and demonstration (RD&D). Specifically, HFTO's mission is to enable affordable clean hydrogen and fuel cell technologies for a sustainable, resilient, and equitable net-zero emissions economy. HFTO strategically deploys funding for RD&D activities to achieve the goals that support this mission. Funded efforts fall roughly into two broad areas:

Research and development (R&D) activities, which aim to improve materials, components, and subsystems at laboratory scale. These activities address many underlying technical barriers to reducing the cost and improving the performance of key technologies, such as electrolyzers, fuel cells, and systems for storing, delivering, and dispensing hydrogen.

Demonstration and enabling activities, which involve integration and operation of complete systems under real-world conditions to validate performance and de-risk investment, along with deployment of commercial-scale systems to identify and help overcome nontechnological barriers. Activities focus on key strategic applications, such as demonstrations of fuel-cell-powered vehicles, fueling infrastructure for medium- and heavy-duty trucks, and nuclear-to-hydrogen production.

B. Program Purpose

The RD&D activities to be funded under this NOFO will support the "whole-of-government" approach to drive innovation that can lead to the deployment of clean energy technologies, which are critical for emissions reductions. As laid out in the *U.S. National Clean Hydrogen Strategy and Roadmap*, the federal government is undertaking a holistic, whole-of-government approach to overcoming the challenges facing clean hydrogen. To implement the national strategy, the Hydrogen Interagency Task Force[14] (HIT)

[11] *Department of Energy Hydrogen Program Plan*, www.hydrogen.energy.gov/pdfs/hydrogen-program-plan-2020.pdf
[12] *U.S. National Clean Hydrogen Strategy and Roadmap,* www.hydrogen.energy.gov/library/roadmaps-vision/clean-hydrogen-strategy-roadmap
[13] *U.S. National Blueprint for Transportation Decarbonization,* https://www.energy.gov/eere/us-national-blueprint-transportation-decarbonization-joint-strategy-transform-transportation
[14] *Hydrogen Interagency Task Force, https://www.hydrogen.energy.gov/interagency*

coordinates activities across multiple agencies, including long-standing efforts within DOE's Hydrogen Program.[15]

This NOFO supports the vision outlined in the *U.S. National Clean Hydrogen Strategy and Roadmap* targeting topics critical to enabling increased adoption of clean hydrogen across sectors, including in heavy-duty vehicles, also supporting the *U.S. National Blueprint for Transportation Decarbonization*. Projects selected in this NOFO will support the goals of the Hydrogen Energy Earthshot™ (Hydrogen Shot),[16] which targets affordable clean hydrogen production at $1/kg within the decade, and the H2@Scale Initiative,[17] which aims to advance affordable hydrogen production, transport, storage, and utilization to enable decarbonization and revenue opportunities across multiple sectors.

C. Program Goals and Objectives

This NOFO supports the vision outlined in the *U.S. National Clean Hydrogen Strategy and Roadmap* of affordable clean hydrogen for a net-zero carbon future and a sustainable, resilient, and equitable economy. It targets four topics of interest critical to enabling increased adoption of clean hydrogen technologies across sectors, particularly in medium- and heavy-duty (MD/HD) vehicles and other heavy-duty transportation applications. This NOFO's focus on MD/HD vehicles supports the vision for clean hydrogen in the *U.S. National Blueprint for Transportation Decarbonization*. Increased adoption of hydrogen technologies will help achieve economies of scale and drive down costs, supporting efforts to reach the Hydrogen Shot goal and achieve net-zero greenhouse gas (GHG) emissions by 2050[18]. By supporting the development of clean hydrogen technologies, this NOFO contributes to the long-term viability of DOE's Regional Clean Hydrogen Hubs (H2Hubs) and other commercial-scale deployments. The H2Hubs Program is an $8 billion federal investment to create networks of hydrogen producers, consumers, and local connective infrastructure to accelerate the use of hydrogen as a carbon-free energy carrier and input to several important chemical processes.

Hydrogen and fuel cell technologies are part of a comprehensive portfolio of solutions to address the challenges facing clean hydrogen and position America as a global leader in clean energy technology and clean energy jobs. As shown in Figure 1, the H2@Scale vision is for hydrogen to play a role as a uniquely versatile decarbonization tool that can be produced using any form of energy in almost any part of the country and can be used across all sectors of the economy. This versatility means that clean hydrogen can be used in high-impact applications, particularly in the hardest-to-decarbonize sectors of the economy (such as heavy-duty transportation and industrial applications). It can also support the expansion of clean-power generation by providing a means for long-duration energy storage and offering flexibility and multiple revenue streams for clean-power generators and providers. For clean hydrogen to achieve its potential, key challenges around affordability, durability, and reliability must be addressed. Innovations are needed to reduce the cost and improve the performance of technologies throughout the clean-hydrogen value chain, from production to storage, transportation, and use.

[15] *Department of Energy Hydrogen Program,* https://www.hydrogen.energy.gov/
[16] *Hydrogen Shot*, https://www.energy.gov/eere/fuelcells/hydrogen-shot
[17] *H2@Scale Initiative*, https://www.energy.gov/eere/fuelcells/h2scale
[18] EO 14008, "Tackling the Climate Crisis at Home and Abroad," January 27, 2021.

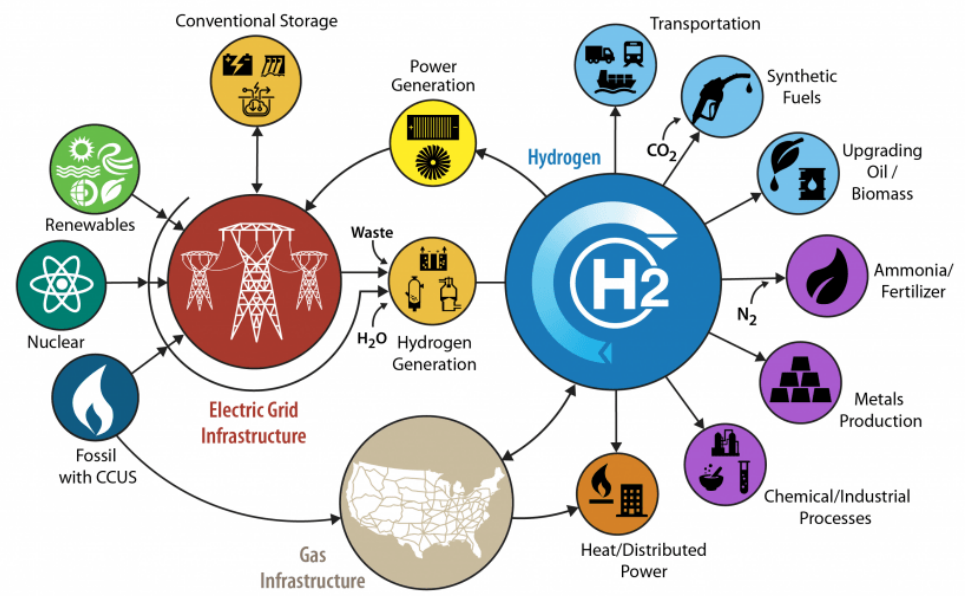

Figure 1. The H2@Scale vision

Achieving the Hydrogen Shot goal will unlock a significant increase in markets for clean hydrogen, including clean steel manufacturing, clean ammonia, energy storage, and heavy-duty transportation. This will, in turn, create more clean energy jobs, reduce GHG and criteria pollutant emissions, increase energy security and resiliency, and position America for leadership in global markets for clean hydrogen and its derivatives.

HFTO supports a broad portfolio of RD&D projects for materials, components, and systems throughout the clean hydrogen value chain. These efforts are advancing technologies for renewable hydrogen production, hydrogen storage, hydrogen delivery and fueling infrastructure, and fuel cells (e.g., for MD/HD transportation applications), among others. HFTO also conducts demonstrations of systems in real-world operating conditions, including first-of-a-kind demonstrations of integrated energy systems. To support deployment and commercialization, HFTO also conducts a variety of enabling activities to: advance processes and technologies for manufacturing hydrogen and fuel cell components and systems; improve supply chains and workforce capacity; improve safety practices and awareness; enable the adoption of essential codes and standards; and support partnerships and activities that ensure the economic and environmental benefits of HFTO investments are available to underserved communities.

D. Expected Performance Goals

The topics and expected performance goals in this NOFO are summarized below. More-detailed technical descriptions of each topic are provided in the sections that follow.

Topic 1: Photoelectrochemical Water Splitting Device Scale Up

This topic focuses on hydrogen production via photoelectrochemical (PEC) water splitting. Since this is a production pathway that is far less dependent on the cost of electricity than electrolysis and has the potential to meet the Hydrogen Shot goal, these efforts will complement HFTO's electrolysis activities funded by the Bipartisan Infrastructure Law (BIL). This topic seeks proposals to develop and demonstrate PEC devices using low-cost, scalable synthesis and fabrication techniques. Previously, PEC

devices have been demonstrated to produce hydrogen from sunlight at benchtop and small demonstration scales. Typical materials for PEC devices, such as III-V light absorbers, have relied on low-throughput, high-cost fabrication steps that are not amenable to scaled-up manufacturing. The development of commercially relevant facile synthesis and fabrication techniques and innovative system designs are important pathways for reducing the cost of PEC devices.

Projects are expected to achieve final reactor demonstrations with device areas of at least 0.25 m^2 that operate over a two-week diurnal period at hydrogen production rates of 1 g/h. Projects will also need to propose a pathway to future scale up to over 1 m^2 device area, with technoeconomic analysis showing projected at-scale manufacturing costs. Proposals involving both planar (Types III and IV) and particle (Type II) PEC systems will be considered, excluding any systems where hydrogen and oxygen are co-evolved. Projects should not involve materials discovery but should instead focus on addressing challenges associated with scaling up existing PEC materials. Solar concentrators may also be included, but the area of the solar concentrator should not be included in the device area requirement. In addition, HFTO seeks system design perspectives and analyses to enable optimized, large-scale, and efficient systems for large volumes of hydrogen production using PEC approaches. Applicants coordinating with industry partners with manufacturing expertise in relevant materials spaces, such as the solar industry, are preferred.

Topic 2: High-Performance Materials for Hydrogen Service, Including Cryogenic and/or High-Pressure Conditions

This topic seeks proposals to develop advanced materials for a variety of hydrogen infrastructure needs, to ensure that safe, low-cost, and scalable hydrogen storage and delivery are available to meet growing hydrogen production and end use. This topic area includes two subtopics: 2A: High-Performance Composite Materials for High-Pressure Hydrogen Storage Tanks and Pipelines, and 2B: High-Performance Materials Compatible for Use in Hydrogen Service in Collaboration with H-Mat.

Topic 2A targets high-pressure applications, where high-strength fibers, resins, and liner materials that are resistant to hydrogen permeation and diffusion, are required. Expected performance goals are material strength and system performance that exceed that of current materials used in 700-bar hydrogen storage tanks and composite pipelines for 100 bar working pressure. These goals should be accompanied by strategies to ensure these materials can be produced at large scale and low cost, and can be recycled or reused. An additional goal is projecting performance and cost of tanks or pipelines produced using the developed technology in an end-use application through technoeconomic analysis.

Topic 2B broadly targets materials that can resist or withstand the effects of hydrogen exposure that can make them vulnerable to damage and degradation. This applies to metals and polymers operating in a wide range of pressure, temperature, and external loading conditions that may extend up to at least 1,000 bar pressure and from cryogenic liquid hydrogen to several hundred degrees Celsius temperatures. Expected performance goals for metallic materials for use in fueling station compressors, dispensers, and storage are equipment durability of 5 years, 10 years, and 30 years, respectively. For polymer materials for use in hydrogen dispensing hoses, operational lives of at least 25,000 cycles, and burst pressures of at least 3,500 bar are expected. Goals also include an improved understanding of microstructure-property attributes and hydrogen-surface and hydrogen-corrosion interactions, and predicting material performance. Through collaboration with the H-Mat consortium, efforts will contribute to overcoming current performance limitations and enabling the discovery of improved materials.

Topic 3: Sustainable High-Temperature Proton Exchange Membranes and Ionomers for Heavy-Duty Transportation Applications

The topic seeks proposals to develop sustainable, non-perfluorosulfonic-acid membrane and ionomer technologies suitable for high temperature (up to 120° C) operation in fuel cells for heavy-duty (HD) transportation applications. To address concerns of environmental sustainability for state-of-the-art incumbent proton exchange membrane (PEM) materials as well as high temperature performance for PEM fuel cells in HD transportation applications, this topic seeks novel chemistries that could result in cost-competitive, scalable, and durable membranes that can achieve performance targets and would contribute to meeting the 2030 fuel cell system targets for HD transportation (25,000-hour lifetime and $80/kW fuel cell system cost). Membranes and ionomers are critical fuel cell components that can limit performance and durability, especially under high-power conditions with high temperature and low relative humidity. Higher-temperature fuel cell operation (up to 120 °C) can improve stack efficiency and power output, and more effectively reject heat. However, operating at high temperature presents challenges for established materials, such as accelerated membrane degradation and reduced membrane proton conductivity and performance.

The topic solicits innovative projects that will develop membranes and ionomers that can: (1) demonstrate the ability to reach 25,000-hour durability with suppressed gas crossover while maintaining high fuel cell efficiency and performance; and (2) operate effectively at temperatures in the range of 100–120 °C and low relative humidity (<30%). Projects should explore the relationships between operating conditions and membrane performance (conductivity and durability). Approaches that target fluorine-free ionomers and membranes are strongly encouraged. While membrane support materials are not the main focus of this topic, approaches that also include the development of supporting expanded polytetrafluoroethylene (e-PTFE) alternatives are encouraged.

Topic 4: Domestic Hydrogen Fuel Cell Electric Motorcoach Bus Development and Demonstration

This topic seeks proposals to enable the development and demonstration of domestically produced, long-range hydrogen fuel cell electric motorcoach buses (also known as “over-the-road”, “coach”, or “charter” buses). Similar to fuel-cell forklifts—which were a highly successful focus area for previous HFTO-funded RD&D—motorcoach buses offer a targeted, niche application with limited zero-emissions options for full decarbonization of the market segment. Systems development, integration, and demonstration of such niche applications can help de-risk hydrogen and fuel cell technologies and offer opportunities to gather data to help guide future RD&D as well as catalyze system developers, component suppliers, and future domestic manufacturing.

The overall objective of this topic is to demonstrate an economical and scalable hydrogen fuel cell electric motorcoach bus that can meet incumbent motorcoach performance without compromising space or passenger comfort, including >300-mile driving range, >75-mph maximum speed, fueling rates of <20 minutes, >50-passenger capacity, underneath cargo storage, and seating-space to provide the same passenger comfort and convenience provided by conventional motorcoaches today. As part of the proposal, the applicant should include performance metrics for a baseline reference motorcoach vehicle and fleet profile, as well as goals for the hydrogen fuel cell electric motorcoach bus they propose to develop. Once developed, each project will be required to demonstrate operation of a hydrogen fuel cell electric motorcoach bus in a real-world operational environment at a suitable location. Operation and performance validation is encouraged to be conducted at a site with potential for follow-on fleet

applications. This topic also encourages activities that help validate fuel cell functionality and hydrogen-related infrastructure in different climates, as well as in rural conditions.

E. Teaming Partner List (Optional)

DOE is compiling a Teaming Partner List to facilitate the formation of project teams for this NOFO. The Teaming Partner List allows organizations that may wish to participate on a project to express their interest to other applicants and explore potential partnerships.

The Teaming Partner List will be available on eXCHANGE and will be regularly updated to reflect new teaming partners who provide their organization's information.

SUBMISSION INSTRUCTIONS: View the Teaming Partner List by visiting the eXCHANGE homepage and clicking on "Teaming Partners" within the left-hand navigation pane. This page allows users to view published Teaming Partner Lists. To join the Teaming Partner List, submit a request within eXCHANGE. Select the appropriate Teaming Partner List from the drop-down menu, and fill in the following information: Investigator Name, Organization Name, Organization Type, Topic Area, Background and Capabilities, Website, Contact Address, Contact Email, and Contact Phone.

DISCLAIMER: 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 the Teaming Partner List, DOE is not endorsing, sponsoring, or otherwise evaluating the qualifications of the individuals and organizations that are identifying themselves for placement on this Teaming Partner List. DOE will not pay for the provision of any information, nor will it compensate any applicants or requesting organizations for the development of such information.

F. Topics

General Information for All Topics

Anticipated Funding and Project Details

DOE's anticipated funding levels, including the federal funding per award, are provided below:

Topic Area	Total Funding Level*	Anticipated Number of Awards	Federal Funding Per Award	Max. Project Duration (Months)	Min Required Non-Federal Cost Share (%)
Topic 1: Photoelectrochemical Water Splitting Device Scale Up	**Up to $10,000,000**	**3 to 4**	**$2,000,000 to $3,000,000**	**36**	**20%**
Topic 2A: High-Performance Composite Materials for High-Pressure Hydrogen Storage Tanks and Pipelines	**Up to $10,000,000**	**3 to 5**	**$2,000,000 to $3,000,000**	**36**	**20%**

Topic 2B: High-Performance Materials Compatible for Use in Hydrogen Service in Collaboration with H-Mat	**Up to $6,000,000**	**3 to 6**	**$1,000,000 to $2,000,000**	**36**	**20%**
Topic 3: Sustainable High-Temperature Proton Exchange Membranes and Ionomers for Heavy-Duty Transportation Applications	**Up to $10,000,000**	**3 to 5**	**$2,000,000 to $3,000,000**	**36**	**20%**
Topic 4: Domestic Hydrogen Fuel Cell Electric Motorcoach Bus Development and Demonstration	**Up to $10,000,000**	**1 to 2****	**$5,000,000 to $10,000,000****	**36 to 48****	**50%**

*Subject to availability of appropriations

**DOE anticipates that applications focused on retrofit designs will have a shorter period of performance and smaller budgets compared to applications focused on complete ground-up designs.

Project Budget

Applicants should propose projects up to the maximum total DOE funding per project plus the minimum non-federal cost share as shown in the table above. For example, applicants may propose:

- For Topics 1-3 with 20% cost share, $2,000,000 DOE share and $500,000 cost share for $2,500,000 total.
- For Topic 4 with 50% cost share, $10,000,000 DOE share and $10,000,000 cost share for $20,000,000 total.

The cost share percentage is calculated by dividing the cost share by the total allowable project costs for the award where the total allowable project costs include government share (including FFRDC costs if applicable) and cost share. To help applicants calculate proper cost share amounts, DOE has included a cost share information sheet and sample cost share calculation in the NOFO Part 2, Section II. A.7. *Cost Share Calculation Examples*.

The funding request should be commensurate with the level of work proposed. For topics that *require* collaboration with a national laboratory consortium (e.g., HydroGEN, H-Mat, M2FCT), proposed consortium activities should not be included in the project budget. Non-consortium national laboratory activities should be included in the proposed budget where the national laboratory is a subrecipient.

Project Structure

Applicants should plan projects between two to four phases, commensurate with the topic's maximum project duration and the scope of the proposal, with a quantitative Go/No-Go decision point separating each phase (budget period). For Topics 1-3, each budget period should be 12 months long. Topic 4

applications should have budget periods structured as 12 or 18 months, dependent upon the overall project length. Suggested phases include planning, initial design, operation, testing, validation, or other appropriate phase descriptions. DOE encourages proposals with distinct phases long enough to generate substantial data and preference will be given to proposed projects with a high likelihood of technological, performance, and manufacturing advancement of materials after the DOE-funded phases of the project are complete.

Project Teaming Arrangement

Teaming arrangements that include multiple stakeholders across academia, industry, and national laboratories (as appropriate) are encouraged. Applicants should succinctly describe the role, qualifications, experience, and capabilities of the proposed project team partners to execute the project plan successfully. If the project lead *does not* have the facilities and resources to carry out the proposed project work, it will be necessary to include project partner(s) who can perform that role. For topics that *require* collaboration with national laboratory consortia, consortia members should not be included as team members or involved in application development.

Applicants are encouraged to meaningfully and substantially collaborate with Minority Serving Institutions (MSIs) such as Historically Black Colleges and Universities (HBCUs), Tribal Colleges and Universities (TCUs), and Other Minority Institutions.

Strong preference will be given to applicants with domestic capability and intent to manufacture, invest, and market to customers in the United States. Please see each Topic description for specific expertise or capability requirements.

For topics that are *required* to partner with national laboratory consortia (e.g., HydroGEN, H-Mat, M2FCT), all team partners for the selected awardees will be encouraged to sign a standard non-disclosure agreement (NDA) as part of the award negotiation process. Team partners may also be required to sign cooperative research and development agreements (CRADAs) and/or materials transfer agreements (MTAs) with the national laboratory partners. EERE highly encourages projects to share nonproprietary data with the consortium data team for publication in the consortium's online materials database.

Topic 1: Photoelectrochemical Water Splitting Device Scale Up

Introduction and Background

By using sunlight to split water—without the need for electricity—photoelectrochemical (PEC) water splitting systems have the potential to achieve higher solar-to-hydrogen (STH) efficiencies than photovoltaic-powered electrolysis systems. PEC systems, however, have not been widely demonstrated at large scales. To advance PEC technology, DOE has supported several collaborative efforts through the *Fuels from Sunlight Innovation Hubs,*[19] addressing key scientific barriers, including the discovery of novel materials. These efforts have also included the development of sophisticated modeling and characterization tools to facilitate fundamental understanding of underlying principles. Recent efforts through the HydroGEN consortium[20] have focused on understanding how to move PEC technologies

[19] BES DOE Energy Innovation Hubs | U.S. DOE Office of Science(SC) (osti.gov), https://science.osti.gov/bes/Research/DOE-Energy-Innovation-Hubs

[20] HydroGEN Advanced Water Splitting Consortium, https://www.h2awsm.org

beyond the benchtop to achieve commercial viability.[21] These efforts have identified the need to demonstrate increased device and system sizes and address the high cost and slow production rates of current fabrication methods. This topic specifically addresses challenges associated with safely and affordably scaling up promising photoelectrode- or particle-based PEC reactor systems while maintaining device performance and durability.

DOE has defined four standard types of PEC systems,[22] with Types II, III, and IV of interest in this topic.[23] Type III and IV photoelectrode PEC systems have achieved STH efficiencies over 20%, while particle-based systems (which are inherently lower-cost, but with lower conversion efficiency) typically exhibit STH efficiencies of < 5%.[24] Most photoelectrode demonstrations to date have been for smaller benchtop systems, with recent EERE-funded PEC efforts targeting photoelectrode areas of up to 200 cm^2, with associated production rates of 0.1 gram per hour (g/h).[25,26] On the other hand, exemplary particle-based systems have been demonstrated at larger areas (up to 100 m^2), but only for Type I systems that co-evolve hydrogen and oxygen, which are not supported under this funding opportunity.[27]

To advance the status of PEC technology and achieve the Hydrogen Shot goal, device sizes and hydrogen production rates need to be increased and costs need to be reduced. For Type II particle-based systems, this will likely require addressing engineering challenges associated with reactor design, such as gas collection and management. For Type III and Type IV photoelectrode systems, this will likely require developing low-cost, high-throughput fabrication techniques. For all systems, supporting analyses are necessary to demonstrate a pathway to optimized, large scale, and efficient hydrogen production.

Description and Objectives

Through this topic, EERE seeks proposals to develop and demonstrate large-area PEC water splitting devices, using low-cost, reproducible synthesis and fabrication techniques. **Proposed PEC reactor demonstrations must include device areas of at least 2,500 cm^2, not including solar concentration area, and operate diurnally over a two-week period at a rate of at least 1 g/h hydrogen production.** Devices achieving this production rate at the minimum size requirement will need to achieve STH

[21] Deutsch, T. G., et al. (2024, May). Techno-Economics of Photoelectrochemical Water Splitting and Progress in Cost Reduction of High-Efficiency III-V Photoabsorbers. In *245th ECS Meeting (May 26-30, 2024)*. ECS. https://ecs.confex.com/ecs/245/meetingapp.cgi/Paper/186437;
Acevedo, Y., et al. (2024, May). Levelized Cost and Carbon Intensity of Solar Hydrogen Production from Water Electrolysis Using a Scalable and Intrinsically Safe Photocatalytic Z-Scheme Raceway System. In *245th ECS Meeting (May 26-30, 2024)*. ECS. https://ecs.confex.com/ecs/245/meetingapp.cgi/Paper/186368
Marina, O., et. al. (2024 May). Benchmarking, Protocol Development and Community Engagement of Advanced Water Splitting Technologies. 2024 AMR. https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/review24/p170_marina_2024_o.pdf?sfvrsn=96514c31_5

[22] Descriptions of PEC reactor Types 2, 3 and 4 can be found in Technoeconomic Analysis of Photoelectrochemical (PEC) Hydrogen Production (energy.gov) https://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/pec_technoeconomic_analysis.pdf

[23] Type 1 systems where oxygen and hydrogen are co-evolved will not be considered under this funding opportunity.

[24] Cheng, Wen-Hui, et al. "Hydrogen from sunlight and water: A side-by-side comparison between photoelectrochemical and solar thermochemical water-splitting." *ACS Energy Letters* 6.9 (2021): 3096-3113.

[25] DE-FOA-0002792: Funding Opportunity in Support of the Hydrogen Shot and a University Research Consortium on Grid Resilience

[26] Haber, J. A., et al. (2024, May). Demonstration of a Robust, Compact Photoelectrochemical (PEC) Hydrogen Generator (energy.gov)

[27] Nishiyama, H., Yamada, T., Nakabayashi, M., Maehara, Y., Yamaguchi, M., Kuromiya, Y., ... & Domen, K. (2021). Photocatalytic solar hydrogen production from water on a 100-m^2 scale. *Nature*, *598*(7880), 304-307, DOI: 10.1038/s41586-021-03907-3.

efficiencies of greater than 10%. Devices with larger surface areas and lower STH efficiencies will also be considered if they can achieve the target production rate.

In support of the final device demonstration, applicants should also develop system designs that address the challenges and barriers related to producing larger volumes of hydrogen through PEC approaches, including liquid and gas management, minimization of electrical losses, efficient integration of materials and components, and cost reduction. Project deliverables will also include supporting designs and technoeconomic analyses for projected PEC systems suitable for hydrogen production at a minimum of 1,500 kg H_2/day. Projects should also examine the opportunities and limitations of future PEC systems capable of operating at the higher rates necessary for centralized hydrogen production (e.g., proposals could project the land-use requirements of a large-scale centralized system). Supporting analyses that include assessments of the impact of large-scale PEC systems on local communities (e.g., water use, footprint) are encouraged. The expected cost and potential for commercialization of the proposed demonstrations and designs are important considerations. Technoeconomic analysis (TEA) is expected to show the cost of PEC-hydrogen on a $/kg basis and high-throughput materials manufacturing cost on a $/$m^2$ photoelectrode basis.

Examples of areas of interest include, but are not limited to:

- Novel techniques to reduce the cost and increase the rate of fabricating photoabsorbers;
- Innovative deposition methods for homogenous and reproducible protection schemes;
- Materials and/or design modifications to minimize ohmic losses in large-area substrates; and
- Fabrication techniques adapted from other industries.

General Requirements

Applications must include a detailed description of the PEC material set, the PEC reactor design, and the PEC device fabrication process and system design to be developed. Applications must identify the specific challenges currently limiting PEC device scale up, including impacts on cost. Applicants must propose an R&D plan that addresses these challenges through fabrication and/or engineering innovations. The anticipated impacts must be defined by clear and quantitative metrics. Applicants must include plans to conduct technoeconomic analysis (TEA) showing the cost of PEC-hydrogen for both the final performance validation and the projected at-scale (1,500 kg H_2/day) system.

The PEC materials to be utilized must be clearly identified in the proposal. There are no restrictions on material class, but efforts must not focus on new materials discovery, and materials with demonstrated viability for PEC are preferred. Proposed work should emphasize addressing the challenges associated with fabricating large-area, high-performing, and low-cost devices. Applicants may focus on typical materials for PEC devices, such as III-V light absorbers, that have relied on low-throughput, high-cost fabrication steps that are not amenable to scaled-up manufacturing, as long as the application proposes ways to overcome these limitations.

Proposed system designs should include considerations of: heat and bubble management; gas collection; balance of system components, including auxiliary equipment such as pumps and separators; and full design of all electrical and fluidic connections. If necessary, devices can be composed of several smaller-area cells to meet the area and production rate requirements, as long as the cells are integrated, including electrolyte and gas interconnections. For the final performance validation, applications should describe the proposed experimental procedures for the collection, quantification, and analysis of PEC-generated hydrogen produced using outdoor or simulated sunlight. Applicants must describe plans to validate the hydrogen production rate.

Teaming Arrangements

In addition to the guidelines in NOFO Part 1, Section II.F.1. *Project Teaming Arrangements*, the project team must, at a minimum, consist of (individuals may hold multiple roles):

- Project lead/Project management
- Team member/Materials synthesis and fabrication
- Team member/Materials testing and evaluation
- Team member/Technoeconomic analysis

Project teams are also encouraged to include:

- Advisor/Photoelectrode manufacturer
- Advisor/System engineering

Applications Specifically Not of Interest

Under this topic, EERE is *not* interested in applications focused primarily on the following:

- Novel PEC materials discovery;
- Type I PEC approaches where oxygen and hydrogen are co-evolved;
- Materials for electrolysis technologies, including liquid alkaline, proton exchange membrane, alkaline exchange membrane, and solid oxide electrolysis cells; and
- Production of CO_2 and/or processing of biomass, municipal waste streams, or fossil fuels.

Topic 2: High-Performance Materials for Hydrogen Service, Including Cryogenic and/or High-Pressure Conditions

High-performance materials are essential for ensuring affordable, safe, and reliable transport, storage, and use of hydrogen to enable large-scale adoption of hydrogen across sectors. This topic area focuses on developing innovative materials for use in hydrogen applications and advancing our fundamental understanding of hydrogen's interaction with materials. Projects under sub-topic 2A will develop high-performance composite materials for use in high-pressure hydrogen storage tanks and pipelines. Projects under sub-topic 2B will develop advanced materials compatible for hydrogen service that could include cryogenic and high-pressure conditions. Projects under sub-topic 2B will be required to collaborate with the Hydrogen Materials Compatibility Consortium (H-Mat^{SM}).

Topic 2A: High-Performance Composite Materials for High-Pressure Hydrogen Storage Tanks and Pipelines

Introduction and Background

High-pressure storage tanks and fiber reinforced polymer (FRP) pipelines are key technologies for hydrogen storage and transmission. Advanced tank and pipeline materials that enable lower manufacturing and installation costs, improved performance and reliability, and the recovery and reuse of materials at end of life are key to achieving U.S. decarbonization goals.

Storage Tanks

Composite overwrapped pressure vessels (COPVs) are the industry standard for high-pressure hydrogen storage. These lightweight storage tanks are made of either metal (Type 2 & 3) or polymer (Type 4) liners overwrapped with carbon-fiber-reinforced polymer composites. Typical pressures for stationary storage applications are 100 to 500 bar (1,450 to 7,250 psi), stationary cascade storage systems used at fueling stations can have pressures as high as 1,000 bar (14,500 psi), while onboard vehicle storage

pressures are typically 350 and 700 bar (5,000 and 10,000 psi). Large COPVs can also be used on tube trailers to transport large quantities of gaseous hydrogen at pressures typically up to 500 bar.

To allow hydrogen tanks to withstand high pressures, strenuous duty cycles, and challenging operating conditions, the carbon fibers, resins, and liners used in COPVs must be lightweight, high-strength materials with low susceptibility to hydrogen-induced degradation. In commercial COPVs a high tensile strength carbon fiber, such as Toray T700S, is coupled with an epoxy resin to produce the COPV composite overwrap that is then filament-wound over aluminum, steel, or polymer liners. Challenges with current storage systems include high carbon-fiber costs, sub-optimal gravimetric capacity, slow manufacturing speed and insufficient throughput, and substantial embodied energy. Continued advancement of fibers, resins, and liners is key to reducing costs, improving tank performance, enhancing manufacturing rates and efficiency, and facilitating end-of-life materials recovery and reuse.

While recent EERE-funded activities have focused on reducing the cost of the high-strength, continuous carbon fibers used in COPVs[28], this topic focuses on the other materials that go into manufacturing COPVs, to reduce COPV costs and improve performance. To date, the carbon fiber work has resulted in significant reductions in projected carbon fiber and storage tank costs while maintaining the fiber properties and improving the conversion processes.[29] More work is still needed to meet DOE's ultimate cost target for onboard hydrogen storage of $8/kWh (equivalent to $266/kg-$H_2$).[30] Further advancements in storage tank performance and cost may be realized using innovative fiber preforms, low permeability liners and advanced resins, as well as via robust, sustainable materials for end-of-life recovery. For example, advanced resins, either thermosets or thermoplastics, might not only lead to reduced cost of the composite material, but also lower manufacturing costs through reduced cost and time needed for curing, and improved performance through higher translation efficiency and/or end-of-life recovery of materials.

Pipelines

There are approximately 1,600 miles of hydrogen gas transmission pipelines within the United States. These pipelines are primarily made of steel and are mainly located in the Gulf Coast region, to connect hydrogen producers and petroleum and petrochemical end-users. Steel pipeline integrity within a hydrogen environment is a key challenge, with hydrogen embrittlement and material compatibility being major causes of concern. FRP is an excellent alternative to steel for hydrogen-transmission pipelines. Flexible FRP pipelines are made of a polymer liner, usually high-density polyethylene (HDPE), overwrapped with a structural glass-fiber-epoxy composite. The composite is then covered with a polymeric protective layer to produce the final FRP pipe. Advantages of FRP pipelines include excellent burst and collapse pressure ratings, good chemical and corrosion resistance, and insusceptibility to hydrogen embrittlement. They can be deployed in long continuous segments (up to 0.5 miles) to reduce fabrication and installation costs and can also be pulled through existing oil and gas pipelines to enable refurbishment and repurposing.[31] Current design pressures are as high as 170 bar (2,500 psi) for FRP

[28] DE-FOA-0002229: Fiscal year 2020 H2@Scale New Markets FOA, https://eere-exchange.energy.gov/Default.aspx?foaId=989bfa31-9f1b-4c1b-8e1c-f0ffcc9b6a96

[29] Stetson, N., "HFTO Hydrogen Infrastructure Technologies Subprogram Overview", DOE Hydrogen Program 2024 Annual Merit Review and Peer Evaluation Meeting, https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/review24/in000_stetson_2024_o0e018332-9871-45a3-9c2c-67686e3fadab.pdf?sfvrsn=9885dda4_5

[30] 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

[31] Rawls, G., Codification of Fiber Reinforced Composite Piping. United States 2012. https://doi.org/10.2172/1053023

pipelines with nominal diameters of 6 inches. FRP pipelines also have potential for self-monitoring and communication capabilities, such as fiber optics, to detect leaks and third-party intrusions.

The use of FRP for high-pressure hydrogen transmission was codified into the ASME B31.12 Hydrogen Piping and Pipelines Code in 2017 based on data collected over a 10-year period of EERE-funded performance testing.[32] Like COPVs for hydrogen storage, FRP hydrogen pipelines require high-strength fibers, resins, and liner materials that are resistant to hydrogen permeation and diffusion. Additionally, these materials must be able to withstand the harsh external environments where pipelines are utilized. Impact and abrasion protection, as well as moisture resistance are important characteristics. Continued RD&D of materials that can meet these requirements while ensuring low fabrication and installation costs is essential to enable widespread adoption of FRP pipelines for hydrogen transmission.

Description and Objectives

Through this topic, EERE seeks proposals to develop and demonstrate the use of innovative composite materials to significantly reduce cost, improve performance, and increase throughput of high-pressure storage tanks and FRP hydrogen pipelines. The proposed reinforcing fibers, resins, and/or liner materials must be lightweight, high-strength, and suitable for large-scale manufacturing. Priority will be given to projects focused on RD&D of alternative material systems that enable advanced manufacturing processes, increased production rates, and better material utilization. **Applications are expected to demonstrate material strength and system performance (e.g., gravimetric capacity) exceeding that of incumbent 700-bar hydrogen storage tanks or composite pipelines rated with a minimum nominal working pressure of at least 100 bar.** Lower-cost technologies should, at a minimum, match the performance of incumbent systems, and COPV systems that use them must be able to be certified to acceptable onboard storage tank standards, such as CSA/ANSI HGV2.[33]. Some specific materials of interest for this topic include but are not limited to:

- Lightweight, high-strength hybrid or multi-component fiber tows;
- Woven fabrics that are amenable to high-throughput tank or pipeline manufacturing techniques;
- Damage-tolerant towpregs that can be used for tank or pipeline manufacturing processes such as filament winding and automated fiber/tape placement;
- Sustainable thermoplastic and thermoset resins that enable recovery of high-quality fibers and resin at tank or pipeline end of life;
- Nano-filled, high-performance resins that improve composite toughness and load-transfer efficiency;
- Rapid-cure resins for reduced curing conditions, increased production rates and better material utilization; and
- Lightweight, high-strength liner materials with reduced hydrogen permeability and enhanced toughness.

General Requirements

Applications must include a detailed description of the synthesis/fabrication and characterization plan for the proposed material(s). Evaluation of materials, such as fibers, resins or polymeric liners, should include mechanical and thermomechanical testing, including, but not limited to examinations of: tensile

[32] The American Society for Mechanical Engineers ASME B31.12 – 2023 Hydrogen Piping and Pipelines, 2024 Edition
[33] SA Group/American National Standards Institute (CSA/ANSI) HGV 2-2023, Compressed hydrogen gas vehicle fuel containers, 2023 Edition

strength and modulus; flexural strength and modulus; glass transition temperatures; and composite interfacial shear strength, where applicable. Additional testing should be included to evaluate the performance of the final form of the proposed material(s) for its intended use. This may include (but is not limited to) evaluation of material behavior in a hydrogen environment, hydrogen diffusion and permeation testing, or thermal cycling experiments. Material yield is also important, and proposed strategies must demonstrate the potential to produce the material in quantities sufficient for large-scale tank or pipeline production (e.g., at least 1,000 m for fibers and at least 10 L for resins). Applications focused on pipeline materials must also evaluate fracture and stress corrosion behavior of the constituent materials.

Applications must provide sufficient justification for the proposed material(s). Projects must include a technoeconomic analysis projecting performance and cost of tanks or pipelines produced using the developed technology in an end-use application. Recyclability and/or reuse of the constituent material(s) must also be addressed. Results from the mechanical evaluation of recovered carbon fibers (e.g., fiber length, fiber width, tensile strength, and tensile modulus) are required for projects focused on constituent materials that will enable recycling and reuse of tank or pipeline components.

Teaming Arrangements

In addition to the guidelines in NOFO Part 1, Section II.F.1. *Project Teaming Arrangements*, the project team must, at a minimum, consist of (individuals may hold multiple roles):

- Project lead/Project management
- Team member/Materials synthesis and fabrication
- Team member/Materials testing and evaluation
- Team member/Technoeconomic analysis

Project teams are also encouraged to include:

- Advisor/Hydrogen storage tank or pipeline manufacturer
- Advisor/Hydrogen materials compatibility

Applications Specifically Not of Interest

Under this topic, EERE is not interested in applications focused primarily on the following:

- Development of tank or pipeline manufacturing processes;
- Demonstrations of existing materials, without RD&D improvements beyond the state of the art and without the potential to ***both*** reduce storage tank or pipeline cost, as well as improve performance, such as gravimetric capacity;
- Development of low cost, high-strength continuous carbon-fiber tows; and
- Fibers developed from lignin, pitch, and cellulosic precursor materials.

Topic 2B: High-Performance Materials Compatible for Use in Hydrogen Service in Collaboration with H-Mat

Introduction and Background

As the scale up of hydrogen production and use progresses, it is important to establish components for safe and reliable use in hydrogen infrastructure at a complementary pace. Hydrogen infrastructure refers to the technologies used for transmission, distribution, storage and dispensing of hydrogen. The inherent properties of materials exposed to hydrogen can make them vulnerable to damage and degradation.

Operational conditions can place high demands on both metals and polymers, making them susceptible to changes in crystallinity and defect activation, and degrade their performance. Material defects can lead to swelling, cracking, embrittlement, fatigue, and failure through various mechanisms, depending on the permeation, diffusion, and nature of the hydrogen interaction with the material. Component durability and cost are thus adversely affected, and costly materials are required to ensure reliability. These challenges drive the need to develop a better foundational understanding of the factors influencing cost, performance, compatibility, and service lifetimes of hydrogen components and systems. Developing advanced, lower-cost materials with improved resistance to hydrogen effects is a high priority of this topic.

For Topic 2B, applicants are required to collaborate with the Hydrogen Materials Compatibility Consortium (H-Mat). H-Mat conducts crosscutting RD&D on the compatibility of metal and polymer materials for use in hydrogen service. RD&D related to hydrogen effects in metals is led by Sandia National Laboratories (SNL); evaluation of hydrogen effects in polymers is led by Pacific Northwest National Laboratory (PNNL); and Oak Ridge National Laboratory (ORNL) provides additional characterization and modeling capabilities.[34] Previous EERE-funded projects have focused on multi-scale modeling of hydrogen effects on morphology, understanding defect mechanisms in polymers and steels, and discovering first-in-class approaches to mitigate hydrogen effects. Examples include the engineering of traps that immobilize diffused hydrogen,[35] the investigation of dislocations in steel alloys and their impact on deformation under hydrogen exposure,[36] and the development of new steel alloy formulations and manufacturing methods aimed at improving mechanical strength in hydrogen environments and reducing costs.[37]

Further investigations into material properties and their working limits are essential to determining a material's viability for a given application. This approach is necessary to overcome the performance limitations of incumbent materials and facilitate the discovery of improved materials. Accelerated test methods that can accurately predict behavior under real-world loading conditions could expedite the development and adoption of improved materials.

Description and Objectives

Through this topic, EERE seeks proposals from industry and academia to stimulate RD&D efforts—in collaboration with the H-MAT consortium—in areas of advanced materials development and performance for use in hydrogen service. Priority will be given to projects focused on the development of high-performance materials that enable advanced manufacturing processes and employ in-situ and advanced characterization techniques to assess material response and damage evolution in hydrogen environments, particularly for cryogenic conditions. Proposed activities will be expected to investigate

[34] Hydrogen Materials Compatibility Consortium: https://h-mat.org/

[35] Thompson, G.B., "Tailoring Carbide Dispersed Steels: A Path To Increased Strength and Hydrogen Tolerance", DOE Hydrogen Program 2023 Annual Merit Review and Peer Evaluation Meeting, https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/review23/in022_thompson_2023_o-pdf.pdf?sfvrsn=478ca849_0

[36] Sofronis, P., "Tailoring Composition and Deformation Modes at the Microstructural Level for Next Generation Low-Cost High-Strength Austenitic Stainless Steels", DOE Hydrogen Program 2023 Annual Merit Review and Peer Evaluation Meeting, https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/review23/in026_sofronis_2023_o-pdf.pdf?sfvrsn=c87ab34f_0

[37] Findley, K., "Microstructural Engineering and Accelerated Test Method Development to Achieve Low-Cost, High-Performance Solutions for Hydrogen Delivery and Storage", DOE Hydrogen Program 2024 Annual Merit Review and Peer Evaluation Meeting, https://www.hydrogen.energy.gov/docs/hydrogenprogramlibraries/pdfs/review24/in021_findley_2024_o.pdf?sfvrsn=d47d2aeb_3

the microstructure-property attributes and performance characteristics of the proposed material in the as-manufactured state and while in service at relevant timescales. Mechanisms of hydrogen-surface and hydrogen-corrosion interactions at the atomic level and potential structural damage accumulation should also be explored.

Depending on the application (e.g. piping, tubing, dispenser and compressor components, storage vessels, seals, and bearings), hydrogen operating environments can vary greatly in terms of temperature, pressure, and external loading conditions. With the anticipated increase in the use of cryogenic liquid hydrogen, materials in certain applications can be expected to undergo severe temperature swings between ambient and extremely low cryogenic temperatures. Therefore, developing durable, cost-competitive materials that are compatible with hydrogen service under these conditions and demonstrate optimal performance and improved manufacturability is essential to advancing the industry toward affordable and reliable large-scale hydrogen adoption. This topic seeks proposals that will leverage and support H-Mat's mission to enable the development and demonstration of materials for hydrogen use with improved reliability, performance, and cost. Proposals must describe research on unique polymer or metal materials systems relevant to hydrogen infrastructure technologies. Alternative materials classes may be proposed, provided that sufficient justification is given to assess the viability of the concept. Research needs for this topic are outlined below.

This topic seeks high-reward RD&D concepts that focus on:

- The development of computational modeling tools that screen and/or predict performance of high-performing metal and polymer materials for sustained use in hydrogen and hydrogen blended service environments, which may include cryogenic conditions and/or a wide range of pressures. EERE is particularly interested in models that incorporate machine learning methods to:
    - Facilitate new materials development and validation;
    - Characterize hydrogen-induced fracture and fatigue, crack initiation and propagation, swelling, and cycling loading resistance; and
    - Predict further damage evolution and/or mechanisms of long-term aging and degradation.
- The identification and development of high-performing, lower-cost alternative metal and polymer materials to better understand material response in the presence of hydrogen across multiple length scales. Proposed projects can include examination of key properties, including (but not limited to) tensile strength, fracture toughness, fatigue life, stability, durability, etc. Metallic alloys, common polymers, and other cost-competitive materials for use in pipeline applications that exceed the performance lifetime of existing materials are also of special interest. High performance polymer materials of interest include but are not limited to:
    - Thermoplastics such as high-density polyethylene (HDPE), polybutylene, Nylon, polyetheretherketone (PEEK), polyetherketoneketone (PEKK), polyketones, polyethylene terephthalate (PET), polyethylenimine (PEI), polyvinylidene fluoride (PVDF), Teflon, polychlorotrifluoroethylene (PCTFE), polyoxymethylene (POM);
    - Elastomers such as ethylene propylene diene terpolymer (EPDM), nitrile butadiene rubber (NBR), hydrogenated nitrile butadiene rubber (HNBR), Levapren, silicone, Viton, Neoprene, polyurethane; and
    - Thermosets such as epoxy, polyimide (PI), polyurethane.
- The development and validation of accelerated tests to reduce the cost of experimentation needed to predict materials-behavior in hydrogen.

- The development of key metrics, tests, design requirements and/or materials qualification frameworks to validate performance, qualify new materials, and garner stakeholder support and industry acceptance to expedite commercial use. **Metallic materials for use in fueling station compressors, dispensers, and storage should target equipment durability of 5 years, 10 years, and 30 years, respectively. Polymer materials for use in hydrogen dispensing hoses should target operational lives of at least 25,000 cycles, and burst pressures of at least 3,500 bar, for potential compliance with ANSI/CSA HGV 4.2.**[38]

General Requirements

Applications are required to include a detailed description of the materials theory and design approach, synthesis route and/or advanced manufacturing process, experimental analysis, characterization method and materials qualification plan for the proposed material(s). Performance evaluation of the proposed material(s) must be conducted under conditions that simulate targeted end-use applications. This may include (but is not limited to) environments such as cryogenic hydrogen, hydrogen and natural gas blends, high-temperatures, variable pressures, and corrosive conditions. Testing should elucidate: phenomena of hydrogen-assisted crack growth and fatigue, fracture, and degradation; mechanisms of hydrogen-surface interactions; mechanisms of hydrogen transport; hydrogen-corrosion interactions; crystallographic defects; and hydrogen influence on microstructure and morphology. Applications must clearly identify the expected impact of their materials innovation in terms of well-articulated and quantitative technology-specific metrics. Applications proposing the utilization of advanced manufacturing techniques must explain in detail how the approach drives further process development and supports new composite structures and potential improvements in materials performance, fabrication, and design.

Projects developing novel materials should specify the estimated cost of current state-of-the-art materials used in the intended application, evaluate the cost-reduction potential from the new material over the state of the art across the application life cycle, and include development and experimental evaluation of novel material coupons by the end of the project. Recyclability, reuse, and disposal of the constituent material(s) must also be addressed.

Applicants must provide a scientific justification for the use of the proposed material and clearly explain how they intend to collaborate with the H-Mat consortium to make use of their world-class RD&D capabilities. Applicants are highly encouraged to collaborate with industry partners specializing in the production of commercial materials to better identify and mitigate supply-chain barriers and/or with commercial manufacturers to inform scalability and production, in either an advisory capacity or as cost-share partners.

In addition to funding associated with the NOFO award, each awardee will gain access to H-Mat resources. Applicants will be expected to work with partners within the H-Mat consortium as integral team members and should specify which researchers and organizations they propose to work with and how their proposal contributes to the H-Mat mission. DOE will provide additional funding directly to the H-Mat national laboratory partners for their collaborative support of the awarded projects; proposed budgets *should not* include funds associated with the use of these H-Mat resources.

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

Teaming Arrangements

In addition to the guidelines in NOFO Part 1, Section II.F.1. *Project Teaming Arrangements*, the project team must, at a minimum, consist of (individuals may hold multiple roles):

- Project lead/Project management
- Team member/Materials design and development
- Team member/Materials performance testing and validation
- Team member/Technoeconomic analysis

Project teams are also encouraged to include:

- Advisor/Materials suppliers
- Advisor/Materials qualification
- Advisor/Advanced manufacturing methods
- Advisor/Lifecycle disposal and reuse

Applications Specifically Not of Interest

Under this topic, EERE is not interested in applications focused primarily on the following:

- Duplicate work or proof of concept research on prior developed and demonstrated materials under previously funded awards;
- Materials not appropriate for use in hydrogen or hydrogen and natural gas blends;
- RD&D of known and commercially available materials without description of potential advancements and improvements expected from the proposed efforts;
- Development and demonstration of materials that do not show promise for cost-competitiveness and performance improvements compared with current state-of-the-art materials for the end-use application of interest; and
- Manufacture of components utilizing proposed or previously developed materials.

Topic 3: Sustainable High-Temperature Proton Exchange Membranes and Ionomers for Heavy-Duty Transportation Applications

Introduction and Background

Hydrogen-fueled proton exchange membrane (PEM) fuel cells are an attractive technology to power multiple applications, particularly zero-emissions medium- and heavy-duty (MD/HD) on-road vehicles (e.g., trucks and buses), vehicles for off-road use (e.g., mining and construction), and other heavy transportation applications (e.g., marine and rail). They offer several advantages over incumbent technologies such as diesel engines, including higher efficiency, reduced emissions, improved torque response, and lower noise pollution. Additionally, hydrogen-fuel-cell-powered vehicles offer fast fueling and adequate fuel storage for applications demanding long ranges and/or long, uninterrupted periods of operation.

Long-haul truck applications demand a lifetime of up to one million miles, which is roughly equivalent to 25,000 operating hours. Fuel cell electric MD/HD vehicles need to also demonstrate a total cost of ownership that is competitive with incumbent and advanced alternative powertrains. To meet requirements for efficiency, cost, and total lifetime (durability), fuel cells need to have low-cost and highly durable components including catalysts, membranes, and electrode structures. In the most demanding applications, additional challenges include: thermal management; operation in the presence of fuel and air impurities; and start/stop, freeze/thaw, humidity, and load cycles that result in

mechanical and chemical stresses on fuel cell materials, components, and interfaces. DOE has set 2030 targets for heavy-duty transportation fuel cell systems at a 25,000-hour lifetime and \$80/kW_{net} fuel cell system cost.[39] [40] To meet these targets, RD&D is needed to simultaneously reduce the capital costs of fuel cell components and systems while maintaining high efficiency and durability.

Membranes and ionomers are critical components with a large impact on the overall performance and durability of a fuel cell, especially under high-power conditions with high temperatures and low relative humidity. Higher-temperature fuel cell operation (up to 120°C) can improve the stack efficiency and power output and enable more-effective heat rejection, leading to lower-cost radiators and increased efficiency through decreased parasitic power loss from cooling. However, operating a fuel cell at temperatures above 100°C presents challenges for PEM materials, including accelerated membrane degradation—both via mechanical stress due to humidity fluctuations and via chemical degradation that can be accelerated by external factors (e.g., degradation products from other fuel cell components). Also, higher-temperature operation lowers the feasible relative humidity in the fuel cell, resulting in reduced membrane proton conductivity and performance. Commercial PEM fuel cell membranes are typically composed of perfluorosulfonic acid (PFSA) ionomers, and these materials are among the most expensive components of a fuel cell stack. Moreover, the sustainability of PFSA membranes and ionomers is a concern due to the potential environmental impacts during production and end of life.[41] Non-PFSA membranes could produce a lower-cost, more sustainable alternative for PEM fuel cell systems; however, they currently underperform state-of-the-art membranes, requiring improvements in performance, durability, and manufacturability at the required operating temperature and humidity conditions.

Applicants are required to work with DOE's Million Mile Fuel Cell Truck (M2FCT) consortium, which leverages national laboratory resources to improve mechanistic understanding of fuel cell components and enable improvements in performance, cost, and durability. HFTO established the M2FCT consortium to accelerate R&D to improve the durability of fuel cells for MD/HD vehicles to over a million miles of operation, while meeting other relevant performance targets. With participants from national laboratories, universities, and industry, the M2FCT consortium serves as a resource for commercial and research communities. Selected projects will be required to collaborate with the M2FCT consortium to validate technical performance targets listed in the *Description and Objectives* section below.

Description and Objectives

Through this topic, EERE seeks proposals to develop novel non-PFSA chemistries and manufacturable material samples that result in efficient, durable, cost-competitive, scalable, and sustainable membranes for PEM fuel cells for MD/HD vehicle applications. PEM membrane and ionomer technology applications should be proton-conducting and not composed of PFSAs. Membranes should effectively operate at temperatures up to 120°C and low relative humidity (<30%) with minimal gas crossover, and advance progress towards the 2030 heavy-duty fuel cell system targets (25,000-hour lifetime and \$80/kW fuel cell system cost).

[39] Hydrogen and Fuel Cell Technologies Office Multi-Year Program Plan: Fuel Cell Technologies (energy.gov)

[40] U.S. Department of Energy "Hydrogen Class 8 Long Haul Truck Targets" Program Record, December 12, 2019: Million Mile Fuel Cell Truck (M2FCT) consortium: DOE Hydrogen and Fuel Cells Program Record 19006: Hydrogen Class 8 Long Haul Truck Targets (energy.gov)

[41] Kurwadkar, S., Dane, J., Kanel, S. R., Nadagouda, M. N., Cawdrey, R. W., Ambade, B., Struckhoff, G. C., & Wilkin, R. 2022. "Per- and polyfluoroalkyl substances in water and wastewater: A critical review of their global occurrence and distribution." *The Science of the total environment*, *809*, 151003. https://doi.org/10.1016/j.scitotenv.2021.151003.

Proposed membranes must be capable of providing sufficient low temperature conductivity to meet vehicle cold start requirements. To ensure efficient operation, applicants should seek to meet the following technical targets:

- 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).

Developed materials need to be easily scalable and manufacturable at low cost to demonstrate the potential for achieving economies of scale and fulfilling projected demand.

Membrane materials should be produced in sufficient quantities to enable membrane electrode assembly (MEA) integration and evaluation described in the *General Requirements* section, through collaboration with the M2FCT consortium. In addition, applicants will need to validate developed process cost and efficiency advances (compared with the state of the art), supported by technoeconomic analysis.

Applications that include electrode ionomer development for heavy-duty applications are also of interest but should not be solely focused on electrode ionomers. The electrode ionomers must maintain conductivity under high temperature and low relative humidity conditions mentioned above and meet more strenuous long-term durability requirements. Proposed work may include improvements to stability, intrinsic conductivity, and dispersion in electrodes.

Approaches that target completely fluorine-free ionomers and membranes are strongly encouraged. While membrane support materials are not the main focus of this topic, applications can also include the development of supporting expanded polytetrafluoroethylene (e-PTFE) alternatives. Consideration of the lifecycle impacts of the materials is encouraged, including recovery and recycling of platinum and membrane material and the environmental impacts of manufacturing and disposal. Investigation of the impacts of chemical contaminants on membrane durability and conductivity may also be included.

General Requirements

In their proposals under this topic, applicants must:

- Identify the challenges or limitations being addressed and the potential of their proposed technology as it relates to the state of the art; and
- Provide sufficient justification, supported by cost analysis, that the proposed approach has the potential to lead to a solution that produces low-cost, high-quality non-PFSA membranes and ionomers for fuel cells in heavy-duty transportation applications, contributing to meeting the system level cost target of \$80/kW_{net} and a 25,000 hour lifetime by 2030.

Projects must deliver the following:

- Validation of technical performance targets listed in the *Description and Objectives* section, through testing in a PEM fuel cell configuration using M2FCT consortium methodologies. Validation must also be done with sufficient replicates to establish repeatability and demonstrate that the material/component meets the performance and durability requirements for HD vehicle fuel cells throughout the duration of the project. In order to enable independent validation of component performance by the M2FCT consortium, projects will be required to:

- Deliver an adequate amount or size of membrane/ionomer material (≥ 200 milligrams or area of ≥ 50 cm^2) for MEA integration in collaboration with the M2FCT consortium;
- Deliver a set of MEAs (three or more, each with active area ≥ 50 cm^2) **12 months before the end of project** for independent testing and evaluation by the M2FCT core lab consortium to validate progress towards technical targets listed in the *Description and Objectives* section and to ensure sufficient time for further research after obtaining feedback from the consortium;
- Deliver a set of MEAs (six or more, each with active area ≥ 50 cm^2) **by the end of project** for independent testing and evaluation by the M2FCT core lab consortium for validation of technical targets listed in the *Description and Objectives* section; and
- Comprehensive technoeconomic analysis, by the end of the project, to examine the project's impact in terms of potential adoption of new membranes/ionomers into state-of-the-art PEM fuel cell systems—and to verify the progress made toward the 2030 targets for fuel cell systems in HD transportation applications (25,000-hour lifetime and $80/kW).

EERE encourages applicants to visit the M2FCT website[42] to identify expertise, capabilities, or facilities that would benefit their proposed project. While applications should clearly identify the specific M2FCT capabilities they would like to utilize, applicants *should not* include the cost of using M2FCT capabilities in their proposed budget. EERE will provide access to M2FCT capabilities at no cost[43] to the selected projects, based on award negotiations. EERE encourages applicants to list by priority the capabilities they would like to leverage, as M2FCT may not have the funding to perform all requested activities. Depending on EERE resources and the availability of appropriations, EERE may de-scope or negotiate this list during award negotiation.

Teaming Arrangements

In addition to the guidelines in NOFO Part 1, Section II.F.1. *Project Teaming Arrangements*, the project team must, at a minimum, consist of (individuals may hold multiple roles):

- Project lead/Project management
- Team member/Materials design and development
- Team member/Materials performance testing and validation
- Team member/Technoeconomic analysis

Project teams are also encouraged to include:

- Advisor/Materials suppliers
- Advisor/Materials qualification
- Advisor/Advanced manufacturing methods
- Advisor/Lifecycle disposal and reuse

Applications Specifically Not of Interest

Under this topic, EERE is not interested in applications focused primarily on the following:

- Electrolyte materials for solid oxide fuel cells, molten carbonate fuel cells, phosphoric acid fuel cells, polybenzimidazole-type phosphoric-acid fuel cells, and alkaline anion exchange membranes; and

[42] Million Mile Fuel Cell Truck. https://millionmilefuelcelltruck.org.
[43] Subject to review of work scope and funding required.

- Approaches that rely on increased thickness alone to meet durability requirements.

Topic 4: Domestic Hydrogen Fuel Cell Electric Motorcoach Bus Development and Demonstration

Introduction and Background

In 2022, the U.S. motorcoach industry (which includes "over-the-road", coach, and charter buses) consisted of almost 1,400 carriers who operated nearly 25,000 coaches over 30.8 billion passenger miles.[44] Battery powered electric motorcoaches that target shorter driving ranges (180 to 230 miles per day) are in development,[45, 46] but often motorcoaches operate with minimal dwell times or scheduled breaks and/or perform longer trips, including cross-country trips (up to 1,200 miles), with multiple drivers, that require driving ranges and recharging/refueling times beyond the capabilities of battery electric alone. Hydrogen fuel cell electric motorcoach buses can offer the range and refueling times necessary to compete with incumbent technologies to enable a decarbonized solution for the motorcoach industry.

Development of hydrogen fuel cell electric motorcoaches has begun globally.[47] However, these vehicles are not currently commercially available in the United States even though hydrogen fuel cell powered city transit buses have been produced domestically for many years, and states such as California have roadmaps for their commercial performance as a sustainable market solution.[48] Development and demonstration of a domestically produced fuel cell motorcoach would prove technical viability for U.S. fleets and help jumpstart the domestic production needed to further decarbonize the transportation sector.

Motorcoach companies offer a diverse set of services including charters, tours and sightseeing, and commuter services. Compared with city transit buses that stay within a metropolitan region, motorcoach buses are commonly used for intercity and long-distance travel, often with an elevated passenger deck and additional luggage compartments. Intercity motorcoach buses serve a crucial role in offering affordable transportation to rural residents, non-drivers, and long-distance travelers. For millions of rural Americans, they offer the only commercial transportation service, providing a means for commuting to work, access to medical services, and safety in local and regional emergencies.[49, 50]

Projects under this topic will enable the development and demonstration of domestically produced long-range hydrogen fuel cell electric motorcoach buses. Motorcoach buses offer a targeted, niche application with limited zero-emissions options for full decarbonization of the market segment, resembling fuel-cell forklifts, which were a highly successful focus area for previous HFTO-funded RD&D

[44] American Bus Association, "Motorcoach Census", https://buses.org/wp-content/uploads/2024/05/2023-Motorcoach-Census.pdf
[45] MCI J4500 charge battery electric bus https://www.mcicoach.com/mci-j4500-charge-a-luxury-electric-coach-ready-for-north-america/
[46] Van Hool CX45E battery electric bus https://californiahvip.org/vehicles/van-hool-nv-cx45e-battery-electric-bus/
[47] Toyota Europe Newsroom; "Converted zero tailpipe emission coaches with Toyota hydrogen fuel cell modules to be used at the Olympic and Paralympic Games Paris 2024"; Hydrogen coaches with Toyota fuel cell for Paris 2024,
[48] California Fuel Cell Electric Bus Roadmap, https://h2fcp.org/sites/default/files/2019-CaFCP-FCEB-Road-Map.pdf
[49] Victoria Transport Policy Institute, "Evaluating Public Transit Benefits and Costs Best Practices Guidebook" *https://www.vtpi.org/tranben.pdf*
[50] Texas A&M Transportation Institute, "Updated Comparison of Energy Use and Emissions from Different Transportation Modes Using the Latest Available Datasets"; https://buses.org/wp-content/uploads/2024/02/Task1_4_Report_Draft_07Dec2023-edited-FINAL-DRAFT.pdf

efforts. The motorcoach bus market sector itself is building momentum again after the transportation downturn during the pandemic.[51] Systems development, integration, and demonstration of such niche applications can help de-risk hydrogen and fuel cell technologies; offer opportunities to gather data to help guide future demonstrations and deployments; and catalyze system developers, component suppliers, and future domestic manufacturing. Engineering, development, testing, and demonstration of a hydrogen fuel cell motorcoach bus capable of meeting the route requirements of fleet managers, vehicle requirements for passenger travel, and vehicle operating requirements (including fueling times), would demonstrate to industry original equipment manufacturers (OEMs) and fleet operators that fuel cell powered motorcoaches can viably meet the needs of U.S. fleets. It would also help address the nation's decarbonization goals and offer community benefits, including low-cost, zero-emission intercity transportation, and contribute to the administration's Justice40 and equity priorities.

Description and Objectives

Through this topic, EERE seeks proposals to develop and demonstrate an economical and scalable hydrogen fuel cell electric motorcoach bus that can meet incumbent motorcoach performance without compromising space or passenger comfort including: 300+ mile driving range, 75+ mph maximum speed, fueling rates <20 minutes, passenger capacity of 50+, underneath cargo storage, and overall seating and design that provides the passenger comfort and convenience necessary for long trips as expected from conventional motorcoaches produced today. Applications can focus on either ground-up fuel cell electric motorcoach builds or retrofit designs demonstrating fuel-cell-powered electrification of an existing chassis, as long as such designs are considered commercially viable and enable follow-on fleet development. DOE anticipates that applications focused on retrofit designs will have a shorter period of performance and smaller budgets compared to applications focused on complete ground-up designs. The funding request should be commensurate with the level of work proposed.

General Requirements

Applicants are required to include a detailed description of the motorcoach bus vehicle specifications and the specific performance goals that will be targeted for both the vehicle and the broader fleet in which it will operate. Proposals should include anticipated technical goals of the proposed concept including fuel cell/battery hybridization approach needed to meet road grade and cabin heating/cooling needs, amount and type of hydrogen storage, driving range, size of the fuel cell and overall power plant, fuel economy, maximum speed, thermal management, and design/size of the overall coach bus. As part of the application, these parameters should be compared with a conventional motorcoach as a baseline, to ensure performance, passenger expectations, and comfort are not compromised. They should also provide sufficient justification, supported by analysis, that the proposed technology has the potential to achieve the target performance metrics or goals and topic objectives. Applications must also address how hydrogen fueling infrastructure will be provided for the hydrogen fuel cell motorcoach bus demonstration, and as applicable, address cybersecurity challenges and vulnerabilities to clearly identify the complete demonstration pathway.

Applicants must describe how, by the end of the project, a domestically built fuel cell motorcoach will have been developed, built, factory tested, and operated in a real-world environment similar to how it would operate as a part of a fleet deployment. Projects should target the technical readiness level (TRL) range of 6-8 over the project period. Designs should conform to relevant safety codes and standards, fueling protocols, Americans with Disabilities Act (ADA) regulations, and passenger travel requirements.

[51] Schwieterman, Joe; "Momentum for expanding intercity bus service is growing among states, new study shows"; masstransitmag.com

EERE encourages demonstrations that can help validate fuel cell functionality and hydrogen-related infrastructure in different climates as well as rural conditions. In addition, operation and performance validation are encouraged to be conducted at a site with potential for follow-on fleet applications.

Applications under this topic should:

- Organize project activities into three to four phases covering vehicle design, integration and build, initial testing, and real-world demonstration
- Include a total cost of ownership analysis within the project scope
- Identify the vehicle(s) baseline(s) and motorcoach bus target market for operation to show the requirements for validation of performance:
    - Projects will be validated against these baselines to demonstrate meeting operational targets such as, but not limited to:
        - Fuel economy;
        - Maximum speed;
        - Vehicle availability;
        - Range;
        - Efficiency; and
        - Lifetime.
    - Baseline information should describe the type of vehicle(s) used and the typical or representative duty cycle(s) experienced by each vehicle in the baseline fleet system. The baseline should include sufficient range requirements, fueling information, dwell times, overnighting, safety and emergency requirements, as well as other operational patterns to allow for meaningful comparison to existing motorcoach fleets.
- Identify the key vehicle specifications including (but not limited to):
    - Driving range greater than 300 miles with fueling rates <20 minutes. Motorcoach buses that can achieve even higher ranges are strongly preferred;
    - 50+ passenger seating configuration;
    - 75+ mph maximum speed;
    - Underneath cargo storage for at least 1 bag per passenger; and
    - Motorcoach design (e.g. motorcoach weight, length, number of axels, passenger area, accessory power per passenger, etc.)
- Identify any other key coach bus metrics to ensure performance, passenger expectations, and comfort.

Teaming Arrangements

In addition to the guidelines in NOFO Part 1, Section II.F.1. *Project Teaming Arrangements*, applicants should form teams that must include a motorcoach, or vehicle OEM, that will manufacture in the United States, as a lead or partner, and are highly encouraged to form teams that also include the following:

- Motorcoach fleet operators;
- Tier-1 suppliers; and
- Energy supplier(s) and fueling equipment suppliers and operators.

Applications Specifically Not of Interest

Under this topic, EERE is not interested in the following:

- Applications that do not include a motorcoach or vehicle OEM as a project lead or partner;
- Applications involving fuel cell range-extenders: while approaches using fuel cell/battery hybridization are allowed, the fuel cell should provide the primary power; and

- Applications to develop or demonstrate fuel cell electric transit (or city) buses.

G. Applications Specifically Not of Interest

The following types of applications will be deemed nonresponsive and will not be reviewed or considered:

- Applications that fall outside the technical parameters specified in Background and Context and Topics of the NOFO Part 1.
- Applications for proposed technologies that are not based on sound scientific principles (e.g., violates the laws of thermodynamics).
- Applications for proposed efforts described as specifically not of interest under each topic description.

H. Statement of Substantial Involvement

DOE anticipates substantial involvement in work performed under awards resulting from this NOFO. DOE does not limit its involvement to the administrative requirements of the award. Instead, DOE has substantial involvement in the direction and redirection of the technical aspects of the project. DOE's substantial involvement in resulting awards may include the following:

1. DOE shares responsibility with the recipient for the management, control, direction, and performance of the project.
2. DOE 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. DOE may redirect or discontinue funding the project based on the outcome of DOE's evaluation of the project at the Go/No-Go decision point(s).
4. DOE participates in major project decision-making processes.

I. Statutory Authority

The programmatic authorizing statute is the Energy Policy Act of 2005 (EPAct 2005) Public Law 109-58 (Aug. 8, 2005), Title VIII, Sections 801 to 816; 42 U.S.C. Sections 16151 to 16165.

Awards made under this announcement will fall under the purview of 2 CFR Part 200 as adopted and supplemented by 2 CFR Part 910.

J. Reseach & Development (R&D) Community Benefits Plan

DOE is committed to investing in R&D and RD&D of innovations that deliver benefits to the American public and lead to commercialization of technologies and products that foster sustainable, resilient, and equitable access to clean energy. Further, DOE is committed to supporting the development of more diverse, equitable, inclusive, and accessible workplaces to help maintain the nation's leadership in science and technology.

To support the goal of building a clean and equitable energy economy, projects funded under this NOFO are expected to (1) advance diversity, equity, inclusion, and accessibility (DEIA); (2) contribute to the

Justice40 Initiative[52] and other considerations linked with energy and/or environmental justice; and (3) invest in quality jobs. To ensure these objectives are met, applications for Topics 1, 2, and 3 must include a R&D Community Benefits Plan (CBP) that addresses the three objectives stated above. Applications for Topic 4 must include an RD&D CBP that addresses the three objectives stated above. Applicants to all topics should refer to NOFO Part 2, Section IV.B *Application Content Requirements* for more information on the R&D Community Benefits Plan content requirements. Applicants required to submit an RD&D CBP should use the R&D CBP content requirements to develop their plan.

As part of the whole-of-government approach to advance equity, the federal government pursues a comprehensive approach to advancing equity for all, including people of color and others who have been historically underserved, marginalized, and adversely affected by persistent poverty and inequality. Hydrogen and fuel cells can provide benefits and create opportunities for communities that have been historically underserved and overburdened—such as improving air quality, providing resiliency, and creating employment opportunities, including for good-paying union jobs. Consistent with DOE's commitment to benefit all Americans, this NOFO encourages the participation of underrepresented[53] communities and groups. Applicants are encouraged to form meaningful and substantial partnerships with Minority Serving Institutions (e.g., Historically Black Colleges and Universities (HBCUs), Tribal Colleges and Universities, and other minority institutions).

Applicants are encouraged to consult the Justice Underpinning Science and Technology Research (JUST-R) metrics framework when developing their CBP.[54] Proposals are encouraged to not only include efforts to support the development of diverse research teams, but also incorporate activities to support the development of lower-TRL technologies (photoelectrochemical, high-pressure storage tanks, fiber reinforced polymer pipelines, proton exchange membranes, etc.) in a way that will equitably benefit disadvantaged communities (DACs)[55].

The applicant's R&D or RD&D CBP must include at least one *specific*, *measurable*, *attainable*, *realistic*, and *timely* (SMART) milestone per objective (DEIA, Justice40, and workforce) per budget period to

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[52] The Justice40 initiative, established by EO 14008, sets a goal that 40% of the overall benefits of certain federal investments flow to disadvantaged communities. Consistent with Justice40 guidance, DOE recognizes disadvantaged communities as the census tracts defined and identified as disadvantaged by the White House Council on Environmental Quality's Climate and Economic Justice Screening Tool (CEJST), located at https://screeningtool.geoplatform.gov/, as well as all Federally Recognized Tribes (whether or not they have land). See https://www.whitehouse.gov/wp-content/uploads/2023/01/M-23-09_Signed_CEQ_CPO.pdf.

[53] "Underrepresented" refers to populations sharing a particular characteristic, as well as geographic communities, that are shown to have been systematically denied a full opportunity to participate in aspects of economic, social, and civic life, as exemplified by communities that have been denied fair, just, and impartial treatment, which may include women, persons with disabilities, persons who live in rural areas, persons otherwise adversely affected by persistent poverty or inequality, veterans, members of religious minorities, Black, Latino, Indigenous and Native American persons, Asian Americans and Pacific Islanders, other persons of color, and lesbian, gay, bisexual, transgender, and queer (LGBTQ+) persons.

[54] Dutta, Nikita S., et al. "JUST-R metrics for considering energy justice in early-stage energy research." *Joule* 7.3 (2023): 431-437, DOI: 10.1016/j.joule.2023.01.007.

[55] Pursuant to Executive Order (EO) 14008, "Tackling the Climate Crisis at Home and Abroad," January 27, 2021, and the Office of Management and Budget's Interim Justice40 Implementation Guidance M-21-28 and Addendum M-23-09, DOE recognizes disadvantaged communities as the census tracts identified as disadvantaged by the White House Council on Environmental Quality's Climate and Economic Justice Screening Tool (CEJST), located at https://screeningtool.geoplatform.gov/, as well as all Federally Recognized Tribes (whether or not they have land). See https://www.whitehouse.gov/wp-content/uploads/2023/01/M-23-09_Signed_CEQ_CPO.pdf. DOE's Justice40 Implementation Guidance is located at https://www.energy.gov/sites/default/files/2022-07/Final%20DOE%20Justice40%20General%20Guidance%20072522.pdf.

measure progress on the proposed actions. These milestones should also be included in the work plan, in the statement of project objectives (SOPO), and accounted for in the project budget. Funding for CBP activities should be well described in the budget justification.

The plan must be specific to the project. Topic-specific examples of activities may include but are not limited to:

Topics 1-4

- Hiring from local DACs;
- Sourcing materials from minority business enterprises, veteran-owned businesses, and/or women-owned businesses;
- Where applicable, consideration of the ethical implications of sourcing materials such as source of any critical minerals;
- Where applicable, providing safety training for local first responders and community members in surrounding DACs (if applicable infrastructure exists);
- Impact assessment evaluating the benefits and safety of the new technology, particularly as it relates to DACs;
- Distributing research results in a publicly accessible manner to diverse audiences via non-academic reports and/or non-academic oral presentations;
- Assessing the distribution and impacts of hazard exposure, particularly into DACs, including those associated with raw material extraction and wastewater contamination as wells as how these exposures could increase at industrial scale; and
- Performing life cycle assessment and including social life cycle assessments.

Topic 3

- Evaluating human health impacts of non-PFSA membranes throughout the life cycle of production and use.

Topic 4

- Calculating emissions reductions from operating the hydrogen fuel cell motorcoach bus vs. conventional motorcoach vehicles in disadvantaged communities;
- Operating zero-emissions, low-cost, intercity hydrogen fuel cell motorcoach in DACs in locations beneficial to DAC residents (e.g., to medical facilities, educational opportunities, or employment centers); and
- Conducting outreach and education on fuel cell electric vehicles in DACs using the motorcoach as a demonstration vehicle.

IV. Application Content and Form

The section below includes application information specific to this NOFO. Consult the NOFO Part 2, Section IV. *Application Content and Form* for standard information required for all NOFOs such as Document Format, Content Requirements, and Funding Restrictions.

A. Summary

The application process includes multiple submission phases: concept paper, application, and reply to reviewer comments.

Application Submission Phase	Eligibility for Submission
Concept Paper	Required to be submitted by the specified due date and time to be eligible to submit an application.
Application	Must have submitted a concept paper as specified above. Must be submitted by the specified due date and time to be eligible for comprehensive merit review.
Replies to Reviewer Comments	Required to be submitted by the specified due date and time.

B. Concept Paper

Each concept paper must be limited to a single concept, technology, or project. The concept paper must conform to the requirements listed below, including the stated page limits.

Section	Page Limit	Description
Cover Page	1 page maximum	The cover page should include the project title, the specific announcement Topic Area being addressed (if applicable), both the technical and business points of contact (including the Administrative Officer, if applicable), names of all team member organizations, the project location(s), and any statements regarding confidentiality.
Technology Description	3 pages maximum	Applicants are required to succinctly describe: • 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; • How the proposed location of the proposed project will support technology development and long-term success; • The key technical risks/issues associated with the proposed technology development plan; and • The impact that DOE funding would have on the proposed project.

		• Any potential impacts on Indian Tribes, and describe how the applicant would engage with a potentially impacted Indian Tribe(s).
R&D Community Benefits Plan	1 page maximum	Applicants are required to succinctly describe their approach to the Community Benefits Plan, addressing the three core elements: • Advance diversity, equity, inclusion, and accessibility (DEIA); • Contribute to the Justice40 Initiative and other considerations linked with energy and/or environmental justice; and • Invest in quality jobs.
Addendum	1 page maximum	Applicants are required to succinctly describe the qualifications, experience, and capabilities of the proposed project team, including: • Whether the Principal Investigator (PI) or Lead Project Manager (LPM) 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; • 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; and • Applicants may provide graphs, charts, or other data to supplement their Technology Description.

Total concept paper Maximum Page Limit: 6 pages

DOE makes an independent assessment of each concept paper based on the criteria in the concept papers section of the NOFO. DOE will encourage a subset of applicants to submit applications. Other applicants will be discouraged from submitting an application. Please see NOFO Part 2, Section VII. *Selection and Award Notices*.

C. Application Content Requirements

Each application must be limited to a single concept. Applications must conform to the following requirements and must not exceed the stated page limits. DOE provides detailed guidance on the content and form of each standard application document in the NOFO Part 2, Section IV. *Application Content and Form*. Detailed guidance on the content and form of Program specific requirements are provided below the table.

Several of the Application Content Requirements listed below and in the NOFO Part 2 are required of covered individuals.

1. Covered Individual Definition, Designation, and Responsibility

For the purposes of this NOFO, a Covered Individual means an individual who (a) contributes in a substantive, meaningful way to the development or execution of the scope of work of a project proposed for funding by DOE, and (b) is designated as a covered individual by DOE.

DOE designates as covered individuals any principal investigator (PI); project director (PD); co-principal investigator (Co-PI); co-project director (Co-PD); project manager; and any individual regardless of title that is functionally performing as a PI, PD, Co-PI, Co-PD, or project manager. Status as a consultant, graduate (master's or PhD) student, or postdoctoral associate does not automatically disqualify a person from being designated as a "covered individual" if they meet the definition in (a) above.

The applicant is responsible for assessing the applicability of (a) above, against each person listed on the application. Further, the applicant is responsible for identifying any such individual to DOE for designation as a covered individual, if not already designated by DOE as described above.

The applicant's submission of a current and pending support disclosure and/or biosketch/resume for a particular person serves as an acknowledgement that DOE designates that person as a covered individual.

DOE may further designate covered individuals during award negotiations or the award period of performance.

2. Summary of Application Requirements

Component	File Format	Page Limit	File Name
SF-424: Application for Federal Assistance	PDF	n/a	ControlNumber_LeadOrganization_424
Technical Volume Topics 1, 2, and 3	PDF	15 pages	ControlNumber_LeadOrganization TechnicalVolume
Technical Volume Topic 4	PDF	20 pages	ControlNumber_LeadOrganization TechnicalVolume
Resumes	PDF	3 pages each	ControlNumber_LeadOrganization_Resumes
Letters of Commitment	PDF	1 page each	ControlNumber_LeadOrganization_LOCs
Impacted Indian Tribes Documentation	PDF	n/a	ControlNumber_LeadOrganization ImpactedTribes
Statement of Project Objectives Topics 1, 2, and 3	MS Word	10 pages	ControlNumber_LeadOrganization SOPO
Statement of Project Objectives Topic 4	MS Word	15 pages	ControlNumber_LeadOrganization SOPO

Budget Justification Workbook	MS Excel	n/a	ControlNumber_LeadOrganization Budget_Justification
Subrecipient Budget Justification	MS Excel	n/a	ControlNumber_LeadOrganization Subrecipient_Budget_Justification
DOE Work Proposal for FFRDC, (see DOE O 412.1A)	PDF	n/a	ControlNumber_LeadOrganizationWP
Authorization for Non-DOE or DOE FFRDCs	PDF	n/a	ControlNumber_LeadOrganization_FFRDCAuth
Summary for Public Release	PDF	1 page	ControlNumber_LeadOrganization Summary
Summary Slide	MS Power Point	1 page	ControlNumber_LeadOrganization_Slide
SF-LLL Disclosure of Lobbying Activities for Applicant and Subrecipients	PDF	n/a	ControlNumber_LeadOrganization_SF-LLL
Waiver for Foreign Entity Participation	PDF	n/a	ControlNumber_LeadOrganizationFEW
Performance of Work in the United States (Foreign Work Waiver)	PDF	n/a	ControlNumber_LeadOrganizationFWW
Community Benefits Plan for R&D Topics 1, 2, and 3	PDF	5 pages	ControlNumber_LeadOrganization CBP
Community Benefits Plan for RD&D Topic 4	PDF	10 pages	ControlNumber_LeadOrganization CBP
Current and Pending Support	PDF	n/a	ControlNumber_LeadOrganization_CPS
Potentially Duplicative Funding Notice	PDF	n/a	ControlNumber_LeadOrganization_PDFN
Research Security Training Requirement*	n/a	n/a	Include in Current & Pending Support for **each** covered individual
Digital Persistent Identifier*	n/a	n/a	Include in Current & Pending Support for **each** covered individual
Location(s) of Work	Excel	n/a	ControlNumber_LeadOrganization LOW
Transparency of Foreign Connections	PDF	n/a	BusinessSensitive_ControlNumber_LeadOrganization_TFC

*Beginning May 1, 2025, the Research Security Training Requirement and Digital Persistent Identifier must be included in the Current and Pending Support for all covered individuals included in the NOFO application. Please refer to NOFO Part 2, Section IV.B.18-19 for further details.

3. Technical Volume

The Technical Volume must conform to the following content and form requirements. This volume must address the technical review criteria as discussed in Technical Review Criteria.

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

For **Topics 1, 2, and 3**, the Technical Volume to the application may not be more than 15 pages, including the cover page, table of contents, and all citations, charts, graphs, maps, photos, or other graphics, and must include all information below. For **Topic 4**, the Technical Volume to the application may not be more than 20 pages, including the cover page, table of contents, and all citations, charts, graphs, maps, photos, or other graphics, and must include all information below. The applicant should consider the weighting of each of the technical review criteria (see Technical Review Criteria) when preparing the Technical Volume.

The Technical Volume should clearly describe and expand upon information provided in the concept paper.

Technical Volume Content Requirements Overview	
SECTION	**Approximate Percent Content of the Technical Volume**
Cover Page	N/A
Project Overview	10%
Technical Description, Innovation, and Impact	30%
Workplan in Statement of Project Objectives	40%
Technical Qualifications and Resources	20%

Cover Page:
The cover page must include all of the following:

- The project title;
- Specific NOFO topic areas (if applicable);
- Technical and business POCs;
- The project team, including recipient name, entity type and names of all team member organizations;
- The project location(s);
- The proposed Federal funding level, cost share and period of performance;
- Senior/key personnel and other covered individuals; and
- Statements regarding confidentiality.

Project Overview (Approximately 10% of the Technical Volume)
The Project Overview should contain the following information:

- **Background:** The applicant should discuss the background of its 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 application.

- **Project Goal:** The applicant should explicitly identify the targeted improvements to the baseline technology and the critical success factors in achieving that goal.
- **DOE Impact:** The applicant should discuss the impact that DOE funding would have on the proposed project. Applicants should specifically explain how DOE funding, relative to prior, current, or anticipated funding from other public and private sources, is necessary to achieve the project objectives.

Technical Description, Innovation, and Impact (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 or focus area, 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 NOFO, including the potential to meet specific DOE technical targets or other relevant performance targets. The applicant should clearly specify the expected outcomes of the project.
- **Feasibility:** The applicant should demonstrate the technical feasibility of the proposed technology and capability of achieving the anticipated performance targets, including a description of previous work done and prior results. This section should also address the project's access to necessary infrastructure (e.g., transportation, water, electricity transmission), including any use of existing infrastructure, as well as to a skilled workforce.
- **Innovation and Impacts:** The applicant should describe the current state of the art in the applicable field, the specific innovation of the proposed technology or focus area, the advantages of proposed technology over current and emerging technologies, and the overall impact on advancing the state-of-the-art/technical baseline if the project is successful.

Workplan in Statement of Project Objectives (Approximately 40% of the Technical Volume)
The Workplan should include a summary of the Project Objectives, Technical Scope, Work Breakdown Structure (WBS), Project Tasks, Milestones, and any Go/No-Go decision points. The statement of project objectives (SOPO) is to be provided as part of the application. The SOPO should contain the following information:

- **Project Objectives:** The applicant should provide a clear and concise (high-level) statement of the goals and objectives of the project as well as the expected outcomes.
- **Technical Scope Summary:** The applicant should provide a summary description of the overall work scope and approach to achieve the objective(s). The overall work scope is to be divided by performance periods that are separated by discrete, approximately annual decision points (see below for more information on Go/No-Go decision points). The applicant should describe the specific expected end result of each performance period, including milestones in the Community Benefits Plan.
- **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 NOFO. 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 SOPO should provide a summary of appropriate milestones throughout the project to demonstrate progress and success. A milestone may be either a progress measure (which can be activity based) or a SMART technical milestone. SMART milestones should be Specific, Measurable, Achievable, Relevant, and Timely, and must demonstrate a technical achievement rather than simply completing a task. Unless otherwise specified in the NOFO, 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. At a minimum, each project must have at least one project-wide Go/No-Go decision point for each budget period (12 month period) of the project. See NOFO Part 2, Key Facts section. The applicant should also provide the specific technical and community benefits plan criteria to be used to evaluate the project at the Go/No-Go decision point. The summary 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 Workplan should include 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, any milestones, and any Go/No-Go decision points.
- **Build America Buy America (BABA) Requirements for Infrastructure Projects:** Within the first two pages of the workplan include a short statement on whether the project will involve the construction, alteration, and/or repair of infrastructure in the United States. See Build America, Buy America | Department of Energy for applicable definitions and other information to inform this statement.
- **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, including a plan for securing a qualified workforce and mitigating risks to project performance including but not limited to community or labor disputes;
    - A description of how project changes will be handled;
    - If applicable, the approach to Quality Assurance/Control;
    - How communications will be maintained among project team members.
- **Market Transformation Plan**: The applicant should provide a market transformation plan, including the following:

- Identification of target market, competitors, and distribution channels for proposed technology along with known or perceived barriers to market penetration, including a mitigation plan;
- Identification of a product development and/or service plan, commercialization timeline, financing, product marketing, legal/regulatory considerations including intellectual property, infrastructure requirements, data dissemination, and product distribution; and
- Identification of current industry interest, commitments for adoption if the project is successful, and impact of those commitments across the industry.

Technical Qualifications and Resources (Approximately 20% of the Technical Volume)

The Technical Qualifications and Resources should contain the following information:

- A description of the project team's unique qualifications and expertise, including those of key subrecipients;
- A description of the project team's existing equipment and facilities, or equipment or facilities already in place on the proposed project site, 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;
- Relevant, previous work efforts, demonstrated innovations, and how these enable the applicant to achieve the project objectives;
- The time commitment of the key team members to support the project;
- A description of the technical services to be provided by DOE FFRDCs, if applicable;
- The skills, certifications, or other credentials of the construction and ongoing operations workforce;
- For multi-organizational projects, describe succinctly:
  - The roles and the work to be performed by the project manager and Senior/Key Personnel at the recipient and subrecipient levels;
  - Business agreements between the applicant and subrecipient;
  - How the various efforts will be integrated and managed;
  - Process for making decisions on technical direction;
  - Publication arrangements;
  - Strategy to address known resource, including Intellectual property and real property, constraints or challenges; and
  - Communication plans.

D. Funding Restrictions

Funding restrictions applicable to awards funded under this NOFO are identified below. Detailed descriptions of standard funding restrictions are provided in the NOFO Part 2, Section IV.D. *Funding Restrictions*. Detailed descriptions of program specific funding restrictions are provided below the table.

Applicable Funding Restrictions		
Title	**Location**	**Additional Information**
Allowable Costs	NOFO Part 2, Section IV.D. *Funding Restrictions*	Applicable to awards made under this NOFO
Pre-Award Costs	NOFO Part 2, Section IV.D. *Funding Restrictions*	Applicable to awards made under this NOFO
Performance of Work in the United States (Foreign Work Waiver Requirement)	NOFO Part 2, Section IV.D. *Funding Restrictions*	Applicable to awards made under this NOFO
Foreign Travel	NOFO Part 2, Section IV.D. *Funding Restrictions*	Foreign Travel is allowed for awards made under this NOFO with the prior written approval of the Grants Officer assigned to the award
Lobbying	NOFO Part 2, Section IV.D. *Funding Restrictions*	Applicable to awards made under this NOFO
Equipment and Supplies	NOFO Part 2, Section IV.D. *Funding Restrictions*	Purchasing American-made equipment and supplies is applicable to this award.
Davis-Bacon Act Requirements	NOFO Part 2, Section IV.D. *Funding Restrictions*	Applicable to awards made under this NOFO
Construction Signage	NOFO Part 2, Section IV.D. *Funding Restrictions*	Applicable to awards with construction activities made under this NOFO
Build America Buy America Requirements for Infrastructure Projects	NOFO Part 1 (below)	Applicable to awards made under this NOFO

1. Build America Buy America Requirements for Infrastructure Projects

Pursuant to the Build America Buy America Act, subtitle IX of BIL (Buy America or BABA), and in accordance with 2 CFR Part 184, no funds for federal financial assistance which is subject to BABA requirements may be used for a project unless:

1. All iron and steel used in the infrastructure work are produced in the United States;
2. All manufactured products used in the project are produced in the United States; and
3. All construction materials used in the infrastructure work are manufactured in the United States.

Whether a given project must apply this requirement is project-specific and dependent on several factors, such as the recipient's entity type, whether the work involves "infrastructure," as defined in Section 70914 of the BIL, and whether the infrastructure in question is publicly owned or serves a public function.

Applicants are strongly encouraged to consult NOFO Part 2, Section IX.P. *Buy America Requirements for Infrastructure* and 2 CFR Part 184 to determine whether their project may have to apply this requirement, both to make an early determination as to the need of a waiver, as well as to determine what impact, if any, this requirement may have on the proposed project's budget.

BABA requirements apply to DOE recipients that are "non-federal entities." In accordance with OMB Memorandum M-24-02 and 2 CFR 200.1, the term “non-federal entity” includes states, local governments, territories, Indian Tribes, Institutes of Higher Education or nonprofit organizations. DOE does not apply BABA requirements to for-profit entities. A Program Policy Factor that the Selection Official may consider in determining which applications to select for award negotiations by for-profit entities may be applied pursuant to Other Selection Factors. The relevant Program Policy Factor considers the degree to which the proposed project will employ procurement of U.S. iron, steel, manufactured products, and construction materials.

Subawards should conform to the terms of the recipient award from which they flow; in other words, for-profit recipients are not required to flow down these Buy America requirements to subrecipients, even if those subrecipients are non-federal entities as defined above. Conversely, recipients which are non-federal entities must flow the Buy America requirements down to all subrecipients, even if those subrecipients are for-profit entities.

The DOE financial assistance agreement will require each recipient to: (1) fulfill the commitments made in its application regarding the procurement of U.S.-produced products and (2) fulfill the commitments made in its application regarding the procurement of other key component metals and domestically manufactured products that are deemed available in sufficient and reasonably available quantities or of a satisfactory quality at the time of award negotiation. Applicants may seek waivers of these requirements in very limited circumstances and for good cause shown. Further details on requesting a waiver can be found in NOFO Part 2, Section IX.P. *Buy America Requirements for Infrastructure* and the terms and conditions of an award.

V. Submission Requirements and Deadlines

There are several one-time actions applicants must take before applying to this NOFO. Some of these may take several weeks, so it is vital applicants build in enough time to complete them. Failure to complete these actions could interfere with application or negotiation deadlines or the ability to receive an award if selected. These requirements are outlined in detail in the NOFO Part 2, Section I. *Get Registered*.

A. Required Registrations

1. Unique Entity Identifier (UEI) and System for Award Management (SAM)

You must have an active account with SAM.gov. This includes having a Unique Entity Identifier (UEI). SAM.gov registration can take several weeks. To register, go to SAM.gov Entity Registration and click Get Started. From the same page, you can also click on the Entity Registration Checklist for the information you will need to register.
Each applicant must:

1. Be registered in SAM.gov before submitting an application;
2. Provide a valid Unique Entity Identifier in the application; and

3. Continue to maintain an active registration in SAM.gov with current information at all times during which you have an active Federal award or an application or plan under consideration by a Federal agency.

DOE may not make a Federal award to an applicant until the applicant has complied with all applicable UEI 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.

2. eXCHANGE

Register and create an account in the eXCHANGE site identified in the Key Facts section of the NOFO Part 1. This account can be used to apply to open NOFOs in eXCHANGE. To view and submit applications to open opportunities under a specific DOE office(s), you must access the applicable instance of the system. You may need to be registered in more than one instance to submit applications for opportunities managed by different DOE offices.

Each organization or business unit, whether acting as a team or a single entity, should use only one account as the contact point for each submission. Applicants must also designate backup points of contact. **This step is required to apply to this NOFO.**

B. Application Package

1. eXCHANGE

The application package requirements are outlined in IV. Application Content and Form. Several templates for application requirements are included in eXCHANGE. To access these materials, select the appropriate NOFO on the Funding Opportunity page of eXCHANGE.

Note: The maximum file size that can be uploaded to the eXCHANGE website is 50MB. Files larger than 50MB cannot be uploaded and hence cannot be submitted for review. If a file is larger than 50MB but is still within the maximum page limit specified in the NOFO, it must be broken into parts and denoted to that effect. For example:

- TechnicalVolume_Part_1
- TechnicalVolume_Part_2

DOE will not accept late submissions that resulted from technical difficulties due to uploading files that exceed 50MB.

In addition to eXCHANGE, the application forms and instructions are available at EERE Funding Application and Management Forms.

2. Electronic Authorization of Applications and Award Documents

Submission of an application and supplemental information under this NOFO through electronic systems used by the DOE, including eXCHANGE, constitutes the authorized representative's approval and electronic signature.

C. Submission Date and Times

All required submissions must be submitted to the eXCHANGE site identified in the Key Facts section of NOFO Part 1 no later than 5 p.m. ET on the dates provided in the Key Facts section.
There may be more than one deadline, depending on whether a letter of intent and a concept paper is required.

Applicants are strongly encouraged to submit all required application documents at least 48 hours in advance of the submission deadline. Under normal conditions (i.e., at least 48 hours before the submission deadline), applicants should allow at least one hour to submit application documents. Once the application documents are submitted in the eXCHANGE site identified in the Key Facts section, 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 them before the applicable deadline. DOE will not extend the submission deadline for applicants that fail to submit required information by the applicable deadline due to server/connection congestion.

D. Intergovernmental Review

This NOFO is not subject to Executive Order 12372, Intergovernmental Review of Federal Programs.

VI. Application Review Information

A. Standards for Application Evaluation

Applications that are determined to be eligible will be evaluated in accordance with this NOFO, 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 October 1, 2020, which is available at: https://energy.gov/management/downloads/merit-review-guide-financial-assistance-and-unsolicited-proposals-current.

B. Responsiveness review

The following concept papers and applications will be deemed nonresponsive and will not be reviewed or considered:

- Project concepts or approaches not based on established scientific principles.
- Project concepts or approaches identified specifically as NOT of interest (See Applications Specifically Not of Interest).

C. Review criteria

1. Compliance Criteria

All applicant submissions for concept papers and applications must:

- Comply with the applicable content and form requirements listed in Application Content Requirements and Submission Requirements and Deadlines of the NOFO Part 1 and 2;
- Include all required documents;

- Be uploaded successfully in eXCHANGE site indicated in Key Facts including clicking the "Submit" button; and
- Comply with the submission deadline stated in Key Facts.

DOE will not review or consider submissions submitted through means other than the eXCHANGE site indicated in Key Facts, submissions submitted after the applicable deadline, or incomplete submissions.

If required in the Key Facts section, applicants must submit a concept paper by 5:00 p.m. ET on the due date listed on the Key Facts section to be eligible to submit an application. **When required, applicants who do not submit a concept paper cannot submit an application.**

2. Technical Review Criteria

Concept Papers

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

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

- The applicant clearly describes the proposed technology, 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 of the technology, regulatory and financial aspects of the proposal including possible mitigation strategies, and has shown the impact that DOE 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 NOFO.

Applications

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

Review Criterion Overview	
Criterion	**Weight**
Technical Merit, Innovation, and Impact	45%
Project Demonstration and Market Transformation Plan	25%
Team and Resources	15%
Community Benefits Plan: R&D	15%

Criterion 1: Technical Merit, Innovation, and Impact (45%)
This criterion involves consideration of the following factors:

Technical Merit and Innovation

- Extent to which the proposed technology, process, or project is innovative or replicable;
- Degree to which the current state of the technology and the proposed advancement are clearly described;
- Extent to which the application specifically and convincingly demonstrates how the applicant will move the state of the art to the proposed advancement;
- Sufficiency of technical detail in the application to assess whether the proposed work is scientifically meritorious and revolutionary, including relevant data, calculations, and discussion of prior work, with analyses that support the viability of the proposed work;
- Extent to which project has buy-in from needed stakeholders to ensure success of the project;
- Degree to which key manufacturing and supply chain challenges are considered, as applicable, for viable scale up in this and future demonstrations;
- Extent to which project has the potential to reduce emissions and provide clean energy acceleration benefits for a community or region;
- Sufficiency of existing infrastructure to support addition of proposed demonstration, if relevant to the project; and
- **For Topic 4 only**: degree to which siting and environmental constraints are considered for deployment.

Impact of Technology Advancement

- Ability of the project to advance industry adoption;
- Extent to which the project supports the topic area objectives and target specifications and metrics;
- Potential impact of the project on advancing the state of the art;
- Extent to which the project work is replicable and may lead to future demonstrations; and
- Extent to which the project facilitates stakeholder relationships across new or existing stakeholders to gain technical buy-in and increase potential for future deployments.

Project Management

- Adequacy of proposed project management systems including the ability to track scope, cost, and schedule progress and changes;
- Reasonableness of budget and spend plan as detailed in the budget justification workbook for proposed project and objectives;
- Adequacy of contingency funding based on quality of cost estimate and identified risks;
- Adequacy, reasonableness, and soundness of the project schedule, as well as periodic Go/No-Go decisions prior to further funds disbursement, interim milestones, and metrics to track process;
- Adequacy, reasonableness, and soundness of the project schedule, as well as annual Go/No-Go decisions prior to a budget period continuation application, interim milestones, and metrics to track process;
- Adequacy of the identification of risks, including labor and community opposition or disputes, and “timely” and appropriate strategies for mitigation and resolution; and
- Soundness of a plan to expeditiously address environmental, siting, and other regulatory requirements for the project, including evaluation of resilience to climate change.

Criterion 2: Project Demonstration (25%)
This criterion involves consideration of the following factors:

Research Approach, Workplan, and SOPO

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

Identification of Technical Risks

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

Baseline, Metrics, and Deliverables

- Level of clarity in the definition of the baseline, metrics, and milestones; and
- Relative to a clearly defined project 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

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

Criterion 3: Team and Resources (15%)
This criterion involves consideration of the following factors:
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- Capability of the project manager(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;
- Diversity of expertise and perspectives of the team and the inclusion of industry partners that will amplify impact;
- Sufficiency of the facilities to support the work;
- Degree to which the proposed consortia/team demonstrates the ability to facilitate and expedite further demonstration, development, and commercial deployment of the proposed technologies;
- Level of participation by project participants as evidenced by letter(s) of commitment and how well they are integrated into the Workplan; and
- Reasonableness of the budget and spend plan for the proposed project and objectives.

Criterion 4: Community Benefits Plan (R&D or RD&D) (15%)
This criterion involves consideration of the following factors:

Diversity, Equity, Inclusion, and Accessibility

- Extent to which the plan meaningfully considers diversity, equity, inclusion, and accessibility as distinct and interrelated work;
- Clear articulation of the project's goals related to DEIA in terms of what the activity entails, who will be doing the activity, and within what timeframe
- Quality of the project's DEIA goals, as measured by the goals' potential impact, likelihood of success, resources allocated, and the inclusion of appropriate and relevant SMART milestones across the project lifecycle;
- Metrics of accountability to track progress toward meeting each of the DEIA goals; and
- Extent of meaningful partnership with organizations that represent DACs as a core element of their mission, including MSIs, Minority Business Entities, and nonprofit or community-based organizations.

The Justice40 Initiative and other considerations linked with energy and/or environmental justice

- Clear workplan tasks, budget, staffing, research, and timeline for engaging local and regional energy equity communities and other stakeholders;
- The degree to which the budget justification describes and allocates funding and resources to the proposed community benefit plan activities;
- Evaluating the possible near- and long-term implications of the project activities related to their implications for energy justice;
- Approach, methodology, and expertise articulated in the plan for addressing local and regional energy equity and justice issues associated with the technology innovation;
- Assessment of how the plan will result in improved understanding of distributional public benefits and costs related to the innovation if successful; and
- Description of how the project will advance the Justice40 Initiative's goal of having 40% of the overall benefits of covered investments flow to disadvantaged communities.

Quality Jobs

- Clear and comprehensive workplan tasks, staffing, research, and timeline for engaging local and regional workforce stakeholders and/or evaluating the possible near- and long-term implications of the project for the U.S. workforce;
- Describing how the project will support workforce training to address needs for successful innovation;
- Approach to document the knowledge, skills, and abilities of the workforce required for successful commercial deployment of innovations resulting from this research; and
- Likelihood that the plan will result in improved understanding of the local and regional workforce implications related to the innovation if successful.

3. Criteria for Replies to Reviewer Comments

DOE 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 application.

D. Other Selection Factors

In addition to the above criteria, the Selection Official may consider the following program policy factors in determining which 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 NOFO;
- 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 demonstration and commercialization and overcome key market barriers;
- 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);
- The degree to which the proposed project incorporates applicant or team members from Minority Serving Institutions (e.g., Historically Black Colleges and Universities (HBCUs)/Other Minority Institutions (OMIs)); and partnerships with underrepresented businesses, or Indian Tribes.
- The degree to which the proposed project will employ procurement of U.S. iron, steel, manufactured products, and construction materials.
- The degree to which the proposed project contributes to the diversity of organizations and organization types and sizes selected from the subject NOFO when compared to the existing DOE project portfolio.
- The degree to which the proposed project has broad public support from the communities most directly impacted by the project.
- The degree to which the proposed project avoids duplication/overlap with other publicly or privately funded work.
- The degree to which the proposed project supports complementary efforts or projects, which, when taken together, will best achieve the research goals and objectives.
- The degree to which the proposed project enables new and expanding market segments.
- The degree to which the project's solution or strategy will maximize deployment or replication.
- The degree to which the project promotes increased coordination with nongovernmental entities for demonstration of technologies and research applications to facilitate technology transfer.

VII. Selection and Award Notices

Please see the NOFO Part 2, Section VII. *Selection and Award Notices* for information on notifications for Concept Papers (if applicable), Applications, Award Negotiations, and Post-Selection Information Requests.

VIII. Award Administration Information

A. Post-Award Requirements and Administration

DOE requires all award recipients to follow and accept requirements governed by laws and policies – both federal government-wide and DOE or program specific. These post-award requirements include all National and Administrative Policy Requirements; financial assistance general Certifications and Representations; Build America, Buy America requirements; Davis-Bacon Act requirements; Bipartisan

Infrastructure Law-Specific Requirements; Fraud, Waste and Abuse requirements; Safety, Security, and Regulatory requirements; and Environmental Review in Accordance with National Environmental Policy Act requirements.

Post-Award requirements and administration applicable to awards funded under this NOFO are identified below. Detailed descriptions of standard funding restrictions are provided in the NOFO Part 2, Section IV.D. *Funding Restrictions* section. Detailed descriptions of program specific funding restrictions are provided below the table.

Applicable Post-Award Requirements and Administration	
Title	**Location**
Award Administrative Requirements	NOFO Part 2, Section VIII.A. *Award Administration Information*
Subaward and Executive Reporting	NOFO Part 2, Section VIII.A. *Award Administration Information*
Applicant Representations and Certifications	NOFO Part 2, Section VIII.A. *Award Administration Information*
Statement of Federal Stewardship	NOFO Part 2, Section VIII.A. *Award Administration Information*
Uniform Commercial Code (UCC) Financing Statements	NOFO Part 2, Section VIII.A. *Award Administration Information*
Interim Conflict of Interest Policy for Financial Assistance	NOFO Part 2, Section VIII.A. *Award Administration Information*
Whistleblower Protections	NOFO Part 2, Section VIII.A. *Award Administration Information*
Fraud, Waste, and Abuse	NOFO Part 2, Section VIII.A. *Award Administration Information*
Participants and Collaborating Organizations	NOFO Part 2, Section VIII.A. *Award Administration Information*
Current and Pending Support	NOFO Part 2, Section VIII.A. *Award Administration Information*
Prohibition Related to Malign Foreign Talent Recruitment Programs	NOFO Part 2, Section VIII.A. *Award Administration Information*
Foreign Collaboration Considerations	NOFO Part 2, Section VIII.A. *Award Administration Information*
U.S. Manufacturing Commitments	NOFO Part 2, Section VIII.A. *Award Administration Information*
Subject Invention Utilization Reporting	NOFO Part 2, Section VIII.A. *Award Administration Information*
Intellectual Property Provisions	NOFO Part 2, Section VIII.A. *Award Administration Information*
Data Management Plan	NOFO Part 2, Section IV.B *Application Content Requirements**
Environmental Questionnaire	NOFO Part 2, Section IV.B *Application Content Requirements**
Go/No-Go Review	NOFO Part 2, Section VIII.A. *Award Administration Information*
Conference Spending	NOFO Part 2, Section VIII.A. *Award Administration Information*
Invoice Review and Approval	NOFO Part 2, Section VIII.A. *Award Administration Information*
Cost-Share Payment	NOFO Part 2, Section VIII.A. *Award Administration Information*
Implementation of Executive Order 13798, Promoting Free Speech and Religious Liberty	NOFO Part 2, Section VIII.A. *Award Administration Information*

Affirmative Action and Pay Transparency Requirements	NOFO Part 2, Section VIII.A. *Award Administration Information*
Construction Signage	NOFO Part 2, Section VIII.A. *Award Administration Information*
Human Subjects Research	NOFO Part 2, Section VIII.A. *Award Administration Information*
Real Property and Equipment	NOFO Part 1 (below)
Rights in Technical Data	NOFO Part 1 (below)
Cost Share Payment	NOFO Part 1 (below)

* The Data Management Plan and Environmental Questionnaire are not required to be submitted as part of the application for R&D or RD&D proposals. Projects selected for award negotiations are required to provide the Data Management Plan and Environmental Questionnaire as a post-award requirement.

1. Real Property and Equipment

Real property and equipment purchased with project funds (federal share and recipient cost share) are subject to the requirements at 2 CFR 200.310, 200.311, 200.313, and 200.316 (non-federal entities, except for-profit entities) and 2 CFR 910.360 (for-profit entities).

For resulting awards under this NOFO, the recipients may (1) take disposition action on the real property and equipment; or (2) continue to use the real property and equipment after the conclusion of the award period of performance with Grants Officer approval. The recipient's written request for Continued Use must identify the property and include: a summary of how the property will be used (must align with the authorized project purposes); a proposed use period, (e.g., perpetuity, until fully depreciated, or a calendar date when the recipient expects to submit disposition instructions); acknowledgement that the recipient shall not sell or encumber the property or permit any encumbrance without prior written DOE approval; current fair market value of the property; and an estimated useful life or depreciation schedule for equipment.

When the property is no longer needed for authorized project purposes, the recipient must request disposition instructions from DOE. For-profit entity disposition requirements are set forth in 2 CFR 910.360. Property disposition requirements for other non-federal entities are set forth in 2 CFR 200.310 – 200.316. In addition, pursuant to the FY23 Consolidated Appropriations Act (Pub. L. No. 117-328), Division D, Title III, Section 309, at the end of the award period the Secretary or a designee of the Secretary, at their discretion, may vest unconditional title or other property interests acquired under this project regardless of the fair market value of the property.

2. 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 DOE awards under this NOFO 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 award's 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.

3. Cost Share Payment

DOE requires recipients to contribute the cost share amount incrementally over the life of the award. Specifically, the 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).

B. Helpful Websites

EERE eXCHANGE User Guides: https://eere-exchange.energy.gov/Manuals.aspx

How Do I Apply for EERE Funding? https://www.energy.gov/eere/funding/how-do-i-apply-eere-funding

About Community Benefits Plans: https://www.energy.gov/infrastructure/about-community-benefits-plans

C. Questions and Support

1. Questions

Upon the issuance of a NOFO, DOE personnel are prohibited from communicating (in writing or otherwise) with applicants regarding the NOFO except through the established question and answer process described below. Questions regarding this NOFO must be submitted to the identified contact in the Key Facts section of the NOFO Part 1. no 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 NOFO will be posted on the eXCHANGE site listed in the Key Facts. **You must first select the NOFO Number and scroll to the Documents section to view the questions and answers specific to this NOFO**. DOE 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 eXCHANGE site should be submitted to the identified contact listed in the Key Facts.

2. Support

Grants.gov

Grants.gov provides 24/7 support. You can call 1-800-518-4726 or email support@grants.gov. Hold on to your ticket number.

SAM.gov
If you need help, you can call 866-606-8220 or live chat with the Federal Service Desk.

IX. Other Information

Please see the NOFO Part 2, Section IX. *Other Information* for additional information and requirements.