Department of Energy (DOE)
Hydrogen and Fuel Cell Technologies Office

Bipartisan Infrastructure Law: Clean Hydrogen Electrolysis, Manufacturing, and Recycling

Funding Opportunity Announcement (FOA) Number: DE-FOA-0002922
FOA Type: Initial
Assistance Listing Number: 81.087

FOA Issue Date:	03/15/2023
Submission Deadline for Concept Papers:	04/19/2023 5:00pm ET
Submission Deadline for Full Applications:	07/19/2023 5:00pm ET
Expected Submission Deadline for Replies to Reviewer Comments:	09/21/2023 5:00pm ET
Expected Date for DOE Selection Notifications:	Fall 2023
Expected Timeframe for Award Negotiations:	Winter 2023/2024

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

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

- **Unique Entity Identifier (UEI) and System for Award Management (SAM)** - Each applicant (unless the applicant is excepted from those requirements under 2 CFR 25.110) is required to: (1) Be registered in the SAM at https://www.sam.gov before submitting its application; (2) provide a valid UEI number in its application; and (3) continue to maintain an active SAM registration with current information at all times during which it has an active federal award or an application or plan under consideration by a federal awarding agency. DOE may not make a federal award to an applicant until the applicant has complied with all applicable 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.

NOTE: Due to the high demand of UEI requests and SAM registrations, entity legal business name and address validations are taking longer than expected to process. Entities should start the UEI and SAM registration process as soon as possible. If entities have technical difficulties with the UEI validation or SAM registration process, they should utilize the HELP feature on SAM.gov. SAM.gov will work entity service tickets in the order in which they are received and asks that entities not create multiple service tickets for the same request or technical issue. Additional entity validation resources can be found here: GSAFSD Tier 0 Knowledge Base - Validating your Entity.

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

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Modifications

Modifications to the FOA are HIGHLIGHTED in the body of the FOA.

Mod. No.	Date	Description of Modification
0001	03/31/2023	1. **Section IV. D. ix:** Directs applicants to EERE eXCHANGE to access a summary slide template. Further defines the information that is required in the summary slides. 2. **Section I.B.i:.** In Topic 3, Subtopic 3a, removes the anode catalyst activity target for PEM electrolyzers to emphasize integrated MEA performance.

Overview of Key Information

Agency: Department of Energy, Office of Energy Efficiency and Renewable Energy

Overview: Through this Funding Opportunity Announcement (FOA), the Hydrogen and Fuel Cell Technologies Office will provide funding for research, development, and demonstration to:

1. Improve the efficiency, increase the durability, and reduce the cost of producing clean hydrogen using electrolyzers to less than $2 per kilogram by 2026
2. Advance new manufacturing technologies and techniques for clean hydrogen production and use equipment, specifically for electrolyzer and fuel cell technologies
3. Create innovative and practical approaches to increase the reuse and recycling of clean hydrogen and fuel cell technologies

Deadlines:

- **April 19, 2023 at 5pm ET**: Concept papers due
- **July 19, 2023 at 5pm ET:** Full Applications due

Funding Overview: It is anticipated that this FOA will provide Federal funding of $750 million over five years.

Eligible Applicants: The following types of entities are eligible to participate as prime recipients or subrecipients:

1. For-profit entities;
2. Non-profit entities;
3. Institutions of higher education;
4. State and local governmental entities;
5. Tribal Nations;
6. Incorporated Consortia; and
7. Unincorporated Consortia

DOE/NNSA and non-DOE Federally Funded Research and Development Centers (FFRDCs) are eligible to apply for funding as a subrecipient, with certain restrictions as specified in Section III.A.i. of the FOA. All FFRDCs are excluded from applying as a prime recipient.

For Topic 6 of this FOA, United States universities or non-profit organizations are the only entities eligible to apply as prime recipients; however, all entities are eligible to apply as subrecipients.

Key Benefits and Metrics:

- **Reduced cost of clean hydrogen produced using electrolyzers**, measured through specific metrics for stack and system capital cost, efficiency, performance, and durability.
- **Reduced supply chain vulnerabilities,** measured by positive changes in domestic manufacturing capacity and commercial availability of fuel cell and electrolyzer components and stacks.
- **Improved processes for high-throughput, low-cost manufacturing of electrolyzers and fuel cells**, measured in annual manufacturing volumes, line speeds, extent of automation, yield, and cost-effectiveness.
- **Development of sustainable manufacturing and recycling processes,** measured through energy efficiency, cost-effectiveness, use of non-hazardous materials, and recovery rates.
- **Creation of opportunities for underserved communities and groups,** measured through metrics such as new jobs and training resources, partnerships with Minority Serving Institutions and Tribal Nations, engagement with labor organizations, community engagement activities, and other relevant indicators from the R&D Community Benefits Plan (see Section IV.D.xv of the FOA).

Topics: The following topics, in two areas of interest, are included in this funding opportunity. See Section 1.B. of the FOA for more details on the Topics.

Area of Interest 1: Clean Hydrogen Electrolysis Program

- **Topic 1: Low Cost, High-Throughput Electrolyzer Manufacturing**
  Research, development, and demonstration (RD&D) aiming to accelerate manufacturing innovations, thereby enabling electrolyzer stack manufacturers to achieve economies of scale benefits beyond the business-as-usual. These large (up to $50 million each) projects must show pathways to achieving <$100/kW (low temperature electrolyzer) and <$125/kW (high temperature electrolyzer) stack cost by developing and demonstrating high volume-compatible (> GW/year) manufacturing processes.

- **Topic 2: Electrolyzer Component and Supply Chain Development**
  Research and development (R&D) of advanced components critical to the accelerated commercialization of electrolyzers. These mid-size (up to $10 million each) projects will support innovations in and validation of component development and high-volume manufacturing processes that address technology cost and performance challenges while strengthening a domestic manufacturing base and supply chains.

- **Topic 3: Advanced Electrolyzer Technology and Component Development**
  R&D aiming to develop materials, components, and designs that are at lower technology readiness levels (TRL) compared to those in Topics 1 and 2. Although higher risk, these projects have high impact potential to enable meeting or exceeding long-term cost, performance, and lifetime targets in next-generation electrolyzer technologies. These

smaller (up to $5M) projects will consist of applied R&D efforts and must include proof of concept and laboratory validation.

Area of Interest 2: Clean Hydrogen Manufacturing and Recycling

- **Topic 4: Fuel Cell Membrane Electrode Assembly and Stack Manufacturing and Automation**
  RD&D aiming to accelerate fuel cell manufacturing innovation and scale-up, in a similar fashion to Topic 1 above for electrolyzer technologies, enabling diverse fuel cell manufacturer and supplier teams to flexibly address their greatest scale-up challenges and achieve economies of scale benefits. These larger ($20-$30 million) projects are geared toward scaling cell and stack production and addressing the 2030 heavy-duty vehicle (HDV) fuel cell cost, durability, and efficiency targets, as well as manufacturing capacity targets, with transferable benefits to medium-duty vehicle (MDV) and cross-cutting applications.

- **Topic 5: Fuel Cell Supply Chain Development**
  R&D to address critical deficiencies in the domestic supply chain for MDV/HDV fuel cell materials and components. Within this topic, mid-size (up to $10 million each) projects will support the establishment and expansion of manufacturing and production of critical cell materials, while smaller (up to $5 million each) projects will address the need for rapid development and production of alternate membrane materials.

- **Topic 6 Recovery and Recycling Consortium**
  This topic provides up to $50 million to establish a single broad-based nonprofit/university-led consortium of industry, academia, and national labs to address a range of recovery, recycling, refurbishment, and reuse challenges for fuel cell and electrolyzer stacks and components. These efforts will be supported and driven by high-level total cost of ownership (TCO) and life cycle assessment (LCA) analyses to identify low-cost, -energy, and -emissions pathways to optimize market-wide recovery and recycling strategies and methods.

Anticipated Award Size, Funding Amount, and Cost Sharing Requirement[1]

Topic Area Number	Topic Area Title	Anticipated Number of Awards	Minimum required Non-Federal Cost Share (%)	Anticipated Cost Share per Award		Total Anticipated Fed Share
				Award Size (Fed Share)	Applicant Share	
1	Low-Cost, High-Throughput Electrolyzer Manufacturing	6-10	50%	$20M - $50M	$20M - $50M	Up to $300M
2	Electrolyzer Component and Supply Chain Development	10-20	20%	$5M - $10M	$1.25M - $2.5M	Up to $100M
3	Advanced Electrolyzer Technology and Component Development	15-30	20%*	$2M - $5M	$0.5M - $1.25M	Up to $70M
4	Fuel Cell MEA and Stack Manufacturing and Automation	5-7	50%	$20M - $30M	$20M - $30M	Up to $150M
5	Fuel Cell Supply Chain Development	8-16	20%	$3M - $10M	$0.75M - $2.5M	Up to $80M
6	Recovery and Recycling Consortium	1	20%	$50M	$12.5M	Up to $50M
**In Topic 3, cost sharing is not required For Institutions of Higher Education and Nonprofit Organizations*					**Total**	**$750M**

[1] See FOA Appendix A for information on how cost sharing is calculated.

I. Funding Opportunity Description

A. Background and Context

The Hydrogen and Fuel Cell Technologies Office (HFTO) is issuing this Funding Opportunity Announcement (FOA). Awards made under this FOA will be funded, in whole or in part, with funds appropriated by the Infrastructure Investment and Jobs Act,[2] more commonly known as the Bipartisan Infrastructure Law (BIL).

The BIL is a once-in-a-generation investment in infrastructure, designed to modernize and upgrade American infrastructure to enhance United States competitiveness, drive the creation of good-paying union jobs, tackle the climate crisis, and ensure stronger access to economic, environmental, and other benefits for disadvantaged communities.[3] The BIL appropriates more than $62 billion to the Department of Energy (DOE)[4] to invest in American manufacturing and workers; expand access to energy efficiency and clean energy; deliver reliable, clean, and affordable power to more Americans; and demonstrate and deploy the technologies of tomorrow through clean energy demonstrations.

As part of and in addition to upgrading and modernizing infrastructure, DOE's BIL investments will support efforts to build a clean and equitable energy economy that achieves a zero-carbon electricity system by 2035, and to put the United States on a path to achieve net-zero emissions economy-wide by no later than 2050[5] to benefit all Americans.

[2] Infrastructure Investment and Jobs Act, Public Law 117-58 (November 15, 2021). https://www.congress.gov/bill/117th-congress/house-bill/3684. This FOA uses the more common name "Bipartisan Infrastructure Law."

[3] Pursuant to E.O. 14008 and the Office of Management and Budget's Interim Justice40 Implementation Guidance M-21-28, DOE has developed a definition and tools to locate and identify disadvantaged communities. These resources can be located at https://energyjustice.egs.anl.gov/. Pursuant to Office of Management and Budget's Memorandum M-23-09, DOE recognizes disadvantaged communities as defined and identified by the White House Council on Environmental Quality's Climate and Economic Justice Screening Tool (CEJST) Version 1.0, which can be located at https://screeningtool.geoplatform.gov/. DOE's Justice40 Implementation Guidance is located at https://www.energy.gov/sites/default/files/2022-07/Final%20DOE%20Justice40%20General%20Guidance%20072522.pdf.

[4] U.S. Department of Energy. November 2021. "DOE Fact Sheet: The Bipartisan Infrastructure Deal Will Deliver For American Workers, Families and Usher in the Clean Energy Future." https://www.energy.gov/articles/doe-fact-sheet-bipartisan-infrastructure-deal-will-deliver-american-workers-families-and-0

[5] Executive Order (EO) 14008, "Tackling the Climate Crisis at Home and Abroad," January 27, 2021.

BIL Section 40314 authorizes $500 million for the development of manufacturing and recycling of clean hydrogen, and $1 billion for electrolyzer development for the five (5) year period encompassing Fiscal Years (FYs) 2022 through 2026.

The activities to be funded under this FOA implement BIL section 40314 (see Appendix H for the complete language), which amends Title VIII of the Energy Policy Act (EPAct) 2005 to include a new "Section 815—Clean Hydrogen Manufacturing and Recycling" and a new "Section 816—Clean Hydrogen Electrolysis Program." They support the broader government-wide approach to increase the viability of clean fuels, the deployment of renewable energy technologies (e.g., supporting the buildout of a national clean hydrogen network), and maximize the benefits of the clean energy transition as the nation works to curb the climate crisis, empower workers, and advance environmental justice. These provisions are focused on:

- Advancing new technologies and techniques for manufacturing the equipment used in clean hydrogen production, processing, delivery, storage, and use[6]
- Research, development, and demonstration projects to create innovative and practical approaches to increase the reuse and recycling of clean hydrogen technologies[7]
- Reducing the cost of clean hydrogen produced from electrolyzers to less than $2 per kilogram by 2026[8]

i. Program Purpose

HFTO conducts comprehensive efforts to overcome the technological, economic, and institutional challenges facing the widespread adoption and use of clean hydrogen and fuel cell technologies. To this end, HFTO, in collaboration with other DOE offices, supports a broad portfolio of applied research, development, demonstration, and deployment (RDD&D) projects across the full range of technologies for the production, processing, delivery, storage, and use of clean hydrogen.[9] Additional key activity areas include cross-cutting topics to enable

[6] 42 U.S.C. § 16161c(a).
[7] 42 U.S.C. § 16161c(b).
[8] 42 U.S.C. § 16161d. Note that $2/kg is the levelized cost of hydrogen production and includes the cost of electricity (i.e., power input to electrolyzer), capital cost, and operating cost. It does not include the cost of hydrogen storage, distribution, or delivery.
[9] Clean hydrogen is defined in the BIL (*see* Pub. L. 109-58, Title VIII, §822, as added Pub. L. 117-58, Div. D, Title III, §40315(a), codified at 42 U.S.C. 16166(b)(1)). DOE issued draft guidance for stakeholder feedback on September 22, 2022, and plans to finalize the Clean Hydrogen Production Standard in 2023 (see

deployment of hydrogen technologies, such as system development and integration; safety, codes and standards; and systems analysis. Efforts also support robust supply chains, including for any needed critical materials and design for environmental and climate stewardship; efficiency; durability; and recyclability to ensure a strategic and sustainable build out of the clean hydrogen industry. RDD&D activities rely heavily on collaboration among various industry stakeholders, academic institutions, and the national laboratories, including through HFTO-managed consortia.

To complement and ensure success of these RDD&D activities, HFTO is also conducting efforts to reduce vulnerabilities in the supply chain, increase its resilience, and strengthen and diversify the science, technology, engineering, and mathematics (STEM) workforce supporting hydrogen and fuel cell technologies. A critical component of these efforts is building partnerships and activities that ensure the economic and environmental benefits of HFTO investments are available to disadvantaged (underserved or overburdened) communities, which supports the Justice40 Initiative.

BIL investments will support a number of new initiatives to significantly bolster HFTO's efforts. This FOA launches three of those initiatives: the Clean Hydrogen Electrolysis Program, the Clean Hydrogen Manufacturing Initiative, and the Clean Hydrogen Technology Recycling Research, Development, and Demonstration Program. This FOA includes up to $750 million of the total $1.5 billion of BIL funding for these initiatives. In addition to this FOA, other activities supporting these initiatives will include funding for national laboratories, Small Business Innovative Research projects, prizes, and additional FOAs or other funding mechanisms. This portfolio of efforts will leverage and complement HFTO's other ongoing activities, including established research consortia, and build on the knowledge gained from previous RDD&D efforts.

The goal of the Clean Hydrogen Electrolysis Program (EPAct Section 816) is to "reduce the cost of hydrogen produced using electrolyzers to less than $2 per kilogram by 2026.'' It will support RDD&D of components, stacks, and systems across a range of electrolyzer technologies (including both low-temperature and high-temperature) and electrolyzer manufacturing processes and equipment. As improvements in clean hydrogen production must be supported by advances in infrastructure and integration with other systems, this program will also fund a number of other efforts not included in the FOA (to be included in future FOAs

https://www.energy.gov/eere/fuelcells/articles/clean-hydrogen-production-standard. The Credit for Production of Clean Hydrogen in the Inflation Reduction Act sets forth carbon intensities (i.e., kg of CO_2e per kg of qualified clean hydrogen produced) for tax credit eligibility (*see* Pub. L. 117-169, Title 1, §13204, codified at 26 U.S.C. §45V).

and other funding mechanisms). These topics include: clean hydrogen storage technologies; technologies that integrate hydrogen production with compression and drying technologies; and integrated systems that combine hydrogen production with renewable power or nuclear power generation, including hybrid systems that also integrate hydrogen storage.

The Clean Hydrogen Manufacturing Initiative (EPAct Section 815(a)) will support RD&D of technologies and processes for manufacturing the equipment used in the production, processing, delivery, storage, and use of clean hydrogen. Priorities include increasing efficiency and reducing cost, supporting domestic supply chains, and incorporating nonhazardous alternative materials. This initiative will prioritize projects that partner with Tribal energy development organizations, Indian tribes, Tribal organizations, Native Hawaiian community-based organizations, or territories or freely associated states, and projects that are located in economically distressed areas of the major natural gas-producing regions of the United States.

The Clean Hydrogen Technology Recycling Research, Development, and Demonstration Program (EPAct Section 815(b)) will support innovative and practical approaches to increasing the reuse and recycling of clean hydrogen technologies. These efforts will aim to: increase the efficiency and reduce the cost of the recovery of raw materials; minimize environmental impacts from the recovery and recycling processes; develop improved technologies and processes for disassembly, recycling, and resource recovery and address barriers to their commercialization and adoption; develop alternative materials, designs, and manufacturing processes that are more recyclable and reusable; and develop strategies to increase end-user acceptance of, and participation in, the reuse and recycling of materials and components for fuel cells and electrolyzers.

As part of the whole-of-government approach to advance equity and encourage worker organizing and collective bargaining,[10,11,12] and in alignment with EPAct sections 815 and 816 (as enacted by BIL section 40314), this FOA and any related activities will seek to encourage meaningful engagement and participation of workforce organizations, including labor unions, as well as underserved communities and underrepresented groups, including consultation with Tribal Nations consistent with the President's Memorandum on Tribal Consultation and

[10] EO 13985, "Advancing Racial Equity and Support for Underserved Communities Through the Federal Government," January 20, 2021.
[11] EO 14025, "Worker Organizing and Empowerment," April 26, 2021.
[12] EO 14052, "Implementation of the Infrastructure Investment and Jobs Act," November 18, 2021.

Strengthening Nation-to-Nation Relationships.[13] Consistent with Executive Order 14008,[14] this FOA is designed to help meet the goal that 40% of the overall benefits of the Administration's investments in clean energy and climate solutions flow to disadvantaged communities, as defined by the Department pursuant to the Executive Order and to drive the creation of accessible good-paying jobs with the free and fair chance for workers to join a union.

ii. Technology Space and Strategic Goals

Achieving net-zero emissions economy-wide by 2050 poses particular challenges for hard-to-decarbonize sectors where electrification with clean electricity will be technically or economically difficult. These sectors include steel manufacturing,[15] medium- and heavy-duty transportation, and production of chemicals and liquid fuels. Hydrogen and fuel cell technologies are part of a comprehensive portfolio of solutions to address these challenges, and DOE's H2@Scale® vision illustrates the promising pathways for hydrogen to enable the decarbonization of multiple sectors (Figure 1).[16] Hydrogen is a unique and flexible energy carrier that can be produced from a variety of clean energy resources, and it can complement existing electricity and natural gas infrastructure for multiple end-use applications.

DOE recently published the *Draft DOE National Clean Hydrogen Strategy and Roadmap*, which was also required under Section 40314 of the BIL, as a new Section 814 of EPAct 2005.[17] This document contains a technologically and economically feasible national strategy and roadmap to facilitate widespread and large-scale production, processing, delivery, storage, and use of clean hydrogen, in alignment with the H2@Scale® vision. The *Strategy and Roadmap* outlines strategic opportunities to produce 10 million metric tons (MMT) of clean hydrogen in the United States annually by 2030, 20 MMT per year by 2040, and 50 MMT per year by 2050. It includes three key strategies: (1) targeting high-impact uses for clean hydrogen, (2) focusing on regional networks, and (3) reducing the cost of clean hydrogen. This FOA plays a critical role in the third

[13] EO 13175, November 6, 2000 "Consultation and Coordination With Indian Tribal Governments", charges all executive departments and agencies with engaging in regular, meaningful, and robust consultation with Tribal officials in the development of federal policies that have Tribal implications.
[14] EO 14008, "Tackling the Climate Crisis at Home and Abroad," January 27, 2021.
[15] "DOE Industrial Decarbonization Roadmap." https://www.energy.gov/eere/doe-industrial-decarbonization-roadmap.
[16] H2@Scale. https://www.energy.gov/eere/fuelcells/h2scale.
[17] "DOE National Clean Hydrogen Strategy and Roadmap, Draft – September 2022." https://www.hydrogen.energy.gov/pdfs/clean-hydrogen-strategy-roadmap.pdf.

strategy—*with an emphasis on reducing the lifecycle costs of technologies for the production, distribution, storage, delivery, and use of clean hydrogen*.

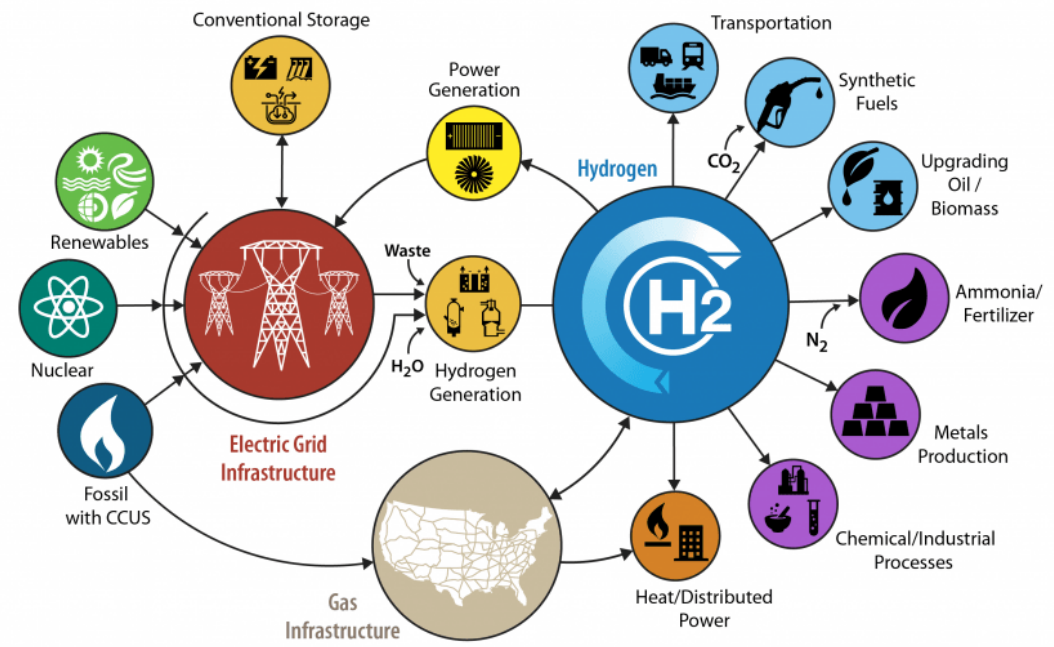

Figure 1. DOE's H2@Scale® vision for how hydrogen can enable decarbonization across sectors.

As demand for clean hydrogen grows, with accelerating global efforts to decarbonize the global economy, so too does the demand for electrolyzers, hydrogen fuel cells, and other hydrogen technologies. For example, the global installed capacity of electrolyzers was estimated to be less than 1 gigawatt (GW) in 2022—but > 100GW of installed electrolyzer capacity is expected by 2030, based on announced projects.[18] This global trend is similar in the United States where announced installations of electrolyzers more than tripled from ~0.2 GW[19] to 0.6 GW[20] in just one year (from June 2021 to 2022). Other DOE funding opportunities, such as the Regional Clean Hydrogen Hubs,[21] and federal incentives, such as the Clean Hydrogen Production Tax Credit,[22] will further drive demand for hydrogen technologies.

[18] IEA (2022), Hydrogen, IEA, Paris. https://www.iea.org/reports/hydrogen, License: CC BY 4.0.
[19] "Electrolyzer Capacity Installations in the U.S." DOE Hydrogen Program Record #20009, 2021.
[20] "PEM Electrolyzer Capacity Installation in the United States." DOE Hydrogen Program Record #22001, 2022.
[21] Regional Clean Hydrogen Hubs. https://www.energy.gov/oced/regional-clean-hydrogen-hubs
[22] 26 U.S. Code § 45 V – Credit for production of clean hydrogen.

Producing clean hydrogen from electrolyzers utilizing clean electricity and water, costs $4-6 per kilogram (kg) today based on specific scenarios for electrolyzer costs, efficiencies, capacity factors, and electricity costs.[23] In 2021, DOE launched the Hydrogen Energy Earthshot[24] ("Hydrogen Shot") initiative, which established a target of $**1** per **1** kilogram of clean hydrogen produced in **1** decade ("1 – 1 – 1"). The Clean Hydrogen Electrolysis Program, with an interim goal of $2 per kilogram of clean hydrogen produced by 2026,[25] will directly support the Hydrogen Shot through RDD&D of advanced water electrolyzer technologies and their associated manufacturing processes and equipment.

Supporting the goals of the Clean Hydrogen Electrolysis Program and the Hydrogen Shot, HFTO has established a number of consortia to help address clean hydrogen production costs. The HydroGEN Consortium[26] and ElectroCat Consortium[27] are collectively developing novel high-performing materials for both low- and high-temperature electrolyzers. The Hydrogen from Next-generation Electrolyzers of Water (H2NEW) Consortium[28] is focused on cell integration processes to improve electrolyzer durability while also pushing the limits of performance. H2NEW's efforts will enable a stack cost of $100/kilowatt (kW) for both low- and high-temperature electrolyzers by 2026. Recent funding opportunities in FY2020 and FY2021 have also supported industry-led high-throughput manufacturing process and equipment development.[29,30] This FOA will leverage the expertise of these existing efforts and build on the successes achieved through previous funding opportunities to develop advanced materials, next-generation device designs, and innovative manufacturing processes.

In addition to addressing electrolyzer technology development, this FOA will support domestic supply chains and high-throughput manufacturing of both electrolyzers and fuel cells. To realize the environmental benefits of clean hydrogen, in addition to reducing the cost of the hydrogen itself, its utilization (e.g., in transportation applications or for power generation) must also be affordable. HFTO has supported extensive efforts to reduce these costs, by

[23] "Cost of Electrolytic Hydrogen Production with Existing Technology" DOE Hydrogen and Fuel Cells Program Record 20004, 2021.
[24] Hydrogen Shot. https://www.energy.gov/eere/fuelcells/hydrogen-shot.
[25] 42 U.S.C. § 1616d.
[26] HydroGEN. https://h2awsm.org/.
[27] ElectroCat. https://www.electrocat.org/.
[28] Hydrogen from Next-generation Electrolyzers of Water (H2NEW). https://h2new.energy.gov/.
[29] HFTO FY21 FOA, Topic 2A: https://www.energy.gov/eere/fuelcells/articles/hydrogen-and-fuel-cells-rd-fy-2021-foa-selections.
[30] HFTO FY20 FOA, Topic 1: https://eere-exchange.energy.gov/Default.aspx?foaId=989bfa31-9f1b-4c1b-8e1c-f0ffcc9b6a96.

developing fuel cell materials, understanding degradation mechanisms, optimizing cell integration, and developing cell- and stack-testing methods to improve performance and durability. These efforts have most recently focused on fuel cell vehicle applications for medium-and heavy-duty vehicles (MDVs and HDVs).

The Million Mile Fuel Cell Truck (M2FCT) Consortium[31] —initiated in 2020—includes national laboratory groups collaborating with teams from industry and academia. This effort focuses on fuel cell durability and performance for MDV/HDVs, aligned with rigorous DOE metrics and targets. This FOA will leverage the material developments and knowledge gained from the M2FCT and previous funding opportunities to accelerate the manufacturing of fuel cell systems. High-volume manufacturing and a secure supply chain of critical components will be required to achieve the ultimate 2030 system cost goal of $80/kW (at a production volume of 100,000 systems per year).[32]

To facilitate near-term coordinated efforts that will demonstrate scaled manufacturing technologies and processes—as directed by Clean Hydrogen Manufacturing and Recycling provisions (EPAct sections 815(a) and 815(b))—HFTO has established a capacity target for heavy duty vehicle (HDV) fuel cell stack production of 20,000 stacks per year (for an individual line or piece of equipment). This increase in production volumes will require a reliable supply of components, automation of the cell and stack assembly, and manufacturing capabilities not seen in the field to date. To address these HDV cost and capacity targets in ways that also meet performance targets, this FOA seeks diverse teams across the supplier and original equipment manufacturer (OEM) value chain. These teams will drive efforts that reinforce and expand the domestic supply chain for key cell materials and components as well as develop and demonstrate pilot-scale manufacturing equipment and methods.

The rapid growth in hydrogen technology markets also highlights the need to improve how hydrogen systems are handled at end-of-life (EOL). Many hydrogen technologies utilize scarce materials, such as platinum-group metals (PGMs), which must be sourced from overseas.[33] In order to secure the supply chain for PGMs and other critical materials and components, recovery and recycling from systems at EOL is crucial. To date, HFTO has funded only a few projects on

[31] Million Mile Fuel Cell Truck. https://millionmilefuelcelltruck.org.
[32] Hydrogen Class 8 Long Haul Truck Targets. https://www.hydrogen.energy.gov/pdfs/19006_hydrogen_class8_long_haul_truck_targets.pdf. Dec 2019.
[33] Water Electrolyzers and Fuel Cells Supply Chain Report" https://www.energy.gov/sites/default/files/2022-02/Fuel%20Cells%20%26%20Electrolyzers%20Supply%20Chain%20Report%20-%20Final.pdf. Feb 2022.

recycling, because there have not yet been many fielded systems that have reached their EOL. However, the supply of available virgin materials can be expected to decline as the demand for fuel cells and electrolyzers grows. This decline in supply will further expand the need for cost-effective recovery and recycling. In advance of those accelerating needs, this FOA aims to enable improvements in recovery and recycling processes and technologies.

Detailed technical descriptions of the specific Topic Areas are provided in Section I.B.

B. Topic Areas

This FOA is broad in scope and will be used to solicit RD&D activities through specific areas of interest (AOIs) aligned with the goals of the new EPAct Sections 815 and 816 (enacted by the BIL). The topics within the AOIs are listed in Table 1 below with detailed information contained in the individual Topic Area Descriptions. All applicants to this FOA for all Topics (1-6) are required to submit a separate R&D Community Benefits Plan (CBP) as part of their application; see Section I.D. As program funds become available, this FOA may be amended or an additional FOA may be issued to solicit applications under newly defined topics.

Table 1. Topic Areas.

Topic Area	Topic Title
Area of Interest 1: Clean Hydrogen Electrolysis Program	
1	Low-Cost, High-Throughput Electrolyzer Manufacturing
2	Electrolyzer Component and Supply Chain Development
3	Advanced Electrolyzer Technology and Component Development
Area of Interest 2: Clean Hydrogen Manufacturing and Recycling	
4	Fuel Cell Membrane Electrode Assembly & Stack Manufacturing & Automation
5	Fuel Cell Supply Chain Development
6	Recovery and Recycling Consortium

All work for projects selected under this FOA must be performed in the United States. See Section IV.J.iii. and Appendix C.

i. Area of Interest 1: Clean Hydrogen Electrolysis Program

This Area of Interest (AOI) includes three topics that support the goals of the Clean Hydrogen Electrolysis Program to reduce the cost of hydrogen produced using electrolyzers to less than

$2/kg H_2 by 2026. The topics cover a broad range of electrolyzer technologies, consistent with the focus areas specified in the BIL, including low-temperature electrolyzers (e.g., liquid alkaline and membrane-based electrolyzers) and high-temperature electrolyzers. Activities under those topics will support more specific focus areas of the BIL, including catalyst development to greatly reduce or eliminate the need for platinum group metals, low-cost membranes and separation materials, and improved component design and material integration to allow for scale-up and domestic manufacturing at a high volume.

Across low- and high-temperature water electrolyzers, key cost drivers are the capital cost, efficiency, lifetime, electricity price, and capacity factor. Capital cost reductions can be achieved through lower cost materials, improved performance (e.g., increased current density at a constant voltage), high-throughput manufacturing processes (>1 GW/yr from a single factory), and innovative system designs. High efficiency and long lifetimes are needed to reduce operating costs (e.g., electricity usage costs) and maintenance costs. These parameters can be improved through novel materials, components, and device designs. Integration with low-cost clean electricity sources will also be essential to reduce operating costs. HFTO has developed targets for stack and system capital costs, efficiency, and lifetime to guide RD&D efforts towards achieving the Clean Hydrogen Electrolysis Program ($2/kg H_2 by 2026) and Hydrogen Shot ($1/kg H_2 by 2031) goals (Table 2).[34]

There are different combinations of performance and cost targets that can achieve these hydrogen production cost goals; those listed in the below table provide a starting guide for technology developers and should be referenced in the applications submitted as appropriate.[35]

[34] DOE Technical Targets for Hydrogen Production from Electrolysis, https://www.energy.gov/eere/fuelcells/doe-technical-targets-hydrogen-production-electrolysis.

[35] Applicants may have more aggressive targets and should provide justification and strategy to achieve them.

Table 2. Technical Targets for Electrolyzer Technologies

Metric	Low-Temperature		High-Temperature	
	2026 Target	Ultimate Target	2026 Target	Ultimate Targets
Stack Capital Cost	$100/kW	$50/kW	$125/kW	$50/kW
Uninstalled System Capital Cost[36]	$250/kW	$150/kW	$500/kW	$200/kW
Stack Performance *(Efficiency)*	3.0 A/cm^2 @ ≤ 1.8 V/cell (PEM); 1.0 A/cm^2 @ ≤ 1.8 V/cell (Alkaline) *(48 kWh/kg)*	3.0 A/cm^2 @ ≤ 1.6 V/cell (PEM); 2.0 A/cm^2 @ ≤ 1.7 V/cell (Alkaline) *(43 (PEM), 45 (Alkaline) kWh/kg)*	≥ 1.2 A/cm^2 @ 1.28 V/cell *(34 kWh/kg)*	≥ 2.0 A/cm^2 @ 1.28 V/cell *(34 kWh/kg)*
Stack Durability	≤ 2.3 mV/khr over 80 khr	≤ 2.0 (PEM), ≤ 2.1 (Alkaline) mV/khr over 80 khr	≤ 3.2 mV/khr over 40 khr	≤ 1.6 mV/khr over 80 khr

The three topics in AOI 1 are mainly differentiated by scale and technology readiness level (TRL).[37] The topics include:

- **Topic 1:** Research, development, and demonstration (RD&D) aiming to accelerate manufacturing innovations, thereby enabling electrolyzer stack manufacturers to achieve economies of scale benefits beyond the business-as-usual. These large (up to $50M) projects must show pathways to achieving <$100/kW (LTE) and <$125/kW (HTE) stack cost by developing and demonstrating high volume-compatible (> GW/year) manufacturing processes.
- **Topic 2:** Research and development (R&D) of advanced components critical to the accelerated commercialization of electrolyzers. These mid-size (up to $10M) projects will support innovations in and validation of component development and high-volume manufacturing processes that address technology cost and performance challenges while strengthening a domestic manufacturing base and supply chains.
- **Topic 3:** R&D aiming to develop materials, components, and designs that are at lower TRL levels compared to those in Topics 1 and 2. Although higher risk, these projects

[36] System cost includes the cost of the stack, mechanical balance of plant, and electrical balance of plant.

[37] Technology Readiness Levels (TRLs) are used to gauge the technical maturity of a project and range from 1 (basic principles observed and reported) to 9 (actual operation of the technology in its final form, under the full range of operating conditions) – see Appendix E and U.S. Government Accountability Office, *Technology Readiness Assessment Guide*, January 2020, Table 11: DOE Technology Readiness Levels, https://www.gao.gov/assets/gao-20-48g.pdf.

have high impact potential to enable meeting or exceeding DOE targets. These smaller (up to $5M) projects will consist of applied R&D efforts but must include proof of concept and laboratory validation.

Further details of all three topics in AOI 1 are included below.

Topic 1: Low-Cost, High-Throughput Electrolyzer Manufacturing

Topic 1: Introduction

In support of Sec. 816 of EPAct 2005, as amended by the BIL, this topic will fund pilot line development of electrolyzer cell and stack manufacturing techniques and processes that enable high-volume commercial manufacturing and help achieve the BIL Clean Hydrogen Electrolysis Program goal of $2/kg H_2. Development and demonstration of proof-of-concept and pre-commercial pilot line manufacturing may be proposed as long as they can be replicable and scalable for commercial deployment in the future. This topic aims to address the greatest barriers to achieving high-throughput, low-cost manufacturing of electrolyzer cells and stacks to enable a manufactured stack cost targets of $100/kW (LTE) or $125/kW (HTE), with pathways for meeting the ultimate target of $50/kW.[38] The stack target is important for meeting the 2026 overall system cost targets of $250/kW (LTE) or $500/kW (HTE).

With the projected expansion of clean hydrogen production in the U.S. to meet decarbonization goals, supporting RD&D with domestic water electrolyzer manufacturers is critical to ensuring a competitive manufacturing base and supply chain. Enabling domestic manufacturing to achieve economies of scale is essential to significantly reduce the capital cost of electrolyzers and enable greater widespread deployment.[39]

To date, there are three types of electrolyzer technologies that have the greatest technological and commercial maturity to meet the growing demand for clean hydrogen: liquid alkaline (LA), proton exchange membrane (PEM), and oxide-conducting solid oxide (O-SOEC). LA electrolyzers are the most commercially mature with manufacturing facilities capable of GW/yr production volumes in several countries. However, there is a need for significant innovations in LA electrolyzers to meet $2/kg H_2, such as enabling rapid dynamic response capabilities beyond those in current systems limited to continuous, steady-state operation. Both PEM and O-SOEC electrolyzers offer performance and cost benefits compared with LA, but these are just starting to be manufactured at the GW-scale at individual facilities in response to market demand. However, for all electrolyzer technologies, cost reductions by simply replicating existing manufacturing processes to achieve economies of scale are limited. Manufacturing

[38] This cost goal includes materials, manufacturing equipment, and labor.

[39] U.S. Department of Energy High-Temperature Electrolysis (HTE) Manufacturing Workshop, HTE Stack Manufacturing Cost Analysis Presentation, https://www.energy.gov/sites/default/files/2022-03/HTE%20Workshop-Strategic%20Analysis.pdf.

advancements are needed to reach GW/yr volumes at lower stack and system costs than current manufacturing processes, which typically involve slow, labor-intensive steps.

Barriers to achieving high-throughput, low-cost manufacturing differ by electrolyzer technology and may differ by manufacturer. These bottlenecks may be overcome, for example: by implementing cell and stack assembly automation; roll-to-roll manufacturing; quality control and in-line defect detection; automated leak checking and conditioning; and continuous thermal processing. In some instances, innovative high-throughput, low-cost manufacturing methods have been developed and demonstrated at the lab scale and need to be scaled-up in size to manufacturing of commercial products (e.g., roll-to-roll manufacturing). In other instances, automation technologies from other industries, such as *pick-and-place* automation in the automotive industry, could be tailored and applied to electrolyzer manufacturing.

This topic is designed to give electrolyzer stack manufacturers the flexibility to address their greatest barriers to high-throughput, low-cost manufacturing, and demonstrate that they can achieve a manufactured stack cost target of $100/kW (LTE) or $125/kW (HTE), on track to achieving a system level target of $250/kW (LTE) or $500/kW (HTE). Electrolyzers manufactured at GW/yr volumes should not compromise performance, as high efficiency and durability are still needed to ultimately achieve the Clean Hydrogen Electrolysis Program goal of $2/kg of hydrogen produced by 2026. Modification of existing commercial manufacturing lines is allowed, however the topic is not intended to fund new manufacturing facilities themselves or duplicate existing processes; the goal is to support **pilot-line development of manufacturing techniques and processes that can enable meeting program goals for subsequent use at commercial scale.** Development and demonstration of proof-of-concept and pre-commercial pilot line manufacturing may be proposed as long as they can be replicable and scalable for commercial deployment in the future.

Topic 1: Anticipated Funding and Award Details

Topic Area	Total Funding Level ($000)	Anticipated Number of Awards	Federal Funding per Award ($000)	Maximum Project Duration (years)	Minimum Required Non-Federal Cost Share (%)
Topic 1: Low-Cost, High-Throughput Electrolyzer Manufacturing	Up to $300,000	6-10	$20,000-$50,000	3	50%

Topic 1: Description and Objectives

This topic seeks applications for RD&D of electrolyzer manufacturing processes, techniques, and equipment for high volume (GW/yr scale) manufacturing and pilot line proof-of-concept demonstrations to meet a DOE stack cost target of $100/kW (LTE) or $125/kW (HTE) by 2026.[40] This topic focuses on innovations in proven technologies ready for manufacturing scale-up for PEM and O-SOEC technologies, and for advanced LA technologies that offer benefits over the widely-commercialized, incumbent LA technology.

There are a wide range of separate manufacturing and assembly processes that will need to be scaled up and ultimately automated to reach economies of scale and low cost electrolyzer stacks. Potential advantages of automation include increased capacity, improved quality, increased raw material yield, and decreased downtime. Electrolyzer manufacturers have the best understanding of which steps in their overall processes will benefit from improvement in terms of throughput increase and cost reduction. As a result, this topic requires that applicants strategically select and propose which manufacturing processes are most critical to ultimately enable $100/kW (LTE) or $125/kW (HTE) stack costs and are expected to quantify projected cost savings and/or throughput increase resulting from the proposed innovations.

All projects will be required to develop manufacturing process(es) and/or equipment and demonstrate the developed process(es)/equipment in the fabrication and assembly of cells and stacks, potentially including post-assembly testing and conditioning steps. These manufacturing and equipment innovations should be compatible with both current and next-generation stack and component technologies and be relevant for subsequent high-volume manufacturing at a commercial scale. Towards reducing stack costs, a goal of this topic is to establish manufacturing capabilities resulting in a demonstrable increase in manufacturing capacity at the cell and/or stack level. Applications of interest may involve, but are not limited to:

- Automation of cell/stack manufacturing including assembly of all repeat components into a stack.
- High-volume fabrication manufacturing processes and equipment for high-quality components, as necessary to support increased cell/stack manufacturing capacity (e.g., high-throughput and defect-free roll-to-roll processes).
- Automation and equipment development focused on enabling the robotic or high-volume handling of cells with required precision, alignment, controls, and quality, including for large active area cells.
- Controls, quality control, and in-line defect detection, and material handling capabilities.
- Development and implementation of automated or high-rate equipment and methods for compression, leak testing, break-in/conditioning, and acceptance testing.

[40] H2 Technologies Overview. DOE Hydrogen and Fuel Cell Technologies Office Annual Merit Review. June 2022. https://www.hydrogen.energy.gov/pdfs/review22/plenary6_stetson_2022_o.pdf.

- Reduction of the number of manufacturing steps.
- Cell and stack redesign to facilitate automated or high-volume assembly.
- Aspects of cell and stack redesign to facilitate disassembly for recycling, remanufacturing, and/or reuse.
- Incorporation of processes such as marking and tracking, and connectivity to *Internet of Things/Manufacturing 4.0* type data acquisition and usage.
- Aspects of equipment design or operation that facilitate flexible change-over for different cell sizes or types, or stack designs for optimized and efficient use of manufacturing lines.

Projects under this topic can be funded for $20M-$50M per project. The largest projects will need to develop multiple processing steps and/or components. Applicants are encouraged to form integrated teams that could include domestic automation and component suppliers to aid supply chain development. Large projects must also demonstrate high-volume cell and stack assembly. The integration of multiple pilot lines is encouraged. The following sections highlight anticipated RD&D needs for the three electrolyzer technologies of focus to this topic.

Topic 1: Electrolyzer Manufacturing Technology Focus Areas

Applications are sought for RD&D of low-cost, high-throughput manufacturing specifically related to PEM, O-SOEC, or LA electrolyzer technologies:

Subtopic 1a – Proton Exchange Membrane Electrolyzers (PEM):

PEM electrolyzers are a promising technology due to their high current density (enabling reduced footprint), differential pressure capability, and efficient dynamic operations. In order to scale-up manufacturing and automation of PEM electrolyzers, significant advances in cell/stack assembly, membrane electrode assembly (MEA) manufacturing (including roll-to-roll processes), and catalyst manufacturing are needed. Development and advancement of manufacturing processes need to be compatible with future generations of PEM technology (e.g., reduced loading platinum-group-metal (PGM) catalysts) with only minor modifications required.

Subtopic 1b – Oxide-conducting Solid Oxide Electrolyzers (O-SOEC):

O-SOECs are a promising technology due to their use of common materials (e.g., PGM-free catalysts) and higher electrical conversion efficiencies due to their high operating temperatures and thermal integration potential. However, O-SOECs require improved manufacturing processes that allow for scale-up to high-volumes to meet cost goals. Thermal treatments, cell and interconnect component manufacturing, and layer assembly are the greatest cost drivers in the manufacturing of O-SOEC stacks; and process improvements in these key areas are essential. Development and optimization are needed in manufacturing processes that enable a reduced number of heat

treatment steps and/or lower heat treatment temperatures; changing process steps from batch to continuous operation; and automated cell/stack assembly.

Subtopic 1c – Advanced Liquid Alkaline Electrolyzers (LA):
LA electrolyzers are a mature technology, however, the current commercial electrolyzers suffer from limited current densities, large footprints, and limited ability to operate dynamically. For this technology applicants must focus on manufacturing and automation of ***novel*** LA electrolyzer components, cells, and stacks, including cell/stack designs (e.g., zero-gap design) allowing for improved performance and/or dynamic operation capability. Replicating manufacturing facilities already operational with only minor modifications is ***not responsive*** to the intent of this topic; and proposed work must clearly address advanced LA technologies (e.g., with improved efficiency and dynamic operation capability compared with today's commercially-manufactured LA electrolyzers) and associated manufacturing processes.

In all cases, environment, health, and safety (EH&S) are high priorities and emphasis must be placed on all aspects of EH&S, including in manufacturing processes and in the installation, operation, and disposal/recyclability of electrolyzer components and systems. Designs and processes that minimize potential hydrogen leakage or other emissions are also encouraged.

Topic 1: General Requirements
Applicants must clearly identify the status of their proposed automated or high-volume fabrication or assembly processes and/or equipment as they relate to the current technological state-of-the-art (SOA) in their respective electrolyzer technology area (PEM, O-SOEC, or LA); and provide sufficient technoeconomic justification that the proposed approach has the potential to lead to a manufacturing solution for low-cost, high-quality electrolyzers produced at the GW/yr scale, targeting a stack cost of $100/kW (LTE) or $125/kW (HTE). Cells and/or stacks may be required to be provided for independent, third party, evaluation at DOE's discretion. Applications must include the following elements:

- Summary of the current status of the commercial electrolyzer technology being addressed, including cell and/or stack performance and durability in SOA systems, and a clear description of the technology advancements that will be incorporated into the electrolyzer beyond what used for commercial products today
- Summary of the current status of the manufacturing process (including current manufacturing capacity and production volume) and description of the applicant's most critical barrier(s) to attaining low-cost, high-volume electrolyzer manufacturing, including manufacturing processes with the greatest potential for cost reduction and throughput increase, along with the innovations the proposed work would result in to overcome these limitations and accelerate progress toward achieving GW/yr scale at $100/kW (LTE) or $125/kW (HTE) stack cost.

- Technical plan for the design, fabrication, and validation of proposed manufacturing equipment for electrolyzer stack components and/or assemblies, with quantitative targets and timelines, and including:
    - *Clear and quantitative end-of-project goals with respect to meeting DOE targets.*
    - *Cell and/or stack testing to validate operational performance and durability.*
    - *A project task that specifically provides annual updates to the stack cost, and progress toward reaching the 2026 DOE target stack cost of $100/kW (LTE) or $125/kW (HTE).*[41]
- Technical plan for the design and build of prototype or pilot-scale cell and/or stack equipment to meet a proposed production volume target consistent with GW/yr scale manufacturing.
- Preliminary technoeconomic analysis[42] of how the proposed manufacturing technology will address stated DOE cost and capacity targets for electrolyzers manufactured at the GW/yr scale, with plans to conduct more comprehensive analysis by project's end.
- Detailed description of how the team will collect data on primary resource consumption (e.g., electricity, fossil fuels/other resources, feedstock materials, water, etc.) for each manufacturing step relevant to the overall environmental impact of the manufacturing process.[43]
- Workforce development, education, and/or training plan as part of the work scope (to be included in the Community Benefits Plan, see additional information below).

Expected outcomes and deliverables for electrolyzer manufacturing RD&D projects include:

- Fabrication and testing electrolyzer stacks and/or cells of a size that will be incorporated into multi-MW electrolyzer system commercial products, with data validating performance and durability.
- Demonstration of manufactured electrolyzer stacks and/or cells in a pilot line process, at a minimum, relevant for subsequent high-volume manufacturing at a commercial scale.
- Demonstration of manufacturing process and equipment throughput rates with sufficient quality assurances.

[41] Applicants may have more aggressive targets than those listed in Table 2 and should provide justification and strategy to achieve them.

[42] TEA of the manufacturing process and/or equipment should use methodology consistent with the Hydrogen Financial Analysis Tool (H2FAST; https://www.nrel.gov/hydrogen/h2fast.html). To estimate the impact on the levelized cost of hydrogen in USD per kg of hydrogen ($/kg H_2), TEA methodology should be consistent with the Hydrogen Analysis production model (H2A or H2A-Lite; https://www.nrel.gov/hydrogen/h2a-lite.html).

[43] Successful teams may be requested to share pertinent data of the manufacturing processes with national laboratories, such as Argonne National Laboratory's GREET team, to inform comprehensive life cycle assessment of electrolyzers.

- Comprehensive technoeconomic analysis of the manufacturing process, impact on capital cost, and operation of the electrolyzer.
- Real-world facility data for primary resource consumption which will inform ongoing emissions analyses and identification of opportunities to improve manufacturing process efficiency and reduce environmental impact (e.g., lower energy consumption, carbon footprint, and other effluents per unit produced).[44]

Topic 1: Project Structure

Applicants should propose projects up to 3 years in length for total DOE funding of $20,000,000-$50,000,000 per project. The funding request should be commensurate with the level of work proposed. Applicants should plan projects as multi-phase efforts with a quantitative Go/No-Go decision point separating each phase (budget period). Projects must satisfy the agreed upon quantitative performance criteria for each phase Go/No-Go decision to move into the next phase. A No-Go decision will result in a discontinuation of support beyond the phase. These RD&D projects **must include at least 50% cost share**.

Topic 1: Teaming Arrangements

It is anticipated that projects will be led by industry (e.g., electrolyzer stack OEM). Collaborative projects comprising appropriate industrial and manufacturing expertise are strongly encouraged. Applicants are highly encouraged to develop diverse, integrated teams including a stack OEM, domestic component suppliers, and U.S.-based automation and/or high-volume equipment suppliers, as appropriate. Universities and national labs are eligible to be subrecipients on projects but are not required. Strong preference is given to applicants using and partnering with domestic material and equipment suppliers.

Please see Section I.B.iii for more information on teaming. Applications to this topic are strongly encouraged to include one or more of the following institutions as part of their team, particularly in development of workforce, training, and education activities: Tribal organizations, Historically Black Colleges and Universities (HBCUs), other Minority Serving Institutions (MSIs), community-based organizations, territories or freely associated States, community colleges, and/or labor unions.

Teams may be requested to share pertinent data of the manufacturing processes with national laboratories, such as Argonne National Laboratory's GREET team, to inform comprehensive life cycle analysis during the project.

Applicants should describe succinctly the qualifications, experience, and capabilities of the proposed project team to execute the project plan successfully.

[44] Ibid, p. 17

Topic 1: Community Benefits Plan

As described in Sections I.D, IV.D.xv, and Appendix F, all applicants to this FOA for all Topics (1-6) are required to submit a separate R&D Community Benefits Plan (CBP) as part of their application, describing efforts to advance diversity, equity, inclusion, and accessibility (DEIA); energy equity; and workforce development. Because teams on this Topic are expected to develop and demonstrate manufacturing technologies and processes suitable for near-term commercial scale-up, it will be especially important to identify and prepare for related workforce development needs. Prime applicants are strongly encouraged to undertake this work in collaboration with subrecipients of diverse expertise, as discussed in the Teaming Arrangements section.

To address these priorities, applicants to Topic 1 should specifically address anticipated workforce needs in their CBP. Examples of activities that applicants might consider for their CBP include, but are not limited to:

- Co-creation of open-source workforce training materials or industry-recognized credentials with one or more community colleges, HBCUs or other MSIs.
- Engaging with relevant labor organizations, government, education, apprenticeship-readiness programs and training institutions to identify training priorities for an electrolyzer manufacturing workforce.
- Characterization of the quality of the jobs that will be offered (for example classification as employees, wages, benefits and opportunities for progression).
- Development of recruitment and retention strategies that prioritize disadvantaged and/or underutilized populations.
- Creation of community awareness sessions in collaboration with local governments and community-based organizations.
- Work with communities to understand challenges and opportunities with technology commercialization.
- Plans to hold outreach events with community/disadvantaged community organizations.

Topic 1: Applications Specifically Not of Interest

- Applications to build manufacturing facilities.
- Applications focused on equipment purchases for replication of existing processes.
- Applications focused on balance of plant, system assembly, or system installation.
- Applications that focus on the development of completely new materials or components, particularly at low TRLs.

Topic 2: Electrolyzer Component and Supply Chain Development

Topic 2: Introduction

Topic 2 supports R&D innovations in the development of advanced electrolyzer components and/or their manufacturing processes that address technology performance improvements, while also aiming to strengthen the manufacturing base and supply chains. The advanced components R&D under this topic with simultaneous manufacturing innovations are intended to ensure a clear near-term path to commercialization via high-throughput processes. Current and emerging component suppliers are highly encouraged to apply. Advanced components developed under this topic should enable higher efficiency, improved durability, and/or lower capital cost in domestically-manufactured electrolyzers, **and** have the potential to be manufactured affordably and without supply chain restrictions at scales compatible with GW/yr electrolyzer production; this scope directly supports goals of the Clean Hydrogen Electrolysis Program.

Today, the domestic electrolyzer supply chain is still in its infancy. A key objective of this topic is to accelerate development of a robust U.S. supply chain of affordable, high-quality electrolyzer components to support the scale-up needs of U.S. electrolyzer stack and systems manufacturers, enabling them to stay competitive in a global market with the growing demands for clean hydrogen. A domestic supply of low-cost components also serves to de-risk the Nation's growing electrolyzer industry as a whole, as it strives to meet the Clean Hydrogen Electrolysis Program cost goal of $2/kg H_2 by 2026 (and the Hydrogen Shot cost target of $1/kg H_2 by 2031).

While the supply chain requirements vary across the different electrolyzer technologies, key gaps and bottlenecks in the domestic supply chain have emerged for each. For example: PEM stack manufacturers have indicated a lack of domestic porous transport layers (PTLs) and catalyst suppliers;[45] for solid oxide electrolyzer cells (SOECs), supply of cell interconnects is a critical gap in the supply chain;[46] and there are relatively few domestic players in the LA electrolyzer supply chain.[47] Establishing a robust, domestic supply chain is needed to not only grow current electrolyzer manufacturing capabilities, but also to develop the next-generation of high-performing and low-cost components.

The areas of greatest potential for component innovation also differ by technology. For example: PEM electrolyzer efficiency could be greatly improved by novel, low resistance

[45] H2-AMP: A Workshop on Advanced Materials for PEM Electrolyzers. DOE Hydrogen and Fuel Cell Technologies Office, 2022. https://www.energy.gov/sites/default/files/2022-04/4-H2-AMP%20Workshop-Plug%20Power.pdf.
[46] High-Temperature Electrolysis (HTE) Manufacturing Workshop Summary Report. DOE Hydrogen and Fuel Cell Technologies Office, 2022. https://www.energy.gov/sites/default/files/2022-08/hte-workshop-report-2022_0.pdf
[47] Advanced Liquid Alkaline Electrolysis Experts Meeting Summary Report. DOE Hydrogen and Fuel Cell. Technologies Office, 2022. https://www.energy.gov/sites/default/files/2022-04/liquid-alkaline-electrolysis-experts-meeting-report.pdf.

membranes and optimized PTLs; O-SOEC thermal treatments and interconnect component manufacturing are significant cost drivers in stack manufacturing; and LA electrolyzers could benefit from advanced designs that enable efficient, higher current density, and dynamic operation. Such innovations are critical in each of the electrolyzer technologies for meeting DOE's performance, durability, and capital cost targets (Table 2) in support of the Clean Hydrogen Electrolysis Program goals.

Designing advanced, high-performing electrolyzer components with manufacturing in mind is critical to accelerate their integration into deployable technologies while mitigating supply chain bottlenecks that could limit the rapid scale-up of U.S. manufacturing. Component suppliers, in particular, are uniquely positioned to contribute to such efforts, specifically through development, scale-up, and near-term commercialization of advanced components that can drive down electrolyzer capital and operating costs. Diverse project teams are encouraged to address the broad challenge. Under this topic, the teams are specifically expected to coordinate with and leverage the expertise and world-class capabilities in electrolyzer R&D at HFTO's H2NEW[48] Consortium to accelerate progress.

Topic 2: Anticipated Funding and Award Details

Topic Area	Total Funding Level ($000)	Anticipated Number of Awards	Federal Funding per Award ($000)	Maximum Project Duration (years)	Minimum Required Non-Federal Cost Share (%)
Topic 2: Electrolyzer Component and Supply Chain Development	Up to $100,000	10-20	$5,000 - $10,000	4	**20%**

Topic 2: Description and Objectives

In support of the Clean Hydrogen Electrolysis Program goals, this topic aims to accelerate R&D of advanced electrolyzer components and/or their associated manufacturing processes/techniques/equipment that enable near-term pathways to commercialization while addressing gaps and bottlenecks in the domestic electrolyzer supply chains. Herein, the scope of "components" may include individual components (e.g., membranes/separators, and interconnects) and complex component assemblies (e.g., individual cells) for PEM, O-SOEC, or LA technologies.

[48]Further details of the H2NEW Consortium are provided in the Description and Objectives section https://h2new.energy.gov/.

The scope of applications may differ depending on the component challenges being addressed for the associated electrolyzer technology. This scope may include but is not limited to: (a) developing novel, high-performing components that can also meet capital cost goals, (b) developing pilot-scale manufacturing processes for novel components to enable both high-throughput and low cost, and/or (c) scaling proven, commercially viable components to high-volume manufacturing. As this topic is intended to encourage participation of current and emerging domestic component suppliers, applications to this topic should focus on component R&D with near-term commercialization potential and a readiness for pilot-scale manufacturing that supports high-volume manufacturing. Applications that focus on higher-TRL cell/stack manufacturing should refer to Topic 1 described above, and applications focused on lower-TRL next-generation materials R&D should refer to Topic 3 described below.

All component R&D should be conducted with future scale-up in mind to support GW-scale stack manufacturing. Preliminary technoeconomic, emissions, and manufacturing scalability analyses is highly encouraged to ensure no fundamental barriers to large-scale, low-cost manufacturing exist. By the end of the project, recipients will be expected to provide quantified projections for the manufacturing cost of the component at GW-scales, along with the associated impacts on the levelized cost of hydrogen with respect to DOE targets. Applicants requesting higher funding levels will be expected to manufacture the advanced component at a relevant pilot-scale. Any proposed manufacturing equipment should have the capacity to fabricate at relevant sizes and rates that justifiably contribute to GW/yr stack manufacturing. Applications focusing on tailoring existing manufacturing processes for components under development are highly encouraged, though development of novel manufacturing processes are also in scope.

Applicants should aim to show substantial progress towards meeting the DOE's stack-level targets for the relevant electrolyzer technology (Table 2). All successful recipients will be expected to validate component performance in an electrolyzer short stack (at least 3 cells), though initial testing may be conducted in a single electrolyzer cell. Stack testing may be performed in collaboration with the H2NEW Consortium (described below), or an electrolyzer stack manufacturer. Stack efficiency and durability will be assessed relative to baseline materials consistent with H2NEW's established test protocols and samples may be required for third party evaluation at the DOE's discretion.

- *The H2NEW Consortium*[49] was established by HFTO in 2020 to conduct component integration R&D for PEM and O-SOEC technologies to enable manufacturable, low-cost, and high-performing electrolyzer cells and stacks that also meet lifetime targets. In terms of PEM development, H2NEW is studying degradation mechanisms to develop accelerated stress tests, benchmarking performance, integrating cell components, performing technoeconomic analysis, and exploring the impact of manufacturing

[49] Hydrogen from Next-generation Electrolyzers of Water (H2NEW). https://h2new.energy.gov/.

techniques on performance. H2NEW is also working to understand O-SOEC degradation mechanisms and potential mitigation strategies so researchers and stack manufacturers can tune operation for extended lifetimes. The consortium has recently expanded to include LA R&D activities, including cell performance benchmarking.

Topic 2: Electrolyzer Component Focus Areas

The specific advanced components R&D of interest under this topic for the different electrolyzer technologies are limited to PEM membrane systems, PEM anodes, PEM anode porous transport layers, O-SOEC cell thermal processing, O-SOEC interconnects, LA cells, and LA separators; specific R&D needs and requirements[50] for each are included below. In all cases, environment, health, and safety (EH&S) are high priorities and emphasis must be placed on all aspects of EH&S, including in manufacturing processes and in the installation, operation, and disposal/recyclability of electrolyzer components and systems. Designs and processes that minimize potential hydrogen leakage or other emissions are also encouraged.

Subtopic 2a – PEM Membrane Systems: This focus area aims to develop new PEM membrane systems[51] that are optimized to perform all necessary functions of electrolyzer operation, and that are amenable to fabrication via high volume processes such as roll-to-roll fabrication. A ***PEM membrane system*** is comprised of multiple elements, including the membrane polymer, reinforcements, radical scavengers, and gas recombination catalysts. A leading limitation of existing PEM electrolyzer performance and efficiency is the use of thick membranes not optimized for electrolyzer operation. Membrane system properties that enable progress towards DOE's targets include: include low resistance (~0.03 Ωcm^2), low permeability (low hydrogen crossover), chemical-mechanical durability and robustness especially at elevated temperature (> 80°C), ability to withstand high pressure differentials (e.g., up to 30 bar), and thin (e.g.,~ 50 µm), though clearly there are performance and cost tradeoffs among these properties that must be optimized. Consistent with the targets in Table 2, the membrane system developed must be integrated into an MEA and meet a minimum performance of **3 A/cm^2 at 1.8 V** and degradation rate of **2.3 mV/khr** over **at least 1000 hr of testing**. Demonstrating the membrane system developed in a high-volume compatible manufacturing process is highly encouraged.

Subtopic 2b – PEM Anodes: This focus area aims to develop anodes with **< 0.3 mg iridium (Ir)/cm^2** fabricated at high-volume on high-throughput (e.g., roll-to-roll) equipment while maintaining high efficiency and durability. The supply chain risk of Ir, namely its limited global production and volatile price, is a major concern for PEM electrolyzers. Thrifting Ir to reduce the mass loading on electrodes presents efficiency

[50] If applicants propose deviations from the targets specified, they should provide justification and clearly show how the modified targets would enable meeting overall DOE goals.

[51] New membranes, including new polymer chemistries, are **NOT of interest** to this topic area.

and durability challenges, especially during dynamic operation. Deposition techniques are extremely important to create an electronically conductive catalyst layer that enables high Ir utilization. Alternative electrode structures, such as the nanostructured architectures, that are readily scalable and scalable deposition techniques are of interest.

Subtopic 2c – PEM Anode Porous Transport Layers: This area focuses on anode PTL R&D for improved performance with scalable, precision manufacturing techniques. The anode PTL serves important functions in PEM electrolyzer cells, providing water transport, removal of evolved oxygen, electrical conductivity between the bipolar plate and catalyst layer, heat removal, and mechanical support. Morphological properties including thickness, porosity, tortuosity, pore-size distribution, wettability, and pore connectivity are all metrics that affect PTL performance, and ultimately affect the efficiency and durability of the electrolyzer. Manufacturing methods, quality, and precision can have a large impact on these properties (and subsequently the performance), especially when integrated into cells with thin membranes and low catalyst loadings (e.g., < 0.3 mg Ir/cm^2). The interfaces between the PTL and the bipolar plate and the PTL and the anode, in particular, need improvement. Approaches to minimize the interfacial contact resistance and to minimize the use of PGMs commonly coated onto the PTL substrate are of interest.

Subtopic 2d – O-SOEC Cell Thermal Processing: This focus area aims to reduce the cost of O-SOEC cell thermal processing steps. One of the most expensive aspects of fabricating O-SOEC cells (and stacks) is the multiple cell thermal processing steps required. Approaches to decrease the costs associated with thermal processing are encouraged, which may include, but are not limited to, decreasing the number of high-temperature firing steps, decreasing the required heat treatment temperatures and firing times, and utilizing novel, quicker sintering approaches that do not require conventional thermal processes (e.g., microwave heating, induction heating, spark plasma sintering, etc.). Approaches that enable continuous manufacturing, such as continuous firing techniques and roll-to-roll processing are also of interest.

Subtopic 2e – O-SOEC Interconnects: This focus area aims to develop low-cost interconnect materials and/or develop high-throughput, low-cost manufacturing techniques to support a strengthened domestic manufacturing base and supply chain for O-SOEC technologies. Interconnects are an expensive component in O-SOEC electrolyzers, there is a lack of domestic suppliers, and materials and manufacturing innovations are needed. Additive manufacturing processes are potentially of interest if a strong case can be made that they are amenable to high-throughput and can be low-cost. Deposition of defect-free coatings on the interconnects are often required and are

of interest, though, preferably, it should be part of a larger proposal that also includes fabrication of the interconnect itself.

Subtopic 2f – LA Cells: This focus area aims to further develop advanced LA cells and scalable manufacturing processes that can meet DOE's technical targets for capital cost, current density, efficiency, and durability, while strengthening a competitive domestic supply chain. Traditional LA electrolyzers were designed to operate continuously and at low current density (0.2-0.6 A/cm^2) and atmospheric pressure. Various novel designs for advanced LA cells have been proposed and developed at the lab-scale, with some beginning to be scaled-up, to overcome these traditional limitations. These innovations through cell designs include high efficiency and durability at higher current density **(>1 A/cm^2 at 1.8 V**), high pressure operation (**e.g., up to 30 bar**), and dynamic operation capability (e.g., have the **capacity to operate on variable clean energy sources**).

Subtopic 2g – LA Separators: This focus area aims to promote the establishment of a domestic supply chain of high-performing, novel LA separators. There are few suppliers of this component worldwide, and little or no presence in the U.S.; establishing a domestic supply is a priority for the growing industry. Historically, LA electrolyzer operation has been hindered by the separator; current density was limited to 0.2-0.6 A/cm^2 due in part to the high ohmic resistance caused by the thick separator, and separators have limited the maximum operating temperature and pressure. Novel separator materials are needed to enable the development of advanced LA electrolyzers designed for high current density, dynamic operation, and/or pressurized operation. Separator materials that exhibit low resistance with chemical stability in heated concentrated potassium hydroxide **(> 80°C, 5-10 M**), mechanical stability under pressure (**e.g., up to 30 bar**), and/or reduced gas permeability are also of interest. Applicants are encouraged to work with advanced LA electrolyzer stack developers and include pilot-scale manufacturing development to support growth of a domestic supply chain.

Topic 2: General Requirements

All proposals for component development in any of the electrolyzer technologies must include the following general elements, and ensure that all relevant technology-specific requirements highlighted in the focus area descriptions are addressed:

- Summary of the current status of the component under development and its respective manufacturing process, including any current manufacturing capacity and production volume, and the specific component challenges or limitations being addressed for the associated electrolyzer technology.
- Description of the proposed component improvements relevant to the associated electrolyzer technology SOA, with quantitative metrics and targets that will be achieved by the end of the project.

- Justification of how the proposed component innovation would enable progress towards \$2/kg H_2 production cost by 2026 based on preliminary technoeconomic assessment,[52] with discussion of the manufacturability/scale-up potential to meet at least GW/yr manufacturing rates; and plans to conduct a comprehensive assessment of the technoeconomic impact on electrolyzer.
- Detailed description of how the team will collect data on primary resource consumption (e.g., electricity, fossil fuels, feedstock materials, water, etc.) for each manufacturing step relevant to the overall environmental impact of the manufacturing process.[53]
- Technical work plan, including proposed collaborative work with the H2NEW Consortium (particularly in areas of performance and durability evaluation), comprising specific plans for:
    - *Component development and validation to meet cost and technical targets[54] for the associated electrolyzer technology, including required testing in an electrolyzer short stack (at least 3 cells).*
    - *If applicable, proposed pilot-scale manufacturing process or equipment development/innovation with target production rates and plans to validate product quality.*

Expected outcomes and deliverables for the electrolyzer component R&D projects include:

- Validation of performance and durability relative to the component innovation under development, using standard methodologies and protocols established by DOE (e.g., through the H2NEW Consortium[55]).
- Comprehensive technoeconomic analysis to quantify projected manufactured cost commensurate with GW/yr electrolyzer manufacturing, including verification of potential to meet \$2/kg H_2 production cost by 2026.
- Real-world facility data for primary resource consumption which will inform ongoing emissions analyses and identification of opportunities to improve manufacturing

[52] TEA of the manufacturing process and/or equipment should use methodology consistent with the Hydrogen Financial Analysis Tool (H2FAST; https://www.nrel.gov/hydrogen/h2fast.html). To estimate the impact on the levelized cost of hydrogen in USD per kg of hydrogen (\$/kg H_2), TEA methodology should be consistent with the Hydrogen Analysis production model (H2A or H2A-Lite; https://www.nrel.gov/hydrogen/h2a-lite.html).

[53] Successful teams may be requested to share pertinent data of the manufacturing processes with national laboratories, such as Argonne National Laboratory's GREET team, to inform comprehensive life cycle assessment of electrolyzers.

[54] Applicants may have more aggressive targets than those listed within this topic description and in Table 2. Justification and strategy to achieve more aggressive targets should be provided.

[55] Justification should be provided for use of a third party other than the H2NEW Consortium for validation.

process efficiency and reduce environmental impact (e.g., lower energy consumption, carbon footprint, and other effluents per unit produced).[56]

Topic 2: Project Structure

Applicants should propose projects 3 to 4 years in length for total DOE funding of $5,000,000-$10,000,000 per project. The funding request should be commensurate with the level of work proposed. Applicants requesting higher funding levels will be expected to manufacture the advanced component at a relevant pilot-scale. Applicants should plan projects as multi-phase efforts with a quantitative Go/No-Go decision point separating each phase (budget period). Projects must satisfy the agreed upon quantitative performance criteria for each phase Go/No-Go decision to move into the next phase. A No-Go decision will result in a discontinuation of support beyond the phase. These R&D projects must include **at least 20% cost share**.

Topic 2: Teaming Arrangements

All projects should involve an industry partner. Electrolyzer component suppliers are highly encouraged as the prime applicant. Stack manufacturers are encouraged to participate as project partners. At minimum, a letter of commitment from one or more electrolyzer stack manufacturers that show interest in this proposed innovation is required for the full application. At the concept paper phase, applicants are encouraged to indicate anticipated support based on preliminary discussions with stack manufacturers. Please see Section I.B.iii. for more information on teaming.

All projects will be expected to collaborate with the H2NEW Consortium to leverage existing resources and expertise. The nature and level of involvement should be defined by the applicant and needs to be included in the proposal. Applicants are encouraged to visit the H2NEW website[57] to identify the specific consortium capabilities, such as material characterization, cell integration, or cell/stack testing, that are best suited to support their proposals. ***Applicants should not interact with H2NEW lab personnel while the FOA is open.*** Other mechanisms will be provided such as webinars and Annual Merit Review presentations to provide transparency to the capabilities of H2NEW. Moreover, ***applicants should not include the cost of consortium capabilities in their proposed budget***; HFTO will provide access to those capabilities at no cost to the selected projects based on award negotiations and availability of funds.

In addition, teams may be requested to share pertinent data of the manufacturing processes with national laboratories, such as Argonne National Laboratory's GREET team, to inform comprehensive life cycle analysis during the project.

[56] Successful teams may be requested to share pertinent data of the manufacturing processes with national laboratories, such as Argonne National Laboratory's GREET team, to inform comprehensive life cycle assessment of electrolyzers.

[57] H2NEW Consortium Website, including capabilities: https://h2new.energy.gov/

Topic 2: Applications Specifically Not of Interest

- Applications to build new manufacturing facilities or replicate existing manufacturing processes.
- Applications focused on foundational electrolyzer research and/or early-stage electrolyzer materials/manufacturing research and development (e.g., completely new membrane polymer chemistries).

Topic 3: Advanced Electrolyzer Technology and Component Development

Topic 3: Introduction

This topic is focused on addressing lower TRL materials, components, and designs to help achieve long-term cost, performance, and lifetime goals in next generation electrolyzer technologies, including advanced PEM, LA, and O-SOEC, as well as emerging electrolyzer technologies such as alkaline exchange membrane (AEM) and proton-conducting solid oxide electrolysis cell (P-SOEC). Each of these advanced electrolyzer technologies has specific needs to improve the performance, efficiency, durability, and/or operating conditions to enable meeting the Clean Hydrogen Electrolyzer Program goal of \$2/kg H_2; and all offer the potential to meet the Hydrogen Shot target of \$1/kg H_2 with further advancements. Aligned with the goals of the Clean Hydrogen Electrolysis Program, the novel materials, components, and designs developed under this topic for next generation electrolyzer systems can help protect against certain market risks (e.g., supply chain limitations) while providing multiple viable options for affordable clean hydrogen. Key considerations also include the stability of materials and components to enable dynamic response and flexibility of systems to ramp up and down based on availability of intermittent renewable energy.

As an example of the potential benefits, challenges to today's PEM electrolyzers related to the limited availability of iridium and other PGMs and/or the potential future limitations on the use of PFSA (perfluorosulfonic acid) materials could be addressed through the development of AEM technologies that do not require these materials. As another example, development of proton-conducting oxide materials for novel P-SOEC designs would enable lower-temperature operations compared to today's O-SOEC electrolyzers, offering opportunities for extended lifetimes with non-PGM materials, along with associated cost reductions. This topic is specifically aimed at higher-risk R&D with high impact potential for diverse electrolysis options. Examples of key R&D needs for the different electrolyzer technologies are included in following sections.

The applied material- and component-level R&D relevant to electrolysis included in this topic complements the ongoing work being performed with three of HFTO's national laboratory consortia: H2NEW, HydroGEN, and ElectroCat (described in following sections); and projects

will be expected to leverage the world-class capabilities and expertise at these consortia to foster innovation and accelerate progress.

Topic 3: Anticipated Funding and Award Details

Topic Area	Total Funding Level ($000)	Anticipated Number of Awards	Federal Funding per Award ($000)	Maximum Project Duration (years)	Minimum Required Non-Federal Cost Share (%)
Topic 3: Advanced Electrolyzer Technology and Component Development	Up to $70,000	15 to 30	$2,000 - $5,000	3	20%*

**For Institutions of Higher Education and Nonprofit Organizations, cost sharing is not required.*[58]

Topic 3: Description and Objectives

This topic is soliciting applications focused on early-stage R&D (TRL 3-5) on novel materials and components for next-generation PEM, LA, and O-SOEC electrolyzer technologies, as well as longer-term technologies such as AEM and P-SOEC.[59] In contrast to Topics 1 and 2, applicants may spend a significant portion of their project on material development work. Applications to this topic must include plans to test the material or component in a complete cell by the end of the project period. Projects focused on interfaces and improving material integration should perform cell testing during early stages of the project. Developed materials and components may be required to be provided for independent, third-party evaluation at DOE's discretion. Project collaborations leveraging appropriate expertise and resources at the H2NEW, HydroGEN, and/or ElectroCat Consortia are expected, with further details in the *Teaming Arrangements* section:

- *The H2NEW*[60] *Consortium* focuses on R&D for PEM, LA, and O-SOEC electrolyzers to enable affordable, durable, and efficient large-scale electrolyzers. H2NEW's interconnected and comprehensive research—including fabrication and integration studies, standardized protocols and cell testing, durability studies, degradation

[58] Section 10725 of the Research and Development, Competition, and Innovation Act, P.L. 117-167 (Aug. 9, 2022) extends the cost share waiver pilot program enacted by Section 108 of the Department of Energy Research and Innovation Act, Public Law 115–246 (Innovation Act) and provides an exemption for institutions of higher education and nonprofit organizations from the 20% cost share requirement for Research and Development activities. The exemption is available for the two-year period beginning on August 9, 2022. Codified at 42 U.S.C. 16352.

[59] Other innovative, low-TRL, but potentially high-impact technologies that are not described herein, such as membraneless electrolyzers, may be proposed if strong justification is provided on their potential to meet the required targets and timelines.

[60] Hydrogen from Next-generation Electrolyzers of Water (H2NEW), https://h2new.energy.gov/.

mitigation strategies, and modeling/analysis—overcomes critical barriers to improve electrolyzers, including enhancing durability, increasing performance, and reducing capital cost.

- *The HydroGEN[61] Consortium* addresses advanced water splitting materials challenges by making unique, world-class national lab capabilities in low- and high-temperature electrolyzers more accessible to academia, industry, and other stakeholders. Their low temperature electrolysis work has been focused on AEM electrolyzers, with some work supporting PEM electrolyzers as well while the high temperature electrolysis work has been focused on P-SOEC electrolyzers with some work in metal-supported O-SOEC. Partners can leverage capabilities and expertise in computational tools and modeling, material synthesis, process and manufacturing scale-up, characterization, system integration, and analysis to meet their project goals.
- *The ElectroCat[62] Consortium* aims to address supply chain vulnerabilities and increase U.S. competitiveness by accelerating the development of PGM-free[63] catalysts for low temperature electrolyzers and fuel cells with a focus on reducing cost and improving durability. At present, depending on system designs, around 30% of the electrolyzer stack is dominated by the cost of the catalyst, owing largely to the use of PGMs.[64] In order to achieve HFTO's ultimate stack cost targets for PEM electrolyzers of $50/kW, transformative materials and materials integration RD&D are essential.

Applications to this topic should focus on materials and components R&D to advance next generation electrolyzer technologies; applicants should clearly indicate the advanced electrolyzer technology for which the material or component is designed to improve. Impact potential of the proposed innovations should be clearly articulated with technology-specific metrics and targets; examples of such metrics and targets are included in the focus area descriptions below.

Topic 3: Electrolyzer Materials and Components Focus Areas

Specific advanced materials and components R&D focus areas of interest relevant to different electrolyzer technologies include: advanced catalysts, ionomers, and membranes for PEM electrolyzers; advanced materials for LA; advanced catalysts and membranes for AEM electrolyzers; engineered materials and interfaces for O-SOEC; and advanced materials for P-

[61] HydroGEN: Advanced Water Splitting Materials, https://h2awsm.org/.
[62] Electrocatalysis Consortium, https://www.electrocat.org/.
[63] The platinum group metals (PGM) are indium, osmium, rhodium, platinum, palladium, and ruthenium.
[64] Mayyas, Ahmad, et.al. (2018). Manufacturing Cost Analysis for Proton Exchange Membrane Water Electrolyzers, National Renewable Energy Laboratory, NREL/TP-6A20-72740, https://www.nrel.gov/docs/fy19osti/72740.pdf.

SOEC.[65] In all cases, EH&S are high priorities and emphasis must be placed on all aspects of EH&S, including in materials/chemical process selection, the ultimate commercial manufacturing processes themselves, and in the assembly, operation, and disposal/recyclability of the proposed components. Designs and processes that minimize potential hydrogen leakage or other emissions are also encouraged. Specific R&D needs and requirements for each are included below.

Subtopic 3a – Advanced Catalysts, Ionomers, and Membranes for PEM Electrolyzers

This focus area seeks applications to support development of novel materials and components for next-generation PEM electrolyzers, particularly in the areas of oxygen evolution reaction (OER) catalysts and non-PFSA membranes and ionomers. Previous analysis indicates that the membrane and OER catalysts are significant contributors to stack cost and major sources of performance limitations for PEM electrolyzers.[66] In addition to needing overall cost reductions and performance improvements, commercial PEM technology is typically based on PFSAs, but these ionomer materials are expensive, particularly at low production volumes. Recently, there has been growing concern that the use of PFSA in electrolyzers and fuel cells may face increased regulatory barriers due to potentially detrimental environmental impacts of the chemicals used to manufacture PFSA membranes. Therefore, non-PFSA PEMs, including those based on hydrocarbon chemistries, could represent a lower-cost, environmentally friendly alternative; however, these membranes require significant advancements in performance and durability for electrolyzer applications. Specific areas of interest include:

- Novel OER Catalysts: Applications in this area should describe the materials that they plan to develop and how those materials have the potential to drive down the overall catalyst cost while maintaining high performance and durability. Novel catalyst approaches could include, but are not limited to, Ir and non-Ir alloys as well as high surface area or extended surface catalysts. Electronically-conductive OER catalyst supports to enable increased catalyst utilization, increased durability, and decreased loading is an area of interest. Proposals must develop catalysts that are PGM-free or aim to meet the DOE goal of **< 0.125 mg Ir/cm^2**~~.and target an anode catalyst activity of **200 A/g Ir**~~. Catalysts and electrodes must be tested under dynamic operating conditions including on/off operation. Applicants must consider the manufacturability of the proposed material.

[65] Development of other innovative, high-impact technologies outside of the focus areas listed is permitted. Strong justification is required.

[66] Advanced Materials for PEM Electrolyzers Workshop Report: https://www.energy.gov/eere/fuelcells/h2-amp-hydrogen-shot-workshop-advanced-materials-pem-electrolyzers.

- Novel Membranes and Ionomers: Applications in this area should be based on proton-conducting ionomers and, preferably, be non-fluorinated, but may include reinforcements or other additives. Applications need to be focused on novel non-PFSA ionomers and membranes for water electrolyzers.[67] Eliminating or minimizing fluorine content is strongly encouraged. Any non-PFSA material approaches that still contain fluorine should include a plan to mitigate the impacts of any fluorinated species used and explain how it addresses potential regulatory barriers associated with this species. The membrane materials that will be developed and how those materials have the potential to meet properties and characteristics required for application in PEM electrolyzers needs to be described. Properties/characteristics that need to be considered and should be quantified include proton conductivity, resistance, permeability (hydrogen crossover), selectivity, chemical-mechanical durability and robustness, ability to withstand high pressure differentials, and thickness with information gained on the tradeoffs among these properties.

Proposed innovations in both catalysts and membranes need to demonstrate meeting the DOE targets of **≥3 A/cm^2 at 1.8 V with a degradation rate of <2.3 mV/khr** in an MEA by the end of the project. Applications that focus on improving non-PFSA membranes or catalysts and electrodes that reduce or eliminate PGM content, including novel high surface area catalyst supports are encouraged. Following material development, proposed technologies must be tested in at least a 25 cm^2 MEA. This may be accomplished in collaboration with the H2NEW Consortium. Applicants must consider the manufacturability of the proposed material. Larger cell testing is strongly encouraged.

Subtopic 3b – Advanced Materials for Next-Generation LA Electrolyzers

This focus area seeks applications to support advanced materials and components that can help achieve DOE performance targets in next-generation liquid alkaline (LA) electrolyzers. Development of novel separators and catalyst materials are of particular interest.

Conventional LA electrolyzers were designed to operate continuously at a low current density to optimize operating and capital costs, and as a result have a large system footprint. These electrolyzers typically operate between 0.2-0.6 A/cm^2 and are not amenable to start/stop operation.[68] Applications should clearly describe how the proposed innovations will advance LA technology with cell performance targets **≥2.0**

[67] Applicants who are interested in developing non-PFSA membranes for fuel cells should refer to Topic 5.
[68] IRENA 2020, Fraunhofer ISE, 2022.

A/cm^2 @ 1.7 V/cell with **≤2.1 mV/khr** degradation rate in concentrated, heated potassium hydroxide (5-10 M) in accordance with DOE's ultimate goals in Table 2. Other advances of interest include: enabling of dynamic operation; reduction/elimination of shunt or reverse currents; bubble management; higher temperature operation; and enabling of pressure differentials. Such advances may be made through innovations in catalysts or separators/composite membranes. Specific components/areas of interest are:

- Advanced electrodes and support structures with high surface areas, high catalytic activity, and high conductivity. PGM-free electrode development is required. Tolerance for reverse currents and the impact of intermittent operation need to be investigated.
- Mitigating degradation and minimizing voltage losses at interfaces (e.g., catalyst/substrate, catalyst/electrolyte, and separator/electrolyte), including the impact from intermittent operation, through material development and interface engineering.
- Novel separator materials, including optimized structures (e.g., porosity, thickness) and composite membranes. A better understanding of the impact of separator properties on performance and how to control them is needed to inform their design. Compared to Topic 2, these efforts should include more fundamental R&D that informs the design of compositions and structures for optimized chemical, mechanical, and thermal properties.

Applicants must plan to **integrate their novel component or material in a single cell electrolyzer configuration (≥25 cm^2) for testing** by the end of the project. This may be accomplished in collaboration with the H2NEW consortium. The use of zero-gap or other advanced cell architectures are highly encouraged.

Subtopic 3c – Advanced Catalysts and Membranes for AEM Electrolyzers

AEM water electrolyzers aim to combine the advantages of both PEM and LA electrolyzers: the alkaline environment enables the use of non-precious metal catalysts[69] and less expensive metal interconnects, and the membrane which enables differential pressure operation and operation at higher current densities than traditional LA electrolyzers.[70] Due to the local alkalinity in the membrane, pure water can be fed to the electrolyzer instead of liquid alkaline electrolyte to reduce balance of plant costs; although, current technology has better performance and durability with a low

[69] Current AEM technologies still use catalysts with trace PGM materials to improve efficiency and durability.
[70] Ayers, K., Danilovic, N., Ouimet, R., Carmo, M., Pivovar, B., and Bornstein, M. (2019). Perspectives on Low-Temperature Electrolysis and Potential for Renewable Hydrogen at Scale. Annu. Rev. Chem. Biomol. Eng. 10, 219–239. doi:10.1146/annurev-chembioeng-060718-030241.

concentration supporting electrolyte feed (e.g., ≤ 0.5 M). Critical needs in the development of high-performance, long-lifetime AEM electrolyzers are stable membranes, ionomers, catalysts, and electrodes that can endure long-term operation. Interfaces between these components and especially catalyst-ionomer interactions can have a significant impact on performance and durability. Applications of specific interest include:

- Development of novel AEM membranes to enable high electrolyzer efficiency with enhanced durability. Durability is seen as the key challenge, especially at expected stack operating temperature above 60°C.[71] Mechanical stability is also a pressing issue with swelling from water uptake and edge failures causing rapid performance decrease.[72]
- Development of novel PGM-free catalysts that replace the trace-PGM catalysts in current AEM electrolyzers while maintaining efficiency and durability, including a focus on integration into electrodes. Studies on electrode interfaces, structure optimization, and catalyst-ionomer interactions are highly encouraged as the electrode structure and the interface with the membrane are seen as a significant source of degradation. Novel catalytic approaches for eliminating the significant performance and durability gap between pure water and supporting electrolyte operation could be part of a proposed project.

Applicants should clearly describe how the proposed membrane innovations will achieve cell performance targets of **≥2.0 A/cm² @ 1.8 V/cell** with **≤4 mV/khr degradation rate**. Following material development, proposed technologies must be tested in at least a 25 cm^2 cell in both water and supporting electrolyte feed (~0.5 M); however, materials may be optimized for the feedstock of choice. This cell testing may be accomplished in collaboration with one of the national lab consortia. Larger cell testing is strongly encouraged.

Subtopic 3d – Engineered Materials and Interfaces for O-SOEC

This focus area aims to develop innovative materials, components, and cells for O-SOEC that address key durability issues for meeting the DOE targets. O-SOECs benefit from high efficiencies (34 kWh/kg) but must operate at high temperatures (≥750°C) to reach those efficiencies. O-SOECs tend to experience rapid degradation rates, resulting in shortened lifetimes (~20,000 hours) compared to DOE targets.

[71] C. Santoro, A. Lavacchi, P. Mustarelli, V. Di Noto, L. Elbaz, D. R. Dekel, F. Jaouen, *ChemSusChem* 2022, 15, e202200027.

[72] Park, E. J., Arges, C. G., Xu, H., and Kim, Y.S. (2022). Membrane Strategies for Water Electrolysis ACS Energy Lett. 2022, 7, 3447−3457. doi.org/10.1021/acsenergylett.2c01609.

In order to improve the lifetime and durability of O-SOECs, applicants may work on mitigating degradation, interface and material engineering, and enabling lower operating temperatures without sacrificing efficiency. Known degradation issues include Ni coarsening and Cr poisoning, which can be mitigated through materials, interface engineering, and/or operations improvements. The oxygen electrode, commonly based on a perovskite material, is another source of degradation and its performance becomes limiting as the temperature is decreased. Approaches to eliminate the barrier layer between the oxygen electrode and the electrolyte are also of interest. Innovations in the following areas are of specific interest:

- Cell/stack component interface development to mitigate degradation.
- Material integration processing to mitigate degradation.
- Material development to enable lower temperature operation (≤700°C).
- Investigations into novel electrode designs (nanostructured electrodes, thinner electrolyte layers) that enhance electrode catalytic activity and minimize performance losses and degradation.

Applicants should clearly describe how the proposed innovations will achieve cell performance targets of **≥1.2 A/cm^2 @ 1.3 V/cell** with **≤3.2 mV/khr degradation** rate at an operation **temperature ≤750°C** in at least a 10 cm^2 cell**.** Testing of cells under dynamic operating conditions is encouraged. Button cell (**active area 1-5 cm^2**) testing is expected to span the duration of the project, with an emphasis on durability assessment. Larger format cell testing (**at least 10 cm^2**) is expected by the end of the project and, preferably sooner. Additional large format cell testing and/or short stack testing is expected for proposals with higher award amounts.

Subtopic 3e – Advanced Materials for P-SOEC

This focus area aims to develop P-SOEC materials for next-generation electrolyzers with a potential to meet DOE cost targets (Table 2). P-SOECs are a promising electrolyzer technology due to the potential to approach the electrical efficiency of O-SOECs at a lower operating temperature (≤ 600°C). Commercial and near-commercial O-SOECs operate at 750-850°C. Operation at or below 600°C enables the use of lower cost steel alloys for stack and balance of plant construction, reduces the rate and impact of contaminant diffusion, simplifies sealing, promotes rapid dynamic system response, and shortens startup/shutdown duration without dramatic impacts on overall system performance or efficiency.

However, P-SOECs still suffer from low faradaic efficiencies, poor durability, and processing challenges. Recent advancements in P-SOEC efficiency and durability have been encouraging, but additional effort is required to translate and build upon these advancements to promote commercial production of and to realize the benefits of P-

SOEC systems. Proposed research activities are expected to focus on materials development, thermal processing improvements, interface engineering, and characterization/optimization of faradaic efficiency with an emphasis on cell-level performance and durability improvements over a wide range of operating conditions. Specific areas of interest are:

- Materials development and/or interface engineering to mitigate degradation.
- Material integration processing to mitigate degradation.
- Material development to enable lower temperature operation.
- Material development to enable better manufacturability and mechanical properties.

Applicants should clearly describe how the proposed innovations will achieve cell performance targets of **≥0.8 A/cm^2 @ 1.3 V/cell** with **≤5 mV/khr degradation** rate and a **faradaic efficiency of ≥85%.** Button cell (**active area 1-5 cm^2**) testing is expected to span the duration of the project, with an emphasis on durability assessment. Larger format cell testing (**at least 10 cm^2**) is expected by the end of the project. Additional large format cell testing and/or short stack testing is expected for proposals with higher award amounts. Cell testing for meeting the above performance targets should be done at an **operating temperature of ≤600°C** and **steam concentration of ≥50%.**

Topic 3: General Requirements

All proposals for materials/component innovations for any electrolyzer technology must include the following general elements, and ensure that all relevant technology-specific requirements highlighted in the focus area descriptions are addressed:

- Summary of the current status of material/component innovation, and the specific challenges or limitations being addressed by the novel material, component, or integration with respect to the associated electrolyzer technology.
- Description of the proposed improvements relevant to the associated electrolyzer SOA, with quantitative metrics and targets for the materials/component innovation that will be achieved by the end of the project.
- Description of the projected impact of the materials/component innovation on electrolyzer stack capital or operating costs based on preliminary technoeconomic assessment, with discussion of the manufacturability/scale-up potential; and plans to conduct a comprehensive assessment of the technoeconomic impact on electrolyzer costs.
- Technical work plan, including proposed collaborative work with the H2NEW, HydroGEN and/or ElectroCat Consortia, comprising specific plans for:
    - *Materials/component development and validation with respect to the cost and technical targets for the associated electrolyzer technology, including specific*

plans to evaluate single cell electrolyzer performance and durability over a minimum of 1000 hr.

Expected outcomes and deliverables for the advanced electrolysis R&D projects include:

- Validation of performance and durability relative to the component innovation under development, using standard methodologies and protocols established by DOE (e.g., through the consortia).[73] Applicants must provide justification if they plan to use a third party for validation other than the DOE lab-led consortia.
- Technoeconomic analysis of the materials/component innovation under development, including verification of whether the innovation could enable meeting DOE electrolyzer targets.

Topic 3: Project Structure

Applicants should propose projects 2-3 years in length for a total DOE funding of $2,000,000 to $5,000,000 per project. The funding request should be commensurate with the level of work proposed. Applicants should plan projects as multi-phase efforts with a quantitative Go/No-Go decision point separating each phase (budget period). Projects must satisfy the agreed upon quantitative performance criteria for each phase Go/No-Go decision to move into the next phase. A No-Go decision will result in a discontinuation of support beyond the phase. The R&D projects in this topic must include **at least 20% cost share. For Institutions of Higher Education and Nonprofit Organizations, cost sharing is not required.**[74]

Topic 3: Teaming Arrangements

All projects will be required to leverage the capabilities at one of the HFTO-funded consortia (H2NEW, HydroGEN, or ElectroCat). The applicant must select the consortium that has the best capabilities and expertise of most relevance and value to the proposed work. The nature and level of involvement should be defined by the applicant and needs to be included in the proposal. Applicants should visit the H2NEW,[75] HydroGEN,[76] and ElectroCat[77] websites and Annual Merit Review presentations[78] to help identify the capabilities that are best suited to

[73] For example, benchmarking protocols for LTE and HTE technologies have been developed through the HydroGEN consortium: https://www.frontiersin.org/research-topics/16823/advanced-water-splitting-technologies-development-best-practices-and-protocols#articles.

[74] Section 10725 of the Research and Development, Competition, and Innovation Act, P.L. 117-167 (Aug. 9, 2022) extends the cost share waiver pilot program enacted by Section 108 of the Department of Energy Research and Innovation Act, Public Law 115–246 (Innovation Act) and provides an exemption for institutions of higher education and nonprofit organizations from the 20% cost share requirement for Research and Development activities. The exemption is available for the two-year period beginning on August 9, 2022. Codified at 42 U.S.C. 16352.

[75] H2NEW, https://h2new.energy.gov/research.html#lte.

[76] HydroGEN, https://h2awsm.org/capabilities.

[77] ElectroCat, https://www.electrocat.org/category/capabilities/.

[78] Hydrogen Program Annual Merit Review, https://www.hydrogen.energy.gov/amr-presentation-database.html.

assist them in material characterization, cell/MEA integration, cell testing, or other activities. ***Applicants should not interact with consortia lab personnel while the FOA is open.***[79] While applicants are required to work with one of these consortia and should clearly identify the capabilities they will use, ***applicants should not include the cost of consortia capabilities in their proposed budget.*** EERE will provide access to those capabilities at no cost to the selected projects based on award negotiations and availability of funds.

Teaming arrangements that include multiple stakeholders across academia, industry, national laboratories, labor, and/or community organizations are encouraged as appropriate, and across technical disciplines are strongly encouraged and preferred. Please see Section I.B.iii for more information on teaming.

Topic 3: Applications Specifically Not of Interest

- Applications on AEM technologies that use platinum group metals >0.05 mg/cm^2.
- Applications on LA technologies that use platinum group metals.
- Applications based on photoelectrochemical, solar thermochemical, microbial-assisted electrolysis, or non-electrolysis hydrogen production technologies.
- Applications based on electrolyzer technologies not based on water-splitting (e.g., chloralkali processes).

ii. Area of Interest 2: Clean Hydrogen Manufacturing & Recycling

This Area of Interest (AOI) comprises three topics that specifically address EPAct Section 815 (as amended by BIL Section 40314) to advance clean hydrogen manufacturing technologies, including for medium-duty vehicle (MDV) and heavy-duty vehicle (HDV) fuel cells; and to implement methods and frameworks to facilitate the reuse and recycling of materials and components relative to clean hydrogen technologies, including both fuel cells and electrolyzers. The broad intent is to support national decarbonization goals by helping to remove barriers to the widespread at-scale deployment of these technologies. The topics in this AOI aim to bridge the gap between material and technology development RD&D and technology deployment, supported by ongoing technology assessments and manufacturing cost analysis.

Two of the topics in AOI 2 are focused on addressing manufacturing and supply chain challenges for MDV/HDV fuel cell stacks and components:

- **Topic 4** aims to accelerate fuel cell manufacturing innovation and scale-up, in a similar fashion to Topic 1 above for electrolyzer technologies, enabling diverse fuel cell manufacturer and supplier teams to flexibly address their greatest scale-up challenges and achieve economies of scale benefits. These larger ($20M-$30M) RD&D projects are

[79] This process is based on previous consortia model best practices for national lab engagement. HFTO intends to have an opportunity for national labs to submit proposals in this topic area through a separate process.

geared toward scaling cell and stack production and addressing the 2030 HDV fuel cell cost, durability, and efficiency targets, as well as manufacturing capacity targets, with transferable benefits to MDV and cross-cutting applications.

- **Topic 5** aims to address critical deficiencies in the domestic supply chain for MDV/HDV fuel cell materials and components. Within this topic, mid-size (up to $10M each) R&D projects will support the establishment and expansion of manufacturing and production of critical cell materials, while smaller (up to $5M each) projects will address the need for rapid development and production of alternate membrane materials.

These topics are expected to rely on HFTO analyses that evaluate fuel cell stack and system cost as a function of production volume for a range of hydrogen fuel cell transportation applications.[80] Specific to HDVs, HFTO analysis provides guidance for cost reduction pathways toward a 2030 system cost goal of $80/kW (at a production volume of 100,000 systems per year) adjusted for 25,000 hours durability.[81] [82] Though this analysis assumes modeled manufacturing technologies at a production volume of 100,000 systems per year, to facilitate near-term coordinated efforts toward the demonstration of such volumes and the strong domestic supply chain necessary to implement them, HFTO has also estimated production rates, based on industry input, for HDV fuel cell stacks at production capacities of 20,000 stacks per year, assuming a single line or piece of equipment. Based on assumptions of 150 kW_{net} stack power output (with approximately 400 cells per stack), 240 days of factory operational time per year, and 2 7-hour-long shifts per day, this overall goal equates to the required commensurate material and component rates or amounts shown in Table 3.

[80] James, Brian, Strategic Analysis Inc. (2022). "Fuel Cell Cost and Performance Analysis," https://www.hydrogen.energy.gov/pdfs/review22/fc353_james_2022_o.pdf.

[81] "Hydrogen Class 8 Long Haul Truck Targets," DOE Hydrogen and Fuel Cell Technologies Office Program Record #19006, October 31, 2019, https://www.hydrogen.energy.gov/pdfs/19006_hydrogen_class8_long_haul_truck_targets.pdf.

[82] 25,000 hours corresponds to 1,000,000 miles for long-haul heavy-duty trucks. While DOE and the M2FCT are focused on 1,000,000 miles as the ultimate goal (e.g., 100,000 miles per year for 10 years) based on industry feedback, it is recognized that lower durability (e.g., 700,000 miles) could also be sufficient, particularly for early market adoption.

Table 3. Estimated manufacturing rates commensurate with the manufacturing capacity target of 20,000 HDV stacks per year.[83]

Component	Rate
Stack	6 stacks/hr
MEA	2400 MEAs/hr
BPP	2400 BPPs/hr
GDL	650,000 m^2/yr
Membrane	370,000 m^2/yr
Catalyst	1,300 kg PGM/yr

The last topic in AOI 2 is focused on innovations in recovery and recycling for both PEM fuel cell and electrolyzer cells and stacks, with specific emphasis on helping to address supply chain barriers to widespread deployment:

- **Topic 6** provides up to $50M to establish a broad-based nonprofit/university-led consortium of industry, academia, and labs to address a range of recovery, recycling, and other Re-X[84] challenges for fuel cells and electrolyzers. These efforts will be supported and driven by high-level total cost of ownership (TCO) and life cycle assessment (LCA) analyses to identify low-cost, low-energy, and low-emissions pathways to optimize market-wide recapture and recycling strategies and methods.

Further details of all three topics in AOI 2 are included below.

Topic 4: Fuel Cell Membrane Electrode Assembly and Stack Manufacturing and Automation

Topic 4: Introduction

In accordance with the Clean Hydrogen Manufacturing and Recycling (EPAct Section 815) provisions, this topic aims to address the most critical bottlenecks to domestic manufacturing capacity, specifically for MDV/HDV PEM fuel cells, with translational benefits to other applications. This will be achieved by supporting diverse teams for the implementation and validation of high-volume and automated cell and stack manufacturing processes that enable the manufacturing capacity target of 20,000 stacks per year, while still demonstrating the potential to meet DOE's 2030 targets.[85]

[83] Information based on a preliminary representative analysis using the Strategic Analysis manufacturing cost model for heavy-duty fuel cell trucks, informed by industry input. MEA (membrane electrode assembly) refers to a seven-layer assembly with a catalyst-coated membrane (CCM), gas diffusion layers (GDL) and gaskets. BPP refers to a bipolar plate assembly of two joined half-plates. Applicants must include a justification for any deviation from the target stack and component rates or amounts. Applicants may also have more aggressive targets and should provide justification and strategy to achieve them.

[84] Re-X includes recycling, recovery, refurbishment, and reuse of stack or cell components of fuel cells and electrolyzers.

[85] Ibid, p. 39.

MDV and HDV PEM fuel cell electric vehicles operating on hydrogen offer several advantages over incumbent technologies, including higher efficiency, reduced emissions, higher torque, and no noise pollution. Rapid expansion of these fuel cell markets, and associated reduction in costs by economies of scale, requires the development and demonstration of high-volume continuous and/or automated methods to assemble and stack cells with required precision and quality. Continuous methods for membrane electrode assembly (MEA) component production (e.g., based on roll-to-roll methods) are known and practiced. However, advances are still required to increase throughput, to improve controls and quality, and to coat low-loaded electrodes with required uniformity. Similarly, "pick-and-place" automation is known in other industries (i.e., for automotive and battery manufacturing). However, relative to cell assembly and stacking, challenges remain in precision alignment and inspection, end effector design to handle specific cell designs and materials, methodologies for marking and tracking, and data-driven controls.[86] Roll-to-piece concepts for cell assembly have also been presented, though with little demonstration of specific equipment, methods, or quality.[87]

Cell component and hardware designs, as well as those for balance-of-stack components, may need to be adjusted to facilitate automated/robotic assembly and stacking. Furthermore, overall stack design may need to be adjusted, which provides an opportunity to assess and implement, as practicable, design elements that facilitate later rapid/automated disassembly for various circularity pathways (recycling, refurbishment, etc.). Incorporating automated compression and leak testing of the assembled stack, and methods to decrease the needed infrastructure and/or time for stack break-in/conditioning are also needs associated with improving overall stack production capacity.[88] Capabilities, expertise, and potential partnerships, across a broad range of related manufacturing disciplines including robotics, smart manufacturing, and recycling, will be needed.[89]

This topic is structured to provide flexibility and enable the MDV/HDV fuel cell value chain to address manufacturing challenges, in parallel with development of a domestic supply chain, by forming diverse, integrated teams of OEMs, suppliers, and US-based automation and equipment infrastructure, as practicable. It is intended for these teams to propose activities

[86] U.S. Department of Energy Manufacturing Automation and Recycling for Clean Hydrogen Technologies Virtual Experts Meeting, May 2022. https://www.energy.gov/eere/fuelcells/manufacturing-automation-and-recycling-clean-hydrogen-technologies-experts-meeting.

[87] Huya-Kouadio J.M, James B.D., Houchins C., Ulsh M. "The Next Generation of Fuel Cell Fabrication Using Roll-to-Stack Automation." Oral presentation at the Fuel Cell Seminar, Long Beach, CA; November 2019.

[88] U.S. Department of Energy Manufacturing Automation and Recycling for Clean Hydrogen Technologies Virtual Experts Meeting, May 2022. https://www.energy.gov/eere/fuelcells/manufacturing-automation-and-recycling-clean-hydrogen-technologies-experts-meeting.

[89] As an example, partnerships leveraging the Manufacturing USA program may be considered: https://www.manufacturingusa.com/.

across whatever range of MEA and stack manufacturing aspects that best address their scale-up needs, while still addressing the overall target of increasing stack manufacturing capacity to 20,000 stacks per year for a single line or piece of equipment and/or the commensurate rates or amounts shown in Table 3 for cell materials and components.

It is understood, however, that advancement of manufacturing capacity and technology must not come at the expense of efficiency and durability, and collaboration and/or coordination with HFTO's M2FCT Consortium is expected in this area. M2FCT[90] leads DOE-funded efforts to improve cell efficiency and durability with a 2025 target for heavy-duty fuel cell truck MEAs of 2.5 kW/g_{PGM} power at 1.07 A/cm^2 and 0.7 V after 25,000 hours, leveraging world-class national laboratory capabilities in modeling, fabrication, and testing. Projects in this topic will specifically need to work in coordination with or in accordance with M2FCT testing methodologies[91] to verify efficiency and durability in produced components or assemblies.

Topic 4: Anticipated Funding and Award Details

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

Topic Area	Total Funding Level ($000)	Anticipated Number of Awards	Federal Funding per Award ($000)	Maximum Project Duration (years)	Minimum Required Non-Federal Cost Share (%)
Topic 4: Fuel Cell MEA and Stack Manufacturing and Automation	$150,000	5-7	$20,000-$30,000	3	50%

Topic 4: Description and Objectives

This topic seeks applications focused on the design, build, and demonstration of pilot-scale manufacturing equipment for automated cell and stack (including balance of stack components) assembly, potentially including additional aspects as needed, such as high-volume MEA component fabrication and post-assembly stack testing or conditioning, for MDV/HDV fuel cell systems. Plans should address required throughput, controls, quality (such as alignment and registration), conditioning/leak checking, and material handling capabilities for these materials or assemblies. The proposed manufacturing equipment should have the capability to meet the manufacturing capacity target of 20,000 stacks per year, including commensurate component-level rate targets given in Table 3 above, as appropriate for the scope of the project. The overall goals of this topic are to establish and validate commercially viable manufacturing capabilities that provide a demonstrable increase in manufacturing capacity at

[90] M2FCT. https://millionmilefuelcelltruck.org/.

[91] M2FCT's HD MEA accelerated stress testing protocol: https://millionmilefuelcelltruck.org/astwg.

the cell and stack level and enabling an associated reduction in cost towards meeting the 2030 HDV stack cost targets.

Complementing the primary objective described above, specific areas of interest to this topic include, but are not limited to the following:

- Automation and equipment development focused on enabling the robotic or high-volume handling of cells with required precision, alignment, controls, and quality.
- High-volume fabrication processes and equipment for high-quality MEAs and components, as necessary to support increased cell/stack capacity.
- Cell and stack redesign to facilitate automated or high-volume assembly.
- Aspects of cell and stack redesign to facilitate disassembly for maintenance and servicing, reclamation of key materials/components, recycling, remanufacturing, and reuse, as applicable.
- Incorporation of processes such as marking and tracking, and connectivity to IoT/manufacturing 4.0 type data acquisition and usage.
- Development and implementation of automated or high-rate equipment and methods for compression, leak testing, and conditioning.
- Aspects of equipment design or operation that facilitate flexible change-over for different cell sizes or types, or stack designs.

Topic 4: General Requirements

Applicants must clearly identify the status of their proposed automated or high-volume fabrication or assembly technology as it relates to the state-of-the-art and the barriers that it overcomes, and provide sufficient justification, supported by cost analysis, that the proposed approach has the potential to lead to a manufacturing solution that meets the stated throughput targets at suitable costs for low cost, high quality, efficient production of MDV/HDV fuel cells. Applications must include the following, specifically related to project outcomes and deliverables, and aligned with topic objectives:

- Summary of the current status of the MDV/HDV PEM fuel cell technology being addressed, including cell and/or stack performance and durability in state-of-the-art systems, and a clear description of the technology advancements that will be incorporated into the fuel cell manufacturing beyond what is in commercial products today.
- Summary of the applicant's current status of manufacturing processing, including current manufacturing capacity and production volume, and description of the applicant's most critical barrier(s) to attaining low-cost, high-volume fuel cell stack (as well as MEA, cell, or other) manufacturing, including manufacturing processes with the greatest potential for cost reduction and throughput increase, along with the

innovations the proposed work would result in to overcome these limitations and accelerate progress toward achieving 20,000 stacks per year.

- Technical plan for the design, fabrication, and installation of proposed stack (single line or piece of equipment required) and/or component (single line or piece of equipment highly preferred) manufacturing equipment operating at the stated throughput targets, with quantitative targets and timelines.
- Technical plan for validation of the proposed prototype or pilot-scale equipment for stack (as well as MEA, cell, or other) manufacturing necessary to meet the stated throughput targets, including:
    - Multiple 1-hour-long runs (i.e., addressing the 6 stacks/hour target).
    - Acceptance testing of the produced components and stacks using a number of replicates determined by standard manufacturing statistical methods to prove repeatability and reproducibility.
    - Cell and stack in-situ testing to validate proposed cell/stack operating and durability metrics that have the potential to meet DOE's 2030 targets and be commercially viable.
- Preliminary technoeconomic analyses[92] that show how the proposed manufacturing technology will address stated DOE cost and manufacturing capacity targets for MDV/HDV fuel cells, with plans to conduct more comprehensive assessments by project's end.
- Data management plan, including a detailed description of how the team will collect data on primary resource consumption (e.g., electricity, fossil fuels/other resources, feedstock materials, water, etc.) for each manufacturing step relevant to the overall environmental impact of the manufacturing process.[93]
- Workforce development, education, and/or training plan as part of the work scope (to be included in the Community Benefits Plan, see additional information below).

In all cases, environment, health, and safety (EH&S) are high priorities and emphasis must be placed on all aspects of EH&S, including the manufacturing processes themselves and in the installation, operation, and disposal/recyclability of fuel cell components and systems. Designs and processes that minimize potential hydrogen leakage or other emissions are also encouraged.

[92] TEA of the manufacturing process and/or equipment should use methodology consistent with the Hydrogen Financial Analysis Tool (H2FAST; https://www.nrel.gov/hydrogen/h2fast.html).

[93] Successful teams may be requested to share pertinent data of the manufacturing processes with national laboratories, such as Argonne National Laboratory's GREET team, to inform comprehensive life cycle assessment of fuel cells.

Expected outcomes and deliverables for the RD&D projects in fuel cell MEA and stack manufacturing and automation include:

- Demonstration of manufactured stacks (as well as MEAs, cells, and other components) using the pilot equipment.
- Demonstration of manufacturing process efficacy and equipment throughput including assessment of required quality of the produced stacks, MEAs, components, etc.
- Testing of manufactured MDV/HDV stacks (as well as MEAs, cells, and other components, as applicable), in accordance with DOE/M2FCT methodologies and targets.
- Independent validation of MEA/cell performance by M2FCT will be required.
- Comprehensive technoeconomic analysis to demonstrate project impacts relative to meeting DOE targets.
- Real-world facility data for primary resource consumption, which will inform ongoing emissions analyses and identification of opportunities to improve manufacturing process efficiency and reduce environmental impact (e.g., lower energy consumption, carbon footprint, and other effluents per unit produced).

Topic 4: Project Structure

Applicants should propose projects up to 3 years in length for a maximum total DOE funding of $30,000,000 per project. The funding request should be commensurate with the extent of work proposed. Applicants should plan projects with multiple phases and with a quantitative Go/No-Go decision point separating each phase (budget period). Projects must satisfy the agreed upon quantitative performance criteria for the phase Go/No-Go decision before DOE will commit support for additional phases. Selected projects will be expected to work in coordination with or in accordance with the testing methodologies of the M2FCT Consortium to verify produced component or assembly efficiency and durability. M2FCT support for the selected projects will be funded directly by DOE and should not be included in the project budget. National labs that are part of the M2FCT Consortium may participate as a subrecipient if the work is distinct from M2FCT supported efforts, and if so, should be included in the project budget. The RD&D projects in this topic **must include at least 50% cost share**.

Topic 4: Teaming Arrangements

It is anticipated that projects will be led by industry. Collaborative projects comprising appropriate industrial and manufacturing expertise are strongly encouraged. Applicants are highly encouraged to develop teaming arrangements between stack/system integrator, stack and component suppliers, and automation or high-volume equipment suppliers, as appropriate. Academia and national labs (see note above for M2FCT Consortium labs) are eligible to be subrecipients on projects but are not required. Applicants are required to utilize proposed equipment and capabilities for domestic manufacturing. Strong preference is given to applicants using and partnering with domestic material and equipment suppliers, as applicable.

Applicants should describe succinctly the qualifications, experience, and capabilities of the proposed project team to execute the project plan successfully.

Applications to this topic are strongly encouraged to include one or more of the following institutions as part of their team, particularly in development of workforce, training, and education activities: Indian Tribes, Tribal organizations, Tribal Colleges and Universities, HBCUs, MSIs, Native Hawaiian community-based organizations, territories or freely associated States, community colleges or community organizations, organizations located in economically distressed areas of major natural gas-producing regions of the United States, and/or labor unions. Please see Section I.B.iii for more information on teaming.

In addition, teams may be requested to share pertinent data of the manufacturing processes with national laboratories, such as Argonne National Laboratory's GREET team, to inform comprehensive life cycle analysis during the project.

Topic 4: Community Benefits Plan

As described in Sections I.D, IV.D.xv, and Appendix F, all applicants to this FOA for all Topics (1-6) are required to submit a separate R&D Community Benefits Plan (CBP) as part of their application, describing efforts to advance diversity, equity, inclusion, and accessibility (DEIA); energy equity; and workforce development. Because teams on this Topic are expected to develop and demonstrate manufacturing technologies and processes suitable for near-term commercial scale-up, it will be especially important to identify and prepare for related workforce development needs. Prime applicants are strongly encouraged to undertake this work in collaboration with subrecipients of diverse expertise, as discussed in the Topic 4 Teaming Arrangements section.

To address these priorities, applicants to Topic 4 should specifically address anticipated workforce needs in their CBP. Examples of activities that applicants might consider for their CBP include, but are not limited to:

- Co-creation of open-source workforce training materials or industry-recognized credentials with one or more community colleges, HBCUs or other MSIs.
- Engaging with relevant labor organizations, government, education, apprenticeship-readiness programs and training institutions to identify training priorities for a fuel cell manufacturing workforce
- Characterization of the quality of the jobs that will be offered (for example classification as employees, wages, benefits and opportunities for progression)
- Development of recruitment and retention strategies that prioritize disadvantaged and/or underutilized populations.
- Creation of community awareness sessions in collaboration with local governments and community-based organizations.

- Work with communities to understand challenges and opportunities with technology commercialization.
- Plans to hold outreach events with community/disadvantaged community organizations.

Topic 4: Applications Specifically Not of Interest

- Activities related to fuel cells other than PEM for medium-/heavy-duty applications, including alkaline, solid oxide, phosphoric acid, phosphoric acid-based (PBI-type), etc.
- Activities related to supply chain development of gas diffusion layers (GDLs), bipolar plates (BPPs), catalysts, or membranes, addressed by other topics in the FOA.
- Activities related to balance-of-plant (BOP), system assembly, or system installation.
- Activities with strong focus on materials development.

Topic 5: Fuel Cell Supply Chain Development

Topic 5: Introduction

This topic supports the Clean Hydrogen Manufacturing and Recycling provision (EPAct Section 815) to enhance the domestic supply chain of critical materials and components for clean hydrogen end-use, with a focus on leveraging existing expertise and infrastructure, and identifying and incorporating non-hazardous alternative materials for hydrogen technologies. Specifically, this topic aims to support R&D to develop innovative manufacturing processes for components and materials used in medium- to heavy-duty vehicle PEM fuel cells (MDV/HDV PEMFCs) with cross-cutting benefits to other fuel cell applications.[94] Emphasis is placed on developing manufacturing processes for critical MVD/HDV fuel cell components to enable reaching the manufacturing capacity target of 20,000 stacks per year, in accordance with the rates shown in Table 3, while still demonstrating the potential to meet DOE's 2030 targets.[95]

This topic focuses on critical materials and components R&D specifically for Proton Exchange Membrane Fuel Cells (PEMFCs), aiming to establish or expand stable, accessible, and high-volume U.S. supply chains and production capacities. The current domestic supply chain for fuel cell materials and components requires further support to meet growing market demands. Specific PEMFC supply chains that would benefit from further development through this topic include gas diffusion layers (GDLs), catalysts, bipolar plates (BPPs), and non-perfluorosulfonic acid (non-PFSA) membranes. Innovations in manufacturing across these four areas will help to de-risk future investments and expedite achieving economies of scale while aligning with climate goals.

[94] Supply chain development activities specifically for water electrolyzers are covered under Topic 2.
[95] Ibid., p. 39.

The PEMFC materials and components developed under this topic, while needing to be compatible with a secure domestic fuel cell supply chain, also need to meet cost and technical requirements to enable meeting DOE's stack- and system-level fuel cell targets. Projects should leverage the expertise and resources of HFTO's M2FCT consortium[96] in this area. HFTO established M2FCT to accelerate R&D that would enable fuel cell durability in MDV/HDV over a million miles of operation, while meeting other relevant performance targets. With participants from national laboratories, universities, and industry, M2FCT serves as a resource for commercial and research communities. In this topic, project awardees will be expected to collaborate with M2FCT to establish relevant component testing procedures and validate performance of materials and components under development.

Topic 5: Anticipated Funding and Award Details

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

Topic Area	Total Funding Level ($000)	Anticipated Number of Awards	Federal Funding per Award ($)	Anticipated Award Duration (years)	Minimum Required Non-Federal Cost Share (%)
Topic 5: Fuel Cell Supply Chain Development	$80,000	8-16	$3,000-$10,000	2-4	20%

Topic 5: Description and Objectives

The objectives of this topic are threefold: (1) Strengthen the domestic supply chain and reduce the cost of MDV/HDV PEM fuel cells; (2) Establish or expand domestic manufacturing capability and process knowledge to support domestic industrial scale-up of critical materials and components with the cost, performance, durability, manufacturability, and recyclability required of HDV fuel cells; and (3) Develop innovative and non-hazardous alternative materials for novel PEM fuel cells compatible with medium- to heavy-duty applications.

This topic will enable scalable manufacturing advancements in the production of high-performing components for the MDV and HDV market. The topic focuses on developing and validating material and component manufacturing at rates that are commensurate with the requirements to achieve a manufacturing capacity of 20,000 stacks per year. At the same time, the produced materials and components should enable fuel cells to meet DOE's 2030 cost and

[96] More information on specific M2FCT expertise and resources can be found at the consortium's website: https://millionmilefuelcelltruck.org/.

durability targets of $80/kW and 25,000 hours of durability for HDV applications.[97] To validate performance and durability, manufactured components should be tested in coordination with M2FCT, or in accordance with the consortium's testing methodologies, as appropriate. Also, applicants will need to validate developed process cost and efficiency advances, supported by technoeconomic and emissions analyses, compared to the state of the art.

Topic 5: Fuel Cell Component Focus Areas

The specific fuel cell components of interest under this topic include GDLs, catalysts, BPPs, and non-PFSA membranes. In all cases, environment, health, and safety (EH&S) are high priorities and emphasis must be placed on all aspects of EH&S, including in the development/manufacturing processes themselves and in the assembly, operation, and disposal/recyclability of fuel cell materials and components. Designs and processes that minimize potential hydrogen leakage or other emissions are also encouraged. Specific R&D needs and requirements for each component are included below.

Subtopic 5a – Gas Diffusion Layers:

GDLs are porous structures usually fabricated from carbon paper or fibers treated to achieve the desired hydrophobicity/hydrophilicity. The GDL resides between the electrode and BPP and has the primary function to aid in reactant and product distribution to the anode and cathode. Easy movement of reactants and products, during steady-state operation and rapid transients, facilitates cell operation at high current density by reducing mass transport resistance and minimizing liquid water build-up and blockage. Unhindered mass transport can result in smaller stacks for a given power level and, consequently, lower system cost. The GDL must also provide sufficient electrical conductivity from the electrode to the current collector.

GDLs represent approximately 15% of HDV stack cost at a volume of 200 systems per year. This percentage drops to 2% at very high production volumes; however, these analyses assume an accessible supply chain and fully developed manufacturing technologies to produce at high volumes.[98] Currently, the domestic supply chain for GDLs is extremely limited, especially for the carbon fiber and carbon paper materials that form the base GDL substrate, as well as for the thermal treatment that is needed to provide the required substrate properties. This lack of supply chain depth has been identified as a potential critical bottleneck to increasing MEA production volume and

[97] 25,000 hours corresponds to 1,000,000 miles for long-haul heavy-duty trucks. While DOE and the M2FCT are focused on 1,000,000 miles as the ultimate goal (e.g., 100,000 miles per year for 10 years) based on industry feedback, it is recognized that lower durability (e.g., 700,000 miles) could also be sufficient, particularly for early market adoption.

[98] James, Brian, Strategic Analysis Inc. (2022). "Fuel Cell Cost and Performance Analysis," https://www.hydrogen.energy.gov/pdfs/review22/fc353_james_2022_o.pdf.

requires investment in technical advancements and demonstration of higher volume production.[99] This topic will enable the development and pilot-scale demonstration of manufacturing technologies and equipment capabilities, preferably in a single line or piece of equipment, that support or contribute to, in the case of carbon fiber or paper production, the target GDL production rate of more than **650,000 m^2 of GDL** material per year to supply 20,000 stacks per year.

In addition to manufacturing and supply chain concerns, current GDLs on the market have largely been designed for light-duty or small-scale motive fuel cell applications. However, heavy-duty applications require cell operation under different target conditions (to maximize fuel efficiency) and for much longer lifetime. These different operating conditions require optimizing GDL properties, for example porosity, mechanical strength, and compressive properties, via material and/or process modifications for substrates and subsequent treatments. This area will enable scalable manufacturing advancements, in coordination with M2FCT and other relevant DOE activities, toward the improvement of GDL properties to achieve DOE's HDV efficiency and durability targets.[100]

This area seeks applications focused on advancement of the domestic supply chain as well as manufacturing technology and capacity for GDLs, and on the optimization of GDL properties for MDV/HDV fuel cell applications. Specific areas of interest in this focus area include but are not limited to:

- Design, build, and validate prototype or pilot-scale manufacturing equipment, preferably a single line or piece of equipment, for high-volume production of carbon fibers or carbon paper that can, when implemented at full scale, meet or justifiably contribute to meeting the new manufacturing capacity target of **6 stacks per hour, or 2400 MEAs/hr, corresponding to over 650,000 m^2 of GDL per year.**
- Develop and understand GDL processing using prototype or pilot-scale manufacturing equipment to enable or facilitate later investments for full-scale manufacturing.
- Perform material and/or process R&D to improve mechanical or compression properties, porosity, and/or treatments to provide required surface energy

[99] Department of Energy Water Electrolyzers and Fuel Cells Supply: Chain Deep Dive Assessment; February 24, 2022. https://www.energy.gov/sites/default/files/2022-02/Fuel%20Cells%20%26%20Electrolyzers%20Supply%20Chain%20Report%20-%20Final.pdf.

[100] Weber, Adam and Rodney Borup (2022). "M2FCT: Million Mile Fuel Cell Truck Consortium," https://www.hydrogen.energy.gov/pdfs/review22/fc339_weber_borup_2022_o.pdf.

(hydrophobic/hydrophilic), etc., to better meet performance and durability targets relevant to MDV/HDV.

Subtopic 5b – Catalysts:

Catalysts in PEM fuel cells are required for rapid and efficient conversion of energy stored in chemical bonds to desired electrical work. Fuel cell performance is directly linked to catalyst activity and longevity, with increasingly demanding requirements for heavy-duty fuel cell applications. These systems rely on long lifetimes over which operational costs are amortized to realize total ownership cost savings through fuel efficiency relative to incumbent technologies.

Catalyst costs make up a significant fraction of heavy-duty stack costs, ranging from one quarter of the total stack cost at low production volume (100 stacks/yr) to over half of the stack cost at high production volume (1,000 to 100,000 stacks/yr) for the modeled FY2022 HDV System.[101] As production volumes increase, the majority of system components can realize a substantial cost reduction due to greater manufacturing volumes, while catalyst costs, which are driven primarily by raw material commodity prices, decrease only slightly with increased manufacturing volume. Therefore, as production volumes increase, the catalyst cost becomes a greater driver of overall stack costs, and future improvements to catalyst performance and durability will realize increasingly greater benefits to overall ownership costs for heavy-duty PEM fuel cell systems.

As MDV/HDV stack demand rises, and manufacturing volumes increase, domestic catalyst production must maintain pace with this growth to ensure balanced domestic supply, stable supply chain dynamics, and reduced reliance on foreign materials and suppliers. Stack production rates of 20,000 stacks per year could require **3-5 kg PGM per operating day**, based on the loadings required for HDV PEM fuel cells to meet durability requirements. Domestic recycling of end-of-life stacks and rapid re-deployment of catalysts offer additional opportunities for US manufacturer engagement. This topic strengthens and expands the domestic fuel cell catalyst supply chain by supporting manufacturing advancements that improve manufacturing efficiencies and expand production scale without sacrificing quality. By focusing primarily on scalable production processes and approaches, this effort provides opportunities to scale production of existing commercial catalysts as well as commercialization of innovative lab-demonstrated catalysts. This topic bolsters domestic manufacturing infrastructure and

[101] James, Brian, Strategic Analysis Inc. (2022). "Fuel Cell Cost and Performance Analysis," https://www.hydrogen.energy.gov/pdfs/review22/fc353_james_2022_o.pdf.

resources and facilitates the development of an agile domestic catalyst manufacturing and recycling ecosystem supporting meeting or exceeding the DOE's 2025 HDV MEA target (**2.5 kW/g_{PGM} power at 1.07 A/cm^2 and 0.7 V after 25,000 hour equivalent AST**).[102,103]

This area seeks applications focused on advancement of the domestic supply chain as well as manufacturing technology and capacity for PEMFC catalysts, including process optimization to facilitate commercialization of MDV/HDV fuel cell applications. Specific areas of interest in catalyst R&D include, but are not limited to:

- Designing, building, and validating prototype or pilot manufacturing equipment, preferably a single line or piece of equipment, for high-volume catalyst production that can, when implemented at full scale, meet or justifiably contribute to producing catalyst batches containing **3-5 kg of PGM,** addressing the PGM required for 20,000 stacks on an annual basis.
- Developing processes that emphasize scalability, tunability, and versatility for catalyst manufacturing and are compatible with both current and next-generation catalysts.
- Developing catalyst synthesis and processing understanding with continuous or semi-continuous prototype or pilot manufacturing equipment that will enable or facilitate later investments for full-scale manufacturing.
- Performing process R&D to achieve durability, activity, and manufacturability that meet HDV fuel cell efficiency and durability targets.

Subtopic 5c – Bipolar Plates:

BPPs separate individual cells in a PEM fuel cell stack and play an important role in fuel cell performance through reactant distribution, heat management, water management, and the transmission of the generated electric current. Bipolar plates are generally fabricated by first forming two half plates that are then joined together to form coolant flow channels within the BPP, and reactant distribution channels on the surfaces. If necessary, a protective coating is applied during the process.

BPPs are estimated to be the third most costly PEMFC stack component in HDV systems, accounting for over 7% of the total stack cost using state-of-the-art technology at high system manufacturing volumes.[104] While the costs of common BPPs drop dramatically

[102] Weber, Adam and Rodney Borup (2022). "M2FCT: Million Mile Fuel Cell Truck Consortium," https://www.hydrogen.energy.gov/pdfs/review22/fc339_weber_borup_2022_o.pdf.
[103] AST Working Group, https://millionmilefuelcelltruck.org/astwg.
[104] James, Brian, Strategic Analysis Inc. (2022). "Fuel Cell Cost and Performance Analysis,"https://www.hydrogen.energy.gov/pdfs/review22/fc353_james_2022_o.pdf.

at higher manufacturing volumes, cost gains with scale are limited by bottlenecks in current production processes that are typically overcome by adding parallel processing lines. Thus, achieving economies of scale and securing the domestic supply chain would benefit from innovative advancements that relieve bottlenecks in several aspects of BPP manufacturing.

Metallic and carbon-based BPP's are potential options for PEM fuel cells for MDV/HDV transportation. Metallic BPPs are advantageous because they enable high power densities. There is considerable domestic expertise and capability in high-volume metal processing, but advancements are needed that improve durability; reduce material cost; accelerate forming, joining and coating processes; reduce tooling costs; and streamline quality control to reach DOE production rate and cost targets.[105] Carbon-based bipolar plates are made of low-cost carbon composite or flexible graphite sheets and offer corrosion resistance and advantages in formability; however, performance concerns related to mechanical stability, and manufacturing bottlenecks related to resin curing and embossing processes may hinder market adoption.[105] Furthermore, a dearth of domestic natural graphite sources poses a risk to the supply chain of graphite based BPP.[106] While there is domestic expertise and capacity for manufacturing both metallic and carbon-based sheets, the expansion of domestic forming, joining, and coating/curing capabilities is needed to address manufacturing bottlenecks, reach DOE production and cost targets, and stabilize the domestic supply chain.

Applicants will need to operationally validate the proposed process or equipment and justify a pathway to cost-competitive component or material production at rates that support manufacturing volumes greater than eight million joined bipolar plates/year, at a production rate of 2400 BPPs per hour, to support the manufacturing capacity target of 20,000 HD PEM fuel cell stacks per year. Manufactured BPPs should aim at meeting BPP performance targets[107] at a cost of \$5/kw_{net} and durability of 25,000 hours in HDV applications.

This area seeks applications focused on developing manufacturing processes and equipment to bolster the U.S. supply chain of BPP and BPP sub-components for

[105] J.P Kopasz, and T. G. Benjamin., "2017 Bipolar Plate Workshop Summary Report" https://publications.anl.gov/anlpubs/2017/11/137641.pdf

[106] Department of Energy Water Electrolyzers and Fuel Cells Supply: Chain Deep Dive Assessment; February 24, 2022. https://www.energy.gov/sites/default/files/2022-02/Fuel%20Cells%20%26%20Electrolyzers%20Supply%20Chain%20Report%20-%20Final.pdf.

[107] U.S. DRIVE, "Fuel Cell Technical Team Roadmap", Table 5, https://www.energy.gov/sites/default/files/2017/11/f46/FCTT_Roadmap_Nov_2017_FINAL.pdf.

MDV/HDV applications. Specific areas of interest in bipolar plate R&D include, but are not limited to:

- Designing, building, and validating manufacturing equipment, preferably a single line or piece of equipment, for high-volume production of bipolar plates and/or subcomponents (including coatings) that can, when implemented in a full BPP production line, support meeting the manufacturing capacity target of 20,000 HDV stacks per year (corresponding to a **production rate of 2400 BPP per hour**).
- Developing an understanding of bipolar plate processing based on the proposed manufacturing equipment and impact on quality and performance.
- Performing process and/or material R&D to improve BPP durability and manufacturability to better meet HDV fuel cell performance and durability targets without increasing cost.
- Validating that manufactured BPPs meet performance targets at a cost of **$5/kW$_{net}$ with 25,000 hours durability**.

Subtopic 5d – Non-PFSA Membranes for Fuel Cells:

Commercial PEM fuel cell membrane technology is typically based on perfluorosulfonic acid (PFSA) ionomers, but PFSA-based membranes are facing increased regulatory barriers domestically and abroad due to potentially detrimental environmental impacts of the chemicals used during manufacturing. Furthermore, these membrane materials are expensive, representing ~10% of the total stack cost at high manufacturing volumes.[108] Therefore, non-PFSA PEMs, including those based on hydrocarbon or other membranes, could represent a lower-cost, environmentally friendly alternative; however, these membranes require improvements in performance, durability, and manufacturability.

This area aims to develop non-PFSA membranes that are alternative non-hazardous materials for PEM fuel cells for MDV and HDV applications.[109] The proposed technology should be adaptable to high-volume manufacturing with a clear pathway to a process that would be capable of exceeding a production rate of **370,000 m^2 per year** to support the new manufacturing capacity target of 20,000 HDV fuel cell stacks per year, while meeting all performance and durability requirements.

This area includes both innovative non-PFSA ionomers and membranes that are suitable for application in PEM fuel cells for MDV/HDV vehicles. PEM membrane and ionomer technology applications should be proton-conducting and non-fluorinated. The topic

[108] James, Brian, Strategic Analysis Inc. (2022). "Fuel Cell Cost and Performance Analysis,"https://www.hydrogen.energy.gov/pdfs/review22/fc353_james_2022_o.pdf.

[109] Non-PFSA membrane development specifically for water electrolyzers is covered under Topic 3.

solicits applications that focus mainly on innovative ionomers and membrane development (up to $3,000,000), as well as applications including additional manufacturing development and scale up (up to $5,000,000).

Specific areas of interest in novel membrane development include, but are not limited to:

- The development of innovative non-PFSA ionomers and membranes, with high proton conductivity in a range of temperature (up to 120°C) and humidity conditions[110], including low H_2 and O_2 crossover, and 25,000 hours durability.
- Performing process R&D to improve non-PFSA membrane manufacturability and validate scalability.

Topic 5: General Requirements

Applicants must clearly identify the challenges or limitations being addressed and the status of their proposed manufacturing technology as it relates to the state-of-the-art. Applicants must provide sufficient justification, supported by cost analysis, that the proposed approach has the potential to lead to a manufacturing solution that meets the manufacturing capacity targets; and to low-cost, high-quality components and subcomponents for HDV fuel cells,[111] contributing to meeting the system level cost target of $80/kW$_{net}$ and a 25,000 hour lifetime by 2030. For non-PFSA membrane R&D, primary emphasis should be placed on development of innovative materials that are suitable for HDV applications.

All proposals for PEM fuel cell material/component manufacturing development must include the following general elements and ensure that all relevant technology-specific requirements highlighted in the focus area descriptions are addressed:

- Summary of the applicant's current status of the material/component properties and its respective manufacturing processes, including current manufacturing capacity and production volume, and the specific component challenges or limitations being addressed with respect to MDV/HDV fuel cells.
- Description of the proposed material/component improvements relevant to MDV/HDV fuel cell performance, with quantitative metrics and targets that will be achieved by the end of the project.

[110] USDrive, "Fuel Cell Technical Team Roadmap", Table 4 https://www.energy.gov/sites/default/files/2017/11/f46/FCTT_Roadmap_Nov_2017_FINAL.pdf.
[111] James, Brian, Strategic Analysis Inc. (2022). "Fuel Cell Cost and Performance Analysis," https://www.hydrogen.energy.gov/pdfs/review22/fc353_james_2022_o.pdf.

- Preliminary technoeconomic analyses[112] of how the proposed material/component innovation will address stated DOE cost and capacity targets for MDV/HDV fuel cells and plans to conduct a comprehensive assessment by project's end.
- Detailed description of how the team will collect data on primary resource consumption (e.g., electricity, fossil fuels/other resources, feedstock materials, water, etc.) for each manufacturing step relevant to the overall environmental impact of the manufacturing process.[113]
- Technical work plan, including proposed collaboration and/or coordination with M2FCT, comprising specific plans for:
    - Manufacturing technology development activities, including plans for the design and build of prototype or pilot manufacturing equipment to meet the throughput targets, and for validation of the equipment operating at the relevant capacity target from Table 3 (including producing components in multiple runs and in quantities sufficient to establish reproducibility via standard manufacturing statistical methods, and acceptance testing of the produced materials).
    - Component or material development and validation to meet cost and technical targets for MDV/HDV applications.

Expected outcomes and deliverables for the fuel cell components R&D projects include:

- The manufacture of materials/components using the pilot equipment at the appropriate scale (with the example of catalyst production with 4 kg PGM per batch; and with exceptions for non-PFSA membrane projects with a materials development focus only).
- Verification of the materials/component manufacturing process capacity to support or contribute to the target production rates commensurate with supply for 20,000 stacks per year, as applicable.
- Validation, through testing in a PEM fuel cell configuration using M2FCT methodologies and with sufficient replicates to establish repeatability, that the material/component meets MDV/HDV PEMFC performance and durability requirements. Independent validation of component performance by M2FCT will be required.
- Comprehensive technoeconomic analysis verifying impacts of the project relative to meeting DOE targets.

[112] TEA of the manufacturing process and/or equipment should use methodology consistent with the Hydrogen Financial Analysis Tool (H2FAST; https://www.nrel.gov/hydrogen/h2fast.html).

[113] Successful teams may be requested to share pertinent data of the manufacturing processes with national laboratories, such as Argonne National Laboratory's GREET team, to inform comprehensive life cycle assessment of fuel cells.

- Real-world facility data for primary resource consumption which will inform ongoing emissions analyses and identification of opportunities to improve manufacturing process efficiency and reduce environmental impact (e.g., lower energy consumption, carbon footprint, and other effluents per unit produced).

Topic 5: Project Structure

Applications should specify a single focus area; however, entities my apply to multiple areas. Applicants should propose projects up to 4 years in length for a maximum total DOE funding of $10,000,000 per GDL, catalyst, or BBP project; or up to $5,000,000 per non-PFSA membrane project. The funding request should be commensurate with the level of work proposed. Applicants should plan projects with multiple phases and with quantitative Go/No-Go decision points separating phases (i.e., budget periods). Projects must satisfy the agreed upon quantitative performance criteria for each phase before DOE will commit support for additional phases. Projects selected for negotiation will be expected to work in coordination with or in accordance with the testing methodologies of the M2FCT consortium to verify produced component or assembly performance. M2FCT support for the selected projects will be funded directly by DOE and should not be included in the project budget. National labs that are part of the M2FCT Consortium may also participate as a subrecipient if the work is distinct from M2FCT supported efforts, and if so, should be included in the project budget. The R&D projects in this topic must include at least 20% cost share.

Topic 5: Teaming Arrangements

It is anticipated that projects will be led by industry. Collaborative projects comprising appropriate industrial and manufacturing expertise are strongly encouraged. Applicants are highly encouraged to leverage existing supply chain and manufacturing infrastructure. Teaming with MEA/stack/system integrators for guidance on required end-use properties and performance is encouraged. Academia and national labs are eligible to be subrecipients on projects but are not required. Note that teams may be requested to share pertinent data of the manufacturing processes with national laboratories, such as Argonne National Laboratory's GREET team, to inform comprehensive life cycle analysis during the project.

Applicants are required to utilize equipment and capabilities developed in the project for domestic manufacturing. Strong preference will be given to applicants using and partnering with domestic material and equipment suppliers, as applicable. Applicants should describe succinctly the qualifications, experience, and capabilities of the proposed project team to execute the project plan successfully. Please see Section I.B.iii for more information on teaming.

Topic 5: Applications Specifically Not of Interest

- Components and subcomponents for use in applications other than PEM fuel cells for medium-or heavy-duty transportation applications, including alkaline, solid oxide, phosphoric acid, phosphoric acid-based (PBI-type), etc.
- Applications that duplicate existing production lines.
- Applications focused on developing new, higher risk/low TRL GDL or BPP materials or manufacturing methods that end with only a small-scale demonstration. Rather, DOE is interested in taking proven, commercially viable materials or forms and scaling manufacturing processes to high volume.
- Applications that demonstrate domestic process manufacturing of existing commercially available catalysts produced at scales that can meet the capacity target shown in Table 3.
- Applications focused solely on fundamental development of novel catalyst materials and/or structures at the bench scale.
- Ionomers for use in the fuel cell catalyst layer only.

Topic 6: Recovery and Recycling Consortium

Topic 6: Introduction

In support of the Clean Hydrogen Manufacturing and Recycling provisions (EPAct Section 815), this topic aims to establish a consortium of industry, academia, nonprofits, and national laboratories to address end-of-life (EOL) and critical supply chain challenges for low-temperature proton exchange membrane (PEM) fuel cell and electrolyzer systems. This effort is motivated by the need to sustainably recover and recycle critical materials for PEM-based systems that could be limited by resource availability and dependence on foreign supply chains.[114] The need of addressing this challenge has increased as a growing number of fuel cell and electrolyzer systems may soon reach EOL and stakeholders from both industry and the environmental and energy justice communities have expressed interest in ensuring an EOL disposal/recycling or secondary use strategy as market adoption grows.

The multi-disciplinary consortium established under this topic will focus on the responsible and economical EOL-recovery and recycling of PEM-based materials and systems, leveraging lessons-learned from related DOE efforts in recovery and recycling (such as the Critical Minerals and Materials Group[115] and Manufacturing USA institutes,[116] among others). Together, the partners of the consortium will address critical barriers for recovery and recycling related to PEM systems, components, and materials including activities in analysis, component recycling,

[114] DOE National Clean Hydrogen Strategy and Roadmap (DRAFT), 2022. https://www.hydrogen.energy.gov/pdfs/clean-hydrogen-strategy-roadmap.pdf.

[115] Critical Minerals and Materials. https://www.energy.gov/eere/amo/critical-minerals-materials.

[116] Manufacturing USA institutes. https://www.manufacturingusa.com/institutes.

and reuse of the systems. Based on results from extensive stakeholder engagement, the priority focus-areas for the initial phase of the consortium will be:

- Development and use of analysis tools to conduct life cycle assessment and technoeconomic analysis of current and future materials and processes for recovery and recycling to assess environmental impacts and costs.
- R&D of platinum group metal (PGM) reclamation, specifically on platinum and iridium utilized as catalysts in both PEM fuel cells and electrolyzers.
- R&D of ionomer/membrane recovery and recycling from membrane electrode assemblies (MEAs).
- R&D of other PEM stack component recycling, including bipolar plates, gas diffusion layers, and porous transport layers.

The consortium will also conduct key enabling activities, including development of:

- Technologies focused on recyclable stacks and stack components based on "design for recyclability" processes.
- Automated stack disassembly processes, to facilitate recycling and reuse of constituent materials.
- Other reclamation and recycling technologies or processes that are deemed essential to reduce supply chain vulnerabilities and ensure a robust and competitive domestic market.

As the market for low temperature PEM fuel cells and electrolyzers ramps up to the GW scale, supply chain vulnerabilities, particularly for critical materials and components such as PGMs and MEAs, will be an increasing challenge, while the number of systems reaching EOL will continue to grow. For instance, manufacturing the PEM electrolyzers and fuel cells required to reach the GW scale will require orders of magnitude more iridium than today's global supply, which is sourced primarily from South Africa and Russia.[117] Only 7% of the world's platinum is produced in the United States, and all the iridium used in the United States is imported, posing supply-chain vulnerabilities for domestic manufacturing.[118] The Department of the Interior included platinum and iridium in a list of 35 mineral commodities deemed "critical."[119] Reports show that current global mining of platinum and iridium can only support 3 to 7.5 GW of annual electrolyzer-manufacturing capacity, whereas estimates of total market demand reach as high

[117] Water Electrolyzers and Fuel Cells Supply Chain Report, Feb. 2022. https://www.energy.gov/sites/default/files/2022-02/Fuel%20Cells%20%26%20Electrolyzers%20Supply%20Chain%20Report%20-%20Final.pdf.

[118] Platinum Group Metal Catalyst Supply Chain Report, Feb 2022. EERE Technical Report Template (energy.gov)

[119] Federal Register, Vol. 83, No. 97 on May 18, 2018, the Department of Interior, Office of the Secretary, issued the final list or critical minerals on page 23295. See https://www.govinfo.gov/content/pkg/FR-2018-05-18/pdf/2018-10667.pdf.

as 100 GW by 2030.[120] There are currently some PEM recycling efforts underway, particularly within the European Union,[121] but these need to be increased in order to ensure sufficient supplies to meet growing demands for clean hydrogen technologies.

To date, most of the efforts in PGM recycling have been focused on platinum and palladium recycling within other industries—e.g., for catalytic converters. More work is needed to enable cost effective and environmentally friendly PGM recycling within the PEM fuel cell and electrolyzer industries, especially for PGMs that have not received as much attention, such as iridium, which can be recovered and recycled from PEM electrolyzers.[117] In addition, the current limited recycling of PGM catalysts from MEAs often utilizes incineration or highly corrosive acids, or both, to recover the materials; some of these processes produce hazardous waste streams. For example, current processes can result in hazardous emissions of hydrofluoric acid when fluorine-containing components are incinerated[122] as part of the recovery. However, little to no work has been done on separating and removing the membrane or other components for recycling.

Beyond PGM catalysts, the recovery and recycling of other components and materials used in PEM systems (such as used membranes and ionomers from MEAs) are also important. Reducing the reliance on virgin feedstocks for these materials and components could help facilitate scale-up of manufacturing and mitigate supply chain issues. With the cost of the MEA accounting for up to 60% or 70% of the fuel cell or electrolyzer stack, respectively, at high volumes, more efforts to stabilize material costs through recycling are critical.[123] In addition to the recovery of membrane and ionomer materials, current state-of-the-art processes can only achieve platinum-recovery rates from MEAs of up to approximately 70%.[124] This further highlights the need for MEA processing innovations. Other stack components, such as gas diffusion layers, bipolar plates, porous transport layers, and others, can also be recovered or reused to support a robust supply chain.[122] For example, electrolyzer bipolar plates are made of titanium coated with a top layer of PGMs. Waste PGMs can be removed/recovered, and the titanium plates can be re-coated for reuse. The titanium itself, while relatively abundant in the United States, can also be recycled.[117]

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[120] IRENA Green Hydrogen Cost Reduction Report, 2020. https://www.irena.org/publications/2020/Dec/Green-hydrogen-cost-reduction.

[121] Best4Hy Project, https://best4hy-project.eu/.

[122] Manufacturing Automation and Recycling Clean Hydrogen Technologies Report, May 2022 https://www.energy.gov/eere/fuelcells/manufacturing-automation-and-recycling-clean-hydrogen-technologies-experts-meeting.

[123] Papageorgopoulos, D. (2022), Fuel Cell Technologies Overview (slide 6), https://www.hydrogen.energy.gov/pdfs/review22/plenary7_papageorgopoulos_2022_o.pdf; and National Renewable Energy Laboratory, Manufacturing Cost Analysis for Proton Exchange Membrane Water Electrolyzers, Ahmad Mayyas, et. al., Technical Report NREL/TP-6A20-72740, August 2019.

[124] Lucien Duclos, et.al., Environmental assessment of proton exchange membrane fuel cell platinum catalyst recycling, Journal of Cleaner Production, Elsevier, 2017, 142.

Designing for recyclability and disassembly offers a significant opportunity to complement work being done on component and materials recovery and recycling for PEM-based systems. For example, today's stacks are difficult to disassemble due to welding and sealing used in current designs. Improved designs will facilitate disassembly and subsequent recovery and recycling.

Understanding how to achieve these technical improvements in cost-competitive ways will require concerted efforts in information collection and analysis. Supply chain analysis, technoeconomic analysis of existing and new processes, and life cycle assessment are crucial for the success of any recovery and recycling program. The consortium established under this topic will take a holistic approach, identifying and addressing knowledge gaps in recovery and recycling processes for PEM-based materials and components, and in novel system designs for recyclability and automated disassembly.

The consortium should address the DOE Hydrogen Program goals for recovery and recycling, which include a target for increasing the efficiency and cost effectiveness of recovery and recycling of raw materials for hydrogen technologies by 2028 (i.e., recovery of 50% of the membrane/ionomer materials and >95% of PGMs from fuel cell membrane electrode assemblies).[114] To achieve these goals, the proposed consortium is expected to identify key challenges, apply lessons learned and best practices from other industries (e.g., batteries, electronic equipment), and develop and demonstrate recovery and recycling methods that address EOL challenges in PEM fuel cells and electrolyzers. The consortium should address how their efforts will contribute to national priorities in environmental and energy justice issues in the community benefits plan (for more information on the R&D Community Benefits Plan, see section IV.D.xv). By achieving these goals, the consortium's efforts will help to: reduce the energy intensity of recovery and recycling processes; reduce greenhouse gas (GHG) emissions and water pollution; and slow the depletion of virgin feedstocks.

Topic 6: Anticipated Funding and Award Details

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

Topic Area	Total Funding Level ($000)	Anticipated Number of Awards	Federal Funding per Award ($000)	Maximum Project Duration (years)	Minimum Required Non-Federal Cost Share (%)
Topic 6: Recovery and Recycling Consortium	$50,000	1	$50,000	5	20%

Topic 6: Description and Objectives

HFTO seeks applications proposing a holistic, consortium-based approach to advancing technologies and processes for recycling and EOL-recovery of materials and components from low-temperature PEM fuel cell and electrolyzer systems. This approach is expected to effectively integrate analysis, R&D, and pilot-scale validation activities over the course of the initial five-year term of the consortium. The consortium will focus on developing and/or improving recovery and recycling processes that are efficient, low cost, and have a low carbon footprint. The consortium should also conduct R&D of PEM-based systems that are specifically designed for recovery and recycling. The consortium's activities will include analysis; development of novel recovery and recycling methods; development of methods to recover, recycle, refurbish, and reuse components and materials; design for recyclability; and pilot scale demonstrations.

This topic aims to establish a Recovery and Recycling Consortium comprising diverse stakeholders with the resources and expertise to accomplish the following objectives:

- Development of technoeconomic, life cycle assessment, and supply chain analyses for current and future recycling and EOL-recovery processes for PEM systems.
- Assessment of current and future recovery and recycling strategies and methodologies for PEM fuel cell/electrolyzer cell and stack assemblies.
- Establishment of novel, cost-effective, and commercially viable PGM recycling processes for PEM fuel cells and electrolyzers to mitigate environmental impacts and reduce resulting hazardous waste.
- Development of efficient processes for recovery, recycling, and reuse of ionomers and membranes from the MEAs of PEM stacks.
- Development of processes to recover, recycle, and reuse various components, including gas diffusion layers, bipolar plates (e.g., titanium and graphite), and coatings of the various components.
- Development of designs for PEM fuel cell and electrolysis components that enable improved recyclability, including designs that make recycling and disassembly easier (including automated high-volume stack disassembly) and methods/approaches for determining the timing of the optimal EOL for recyclable materials and components (which may vary significantly depending on the costs and benefits of recycling at different stages of life of a component or system).
- Validation of the recovered and/or recycled materials without compromising initial performance compared to virgin materials.
- Coordination with other DOE projects and consortia (M2FCT, H2New) to provide input to those efforts to help them incorporate design for recyclability/recovery into their broader R&D efforts.

- Development of a plan for outreach activities and broad stakeholder and community engagement to increase acceptance of and participation in recovery and recycling processes.
- Development of a blueprint for adopting recovery and recycling protocols, which can be used by the broader clean-hydrogen community.

The consortium may also conduct activities in the following areas:

- Scrap recovery and reuse during manufacturing.
- Waste reduction within a manufacturing process.
- Second-life lab-scale demonstrations of various recovered materials.

Topic 6: General Requirements

Applicants must clearly identify the scope and goals they envision for the Recovery and Recycling Consortium. The prime applicant, which is required to be a nonprofit or a university, should partner with a multi-disciplinary team of sub-recipients (including industry stakeholders, national laboratories, and/or other universities) with sufficient technical resources and expertise for achieving the consortium's milestones and overall goals. The prime recipient is expected to assume management responsibilities, coordinating the analytical and R&D efforts of the consortium team, and assuring the consortium is on the right track towards achieving its goals. Additionally, the prime recipient will be expected to harmonize efforts between the HFTO-supported consortium and other relevant DOE initiatives and projects focused on recovery and recycling.

In their proposals, all applicants must provide the following:

- A proposed structure of the consortium over the five-year duration including the project team members, the responsibilities of each team member, and the budgets for each activity.
- A preliminary summary of the current state-of-the-art technology, a baseline for recovery and recycling rates, and the challenges and limitations for the various materials and processes covered within the consortium, including appropriate quantitative metrics, as available.
- A detailed plan for conducting analysis of new, advanced recovery and recycling systems and processes, beyond the current state-of-the-art. The plan should include ways to incorporate existing DOE-funded projects to assist the consortium goals.
- A detailed technical and management work plan—for the prime and all partners—of all the activities within the consortium, with the targets and milestones each activity must reach by the end of the five years. This should demonstrate alignment with the DOE Hydrogen Program's 2028 goals,[125] and it should include:

[125] Ibid, p. 58.

- A holistic approach to address recovery, recycling, refurbishment, and/or reuse for the cell components of PEM fuel cells and electrolyzers (e.g., catalysts, membranes, gas diffusion layers, porous transport layers, and/or bipolar plates).
- Specific plans to address design for recyclability, and—at the stack level—design for automated disassembly to facilitate recycling, reuse, etc.
- Specific plans for pilot-level validation of recycling and/or recovery processes.
- A risk assessment and mitigation plan for the specified activities and targets.
- Specific milestones and Go/No-Go decision points for each of the activities.

By the end of the five-year phase, the Recovery and Recycling Consortium should produce quantitative assessments of the recovery and recycling process performance and provide sufficient detail to assess the environmental, economic, workforce, and other impacts as a function of process scale.

Expected outcomes and deliverables for the Recovery and Recycling Consortium include:

- Technical details of the recovery and recycling processes at the component level for PEM fuel cells and electrolyzers.
- Analysis of the behavior of each recovery and/or recycling process.
- Validation and quantification of the performance of recovery or recycled materials, such as catalysts, membranes, bipolar plates, etc., versus virgin materials. Independent, third party, evaluation of recovered/recycled components may be requested at DOE's discretion.
- Development of a deployment plan covering the widespread adoption of recovery and recycling protocols, which can be used by the broader clean-hydrogen community.

Topic 6: Project Structure

Applicants should include proposals for activities (to be conducted by the consortium) of up to 5 years in length, for a maximum total DOE funding of $50,000,000 for the entire consortium. The funding request should be commensurate with the level of work proposed. Applicants should plan the project as a multi-phase effort with quantitative Go/No-Go decision points for each activity separating each phase (budget period). Analysis will guide R&D efforts and potential target revision. The awarded consortium partners in this topic must include **at least 20% cost share.**

Throughout the five years, additional FOAs may be released to add additional expertise to assist the consortium team and to begin implementing the ideas of the blueprint for validation. Potential future phases of the consortium will continue to facilitate further integration of recovery and recycling into the fuel cell and electrolyzer industry—considering the blueprint developed by the initial consortium (and the results of its validation efforts) and related advances achieved outside the consortium.

Topic 6: Teaming Arrangements

An optimal consortium team should comprise multiple partners covering diverse scientific, engineering, system design/integration, manufacturing, and project management disciplines. DOE is requiring a nonprofit or university to be the prime recipient and consortium lead; industry stakeholders, national laboratories, and/or non-lead universities are expected on the team as subrecipients. The proposed teaming arrangement should include a mix of technical partners that best addresses the consortium's specified technical scope of work and the associated review criteria. DOE highly encourages teams to include stack and component manufacturers and suppliers, universities and national labs, recyclers, and others. Applicants should succinctly describe the qualifications, experience, and capabilities of the proposed project team and how these will support successful execution of the project plan.

Selected teams will be encouraged to work with existing DOE projects and consortia, including HFTO's M2FCT[126] and H2NEW[127] consortia, to leverage resources, analysis, and expertise; and to avoid duplication of efforts. Teams may be requested to share pertinent data of the recycling processes with national laboratories, such as Argonne National Laboratory's GREET team, to inform comprehensive LCA. EOL stacks or components can be supplied to the consortium from DOE partners, if needed, to develop the recovery and recycling processes. Additional efforts to harmonize with other DOE initiatives and activities[128] are encouraged. Please see Section I.B.iii for more information on teaming.

All consortium members must qualify as a domestic entity, absent a waiver approved by DOE. The consortium selected for award negotiations will be required to have a process in place to review membership requests by foreign entities. Applications are required to include a non-disclosure agreement (NDA) and a memorandum of understanding (MOU) signed by all partners of the team.

Topic 6: Applications Specifically Not of Interest

- Applications focused on any technologies outside of proton exchange membrane fuel cell or electrolyzer recycling (including solid oxide, alkaline, alkaline exchange membranes, intermediate temperature membranes).
- Applications focused on recycling of balance-of-plant components.
- Applications for demonstration projects to build out recycling plants or manufacturing capabilities.

[126] M2FCT, millionmilefuelcelltruck.org.
[127] H2NEW, https://h2new.energy.gov/.
[128] Other DOE initiatives include Critical Minerals and Materials (https://www.energy.gov/eere/amo/critical-minerals-materials) and Manufacturing USA institutes (https://www.manufacturingusa.com/institutes) among others.

iii. Teaming Partner List

DOE is compiling a Teaming Partner List to facilitate the formation of new project teams for this FOA. The Teaming Partner List allows organizations who may wish to participate on an application to express their interest to other applicants and to explore potential partnerships. Any eligible entities (see Section III.A for eligibility requirements) can be included in the Teaming Partner List.

Updates to the Teaming Partner List will be available in the EERE eXCHANGE website (see link below). The Teaming Partner List will be regularly updated to reflect new teaming partners who provide their organization's information.

SUBMISSION INSTRUCTIONS: Any organization that would like to be included on this list should access the Teaming Partner List for this FOA (TPL-0000006) on EERE eXCHANGE here: https://eere-exchange.energy.gov/Default.aspx#FoaIdea4fb689-3439-433b-bdf0-31d1e334bdc0. Enter your organization, contact information, the topic in which you are interested, and any background information on your particular interests and capabilities (including MSI designation or disadvantaged community status, if relevant) and press *Register*. See the document titled "Topic and Background Information" posted on EERE eXCHANGE for instructions on what to include in these fields. Each entry should only include one topic area. Submit multiple entries if you are interested in partnering on more than one topic area. For further information regarding teaming partner lists, see https://eere-exchange.energy.gov/Manuals.aspx.

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 self-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.

H2 Matchmaker

As another avenue to find potential project partners, DOE launched H2 Matchmaker,[129] a voluntary online tool created to aid in fostering partnerships among key stakeholders by allowing potential partners to identify each other. H2 Matchmaker is an online information resource intended to help foster

[129] H2 Matchmaker, https://www.energy.gov/eere/fuelcells/h2-matchmaker.

partnerships by increasing awareness and aligning potential needs in specific regions of the United States.

H2 Matchmaker includes an interactive map containing self-reported clean-hydrogen producers, hydrogen consumers, infrastructure provider/operators, and other key stakeholders (e.g., government, tribal, labor, workforce development, safety codes and standards, financier/investor, environmental justice organizations), as well as contact information and capabilities of DOE's national laboratories. Participation by underrepresented groups and workforce organizations, including labor unions, is highly encouraged. H2 Matchmaker includes a Justice40 status designation to indicate participants that may be relevant to the Justice40 Initiative's intent to increase benefits and reduce harm.

H2 Matchmaker will be regularly updated to reflect new teaming partners who provide their organization's information. Any organization that would like to be included in H2 Matchmaker is encouraged to fill out the H2 Matchmaker Self-Identification form available at https://www.energy.gov/eere/fuelcells/h2-matchmaker.

C. Applications Specifically Not of Interest

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

- Applications that fall outside the technical parameters and areas of interest specified in Sections I.A. and I.B. of the FOA.
- Applications for proposed technologies that are not based on sound scientific principles (e.g., violates the laws of thermodynamics).
- Topic 1:
    - Applications to build manufacturing facilities.
    - Applications focused on equipment purchases for replication of existing processes.
    - Applications focused on balance of plant, system assembly, or system installation.
    - Applications that focus on the development of completely new materials or components, particularly at low TRLs.
- Topic 2:
    - Applications to build new manufacturing facilities or replicate existing manufacturing processes.

  - Applications focused on foundational electrolyzer research and/or early-stage electrolyzer materials/manufacturing research and development (e.g., completely new membrane polymer chemistries).
- Topic 3:
  - Applications on AEM technologies that use platinum group metals >0.05 mg/cm^2.
  - Applications on LA technologies that use platinum group metals.
  - Applications based on photoelectrochemical, solar thermochemical, microbial-assisted electrolysis, or non-electrolysis hydrogen production technologies.
  - Applications based on electrolyzer technologies not based on water-splitting (e.g., chloralkali processes).
- Topic 4:
  - Activities related to fuel cells other than PEM for heavy-duty applications, including alkaline, solid oxide, phosphoric acid, etc.
  - Activities related to supply chain development of gas diffusion layers (GDLs), bipolar plates (BPPs), catalysts, or membranes, addressed by other topics in the FOA.
  - Activities related to balance-of-plant (BOP), system assembly, or system installation.
  - Activities with strong focus on materials development.
- Topic 5:
  - Components and subcomponents for use in applications other than PEM fuel cells for medium-or heavy-duty transportation applications, including alkaline, solid oxide, phosphoric acid, phosphoric acid-based (PBI-type), etc.
  - Applications that duplicate existing production lines.
  - Applications focused on developing new, higher risk/low TRL GDL or BPP materials or manufacturing methods that end with only a small-scale demonstration. Rather, DOE is interested in taking proven, commercially viable materials or forms and scaling manufacturing processes to high volume.
  - Applications that demonstrate domestic process manufacturing of existing commercially available catalysts.
  - Applications focused solely on fundamental development of novel catalyst materials and/or structures at the bench scale.
  - Ionomers only for use in the fuel cell catalyst layer.
- Topic 6:
  - Applications focused on any technologies outside of proton exchange membrane fuel cell or electrolyzer recycling (including solid oxide,

alkaline, alkaline exchange membranes, intermediate temperature membranes).
- Applications focused on recycling of balance of plant components.
- Applications for demonstration projects to build out recycling plants or manufacturing capabilities.

D. R&D Community Benefits Plan

DOE is committed to investing in research and development (R&D) innovations that deliver benefits to the American public and leads 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 BIL FOA are expected to (1) advance diversity, equity, inclusion, and accessibility (DEIA); (2) contribute to energy equity; and (3) invest in America's workforce. To ensure these objectives are met, applications must include a Research and Development Community Benefits Plan (R&D Community Benefits Plan[130]) that addresses the three objectives stated above. See Section IV.D.xv and Appendix F for more information on the R&D Community Benefits Plan content requirements.

E. Authorizing Statutes

The programmatic authorizing statute is the Energy Policy Act of 2005 (EPAct 2005) Public Law 109-58 (Aug. 8, 2005), Title VIII, Sections 815-816 (42 U.S.C. Sections 16161c and 16161d) as amended by section 40314 of the BIL.

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

F. Notice of Bipartisan Infrastructure Law-Specific Requirements

Be advised that special terms and conditions apply to projects funded by the BIL relating to:
- Reporting, tracking and segregation of incurred costs;
- Reporting on job creation and preservation;

[130] Most DOE BIL FOAs focused on demonstration and deployment (D&D) also require a Community Benefits Plan; however, the plan content requirements for R&D-focused FOAs vary from the D&D Community Benefits Plan content requirements.

- Publication of information on the Internet;
- Access to records by Inspectors General and the Government Accountability Office;
- Requiring all of the iron, steel, manufactured goods, and construction materials used in the infrastructure activities of applicable projects are produced in the United States;
- Ensuring laborers and mechanics employed by contractors or subcontractors on BIL-funded projects are paid wages equivalent to prevailing wages on similar projects in the area;
- Protecting whistleblowers and requiring prompt referral of evidence of a false claim to an appropriate inspector general; and
- Certification and Registration.

Recipients of funding appropriated by the BIL must comply with requirements of all applicable federal, state, and local laws, regulations, DOE policy and guidance, and instructions in this FOA. Recipients must flow down the requirements to subrecipients to ensure the recipient's compliance with the requirements.

II. Award Information

A. Award Overview

i. Estimated Funding

DOE expects to make a total of approximately $750,000,000 of federal funding available for new awards under this FOA, subject to the availability of appropriated funds. The number of awards and funding for individual awards will depend on the specific topic area. DOE may issue one, multiple, or no awards for each topic area.

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

Topic Area Number	Topic Area Title	Anticipated Number of Awards	Anticipated Minimum Award Size for Any One Individual Award (Fed Share)	Anticipated Maximum Award Size for Any One Individual Award (Fed Share)	Approximate Total Federal Funding Available for All Awards	Anticipated Period of Performance (years)
1	Low-Cost, High-Throughput Electrolyzer Manufacturing	6-10	$20M	$50M	Up to $300M	Up to 3
2	Electrolyzer Component and Supply Chain Development	10-20	$5M	$10M	Up to $100M	3-4
3	Advanced Electrolyzer Technology and Component Development	15-30	$2M	$5M	Up to $70M	2-3
4	Fuel Cell MEA and Stack Manufacturing and Automation	5-7	$20M	$30M	Up to $150M	Up to 3
5	Fuel Cell Supply Chain Development	8-16	$3M	$10M	Up to $80M	2-4
6	Recovery and Recycling Consortium	1	$0	$50M	Up to $50M	5

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

ii. Period of Performance

DOE anticipates making awards that will run from 2 up to 5 years in length, depending on the topic area, comprised of one or more budget periods. Project continuation will be contingent upon several elements, including satisfactory performance and DOE's Go/No-Go decisions. For a complete list and more information on the Go/No-Go review, see Section VI.B.xv.

iii. New Applications Only

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

B. DOE Funding Agreements

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

i. Cooperative Agreements

DOE generally uses cooperative agreements to provide financial and other support to prime recipients.

Through cooperative agreements, DOE provides financial or other support to accomplish a public purpose of support or stimulation authorized by federal statute. Under cooperative agreements, the government and prime recipients share responsibility for the direction of projects.

DOE has substantial involvement in all projects funded via cooperative agreement. See Section VI.B.x. of the FOA for more information on what substantial involvement may involve.

ii. Funding Agreements with Federally Funded Research and Development Center (FFRDCs)[131]

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

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

III. Eligibility Information

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

A. Eligible Applicants

i. Domestic Entities

The proposed prime recipient and subrecipient(s) must be domestic entities. The following types of domestic entities are eligible to participate as a prime recipient or subrecipient of this FOA:

1. Institutions of higher education;
2. For-profit entities;
3. Non-profit entities; and
4. State and local governmental entities, and tribal nations.

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; have majority domestic ownership and control; and have a physical place of business in the United States.

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

The following DOE national laboratories are excluded from applying as either a prime recipient or subrecipient for the following topic areas:[132]

- Topic 2: All personnel at the core labs of the H2NEW consortium, including:
  - Argonne National Laboratory
  - Idaho National Laboratory
  - Lawrence Berkely National Laboratory
  - Lawrence Livermore National Laboratory
  - Los Alamos National Laboratory
  - National Energy Technology Laboratory
  - National Renewable Energy Laboratory

[132] Other funding opportunities that support the Clean Hydrogen Electrolysis Program will be available to DOE/NNSA FFRDCs, including the core labs that are excluded from applying to the topics listed.

  - Oak Ridge National Laboratory
  - Pacific Northwest National Laboratory
- Topic 3: All personnel at the core labs of the H2NEW, HydroGEN, and ElectroCat consortia, including:
  - Argonne National Laboratory
  - Idaho National Laboratory
  - Lawrence Berkely Laboratory
  - Lawrence Livermore National Laboratory
  - Los Alamos National Laboratory
  - National Energy Technology Laboratory
  - National Renewable Energy Laboratory
  - Oak Ridge National Laboratory
  - Pacific Northwest National Laboratory
  - Sandia National Laboratories

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

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

For Topic 6 of this FOA, United States universities or nonprofit organizations are the only entities eligible to apply as prime recipients; however, all entities are eligible to apply as subrecipients.

Entities banned from doing business with the United States government such as entities debarred, suspended, or otherwise excluded from or ineligible for participating in Federal programs are not eligible.

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.

ii. Foreign Entities

In limited circumstances, DOE may approve a waiver to allow a foreign entity to participate as a prime recipient or subrecipient. A foreign entity may submit a Full Application to this FOA, but the Full 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 Full Application for each proposed foreign subrecipient.

Appendix C lists the information that must be included in a foreign waiver request. The applicant does not have the right to appeal DOE's decision concerning a waiver request.

iii. Incorporated Consortia

Domestic incorporated consortia are eligible to apply for funding as a prime recipient or subrecipient. For consortia incorporated (or otherwise formed) under the laws of a state or territory of the United States, please refer to "Domestic Entities" above. For consortia incorporated in foreign countries, please refer to the requirements in "Foreign Entities" above.

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

iv. Unincorporated Consortia

Unincorporated Consortia must designate one member of the consortium to serve as the prime recipient/consortium representative. The prime recipient and consortium members must qualify as domestic entities, absent a foreign entity waiver approved by DOE.

Upon request, unincorporated consortia must provide the DOE Contracting Officer with a collaboration agreement, commonly referred to as the articles of collaboration, which sets out the rights and responsibilities of each consortium member. This agreement binds the individual consortium members together and should include the consortium's:

- Management structure;
- Method of making payments to consortium members;
- Means of ensuring and overseeing members' efforts on the project;
- Provisions for members' cost sharing contributions; and
- Provisions for ownership and rights in intellectual property developed previously or under the agreement.

B. Cost Sharing

Applicants are bound by the cost share proposed in their Full Applications if selected for award negotiations. Cost share requirements differ by topic area, as summarized in the table below:

Topic Area Number	Topic Area Title	Cost Share Requirement
1	Low-Cost, High-Throughput Electrolyzer Manufacturing	50%
2	Electrolyzer Component and Supply Chain Development	20%
3	Advanced Electrolyzer Technology and Component Development	20%*
4	Fuel Cell MEA and Stack Manufacturing and Automation	50%
5	Fuel Cell Component and Supply Chain Development	20%
6	Recovery and Recycling Consortium	20%

**For Institutions of Higher Education and Nonprofit Organizations, cost sharing is not required.*[133]

The cost share must be at least 20% of the total project costs[134] for research and development projects and 50% of the total project costs for demonstration and commercial application projects. [135] The cost share must come from non-federal sources unless otherwise allowed by law.

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

i. Legal Responsibility

Although the cost share requirement applies to the project as a whole, including work performed by members of the project team other than the prime recipient, the prime recipient is legally responsible for paying the entire cost share. If the funding agreement is terminated prior to the end of the project period, the prime recipient is required to contribute at least the cost share percentage of total expenditures incurred through the date of termination.

[133] Section 10725 of the Research and Development, Competition, and Innovation Act, P.L. 117-167 (Aug. 9, 2022) extends the cost share waiver pilot program enacted by Section 108 of the Department of Energy Research and Innovation Act, Public Law 115–246 (Innovation Act) and provides an exemption for institutions of higher education and nonprofit organizations from the 20% cost share requirement for Research and Development activities. The exemption is available for the two-year period beginning on August 9, 2022. Codified at 42 U.S.C. 16352.

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

[135] 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.

The prime recipient is solely responsible for managing cost share contributions by the project team and enforcing cost share obligations assumed by project team members in subawards or related agreements.

ii. Cost Share Allocation

Each project team is free to determine how best to allocate the cost share requirement among the team members. The amount contributed by individual project team members may vary, as long as the cost share requirement for the project as a whole is met.

iii. Cost Share Types and Allowability

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

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

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

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

Project teams may use funding or property received from state or local governments to meet the cost share requirement, so long as the funding was not provided to the state or local government by the federal government.

The recipient may not use the following sources to meet its cost share obligations including, but not limited to:

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

- Expenditures that were reimbursed under a separate federal program.

Project teams may not use the same cash or in-kind contributions to meet cost share requirements for more than one project or program.

Cost share contributions must be specified in the project budget, verifiable from the prime recipient's records, and necessary and reasonable for proper and efficient accomplishment of the project. As all sources of cost share are considered part of total project cost, the cost share dollars will be scrutinized under the same federal regulations as federal dollars to the project. Every cost share contribution must be reviewed and approved in advance by the Contracting Officer and incorporated into the project budget before the expenditures are incurred.

Applicants are encouraged to refer to 2 CFR 200.306 and 2 CFR 910.130 for additional cost sharing requirements.

iv. Cost Share Contributions by FFRDCs

Because FFRDCs are funded by the federal government, costs incurred by FFRDCs generally may not be used to meet the cost share requirement. FFRDCs may contribute cost share only if the contributions are paid directly from the contractor's Management Fee or another non-federal source.

v. Cost Share Verification

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

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

vi. Cost Share Payment

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

at a percentage commensurate with the FFRDC costs, on a budget period basis, resulting in a higher interim invoicing cost share ratio than the total award ratio.

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

C. Compliance Criteria

All applicant submissions must:

- comply with the applicable content and form requirements listed in Section IV of the FOA;
- include all required documents;
- be successfully uploaded in EERE Exchange https://eere-Exchange.energy.gov, including clicking the "Submit" button; and
- be submitted by the deadline stated in the FOA.

DOE will not review or consider submissions submitted through means other than EERE Exchange, submissions submitted after the applicable deadline, or incomplete submissions.

Applicants are strongly encouraged to submit their Concept Papers, Full Applications, and Replies to Reviewer Comments at least 48 hours in advance of the submission deadline. Under normal conditions (i.e., at least 48 hours in advance of the submission deadline), applicants should allow at least 1 hour to submit a Concept Paper, Full Application, or Reply to Reviewer Comments. Once the Concept Paper, Full Application, or Reply to Reviewer Comments is submitted in EERE Exchange, applicants may revise or update that submission until the expiration of the applicable deadline. If changes are made to any of these documents, the applicant must resubmit the Concept Paper, Full Application, or Reply to Reviewer Comments before the applicable deadline. 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. Responsiveness Criteria

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

E. Other Eligibility Requirements

i. Requirements for DOE/NNSA and non-DOE/NNSA FFRDCs Included as a Subrecipient

DOE/NNSA and non-DOE/NNSA FFRDCs may be proposed as a subrecipient on another entity's application subject to the eligibility restrictions provided in Section III.A.i. of the FOA and the following guidelines:

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

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

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

c. 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/NNSA FFRDCs participating as a subrecipient on a project will be funded directly through the DOE field work proposal (WP) process. Non-DOE/NNSA FFRDC 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.

Unless instructed otherwise by the DOE CO for the DOE award, all FFRDCs are required to enter into a Cooperative Research and Development Agreement[136] (CRADA) or, if the role of the DOE/NNSA FFRDC is limited to technical assistance and intellectual property is not anticipated to be generated from the DOE/NNSA FFRDC's work, a Technical Assistance Agreement (TAA), with at least the prime recipient before any project work begins. Any questions regarding the use of a CRADA or TAA should be directed to the cognizant DOE field intellectual property (IP) counsel.

The CRADA or TAA is used to ensure accountability for project work and provide the appropriate management of intellectual property (IP), e.g., data protection and background IP. The CRADA or TAA must be agreed upon by all parties and submitted to DOE or other sponsoring agency, when applicable, for approval, or submitted to DOE for notice under the Master Scope of Work process, when applicable, using any DOE or other sponsoring agency approved CRADA or TAA template without substantive changes by the time the award is made to the prime recipient.

d. Responsibility
The prime recipient will be the responsible authority regarding the settlement and satisfaction of all contractual and administrative issues including, but not limited to disputes and claims arising out of any agreement between the prime recipient and the FFRDC.

e. Limit on FFRDC effort.
The FFRDC effort, in aggregate, shall not exceed 25% of the total estimated cost of the project, including the applicant's and the FFRDC's portions of the effort.

[136] 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.

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

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

G. Questions Regarding Eligibility

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

IV. Application and Submission Information

A. Application Process

The application process includes multiple phases: a Concept Paper phase and a Full Application phase. **Only applicants who have submitted an eligible Concept Paper will be eligible to submit a Full Application**.

All submissions must conform to the form and content requirements described below, including maximum page lengths.

- Each must be submitted in Adobe PDF format unless stated otherwise;
- Each must be written in English;
- All pages must be formatted to fit on 8.5 x 11 inch paper with margins not less than one inch on every side. Use Calibri typeface, a black font color, and a font size of 12 point or larger (except in figures or tables, which may be 10 point font). A symbol font may be used to insert Greek letters or special characters, but the font size requirement still applies. References must be included as footnotes or endnotes in a font size of 10 or larger. Footnotes and endnotes are counted toward the maximum page requirement;
- A **control number** will be issued when an applicant begins the EERE Exchange application process. The control number must be included with all application documents. Specifically, the control number must be prominently displayed on the upper right corner of the header of every page and included in the file name (i.e., *Control Number_Applicant Name_Full Application*);
- Page numbers must be included in the footer of every page; and
- Each submission must not exceed the specified maximum page limit, including cover page, charts, graphs, maps, and photographs when printed

using the formatting requirements set forth above and single spaced. If applicants exceed the maximum page lengths indicated below, DOE will review only the authorized number of pages and disregard any additional pages.

i. Additional Information on EERE Exchange

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

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

B. Application Forms

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

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

TechnicalVolume_Part_1
TechnicalVolume_Part_2

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

C. Content and Form of the Concept Paper

Each Concept Paper must be limited to a single concept or technology. 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 (including Focus Area for Topics 2, 3, and 5), both the technical and business points of contact, names of all team member organizations, the project location(s), and any statements regarding confidentiality.
Technology Description	3 pages maximum **(Topic 3)** 5 pages maximum **(All other topics)**	Applicants are required to describe succinctly: • The proposed component and/or manufacturing technology, including its current status, basic operating principles and how it is unique and innovative; • 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, including to advance the state-of-the-art and/or lead to increased production capability or capacity to make progress towards stated DOE targets; • The key technical risks/issues associated with the proposed technology development plan and possible mitigation strategies; and • The impact that DOE funding would have on the proposed project.
R&D Community Benefits Plan	1 page maximum	Applicants are required to describe succinctly the approach to be taken with the R&D Community Benefits Plan, addressing the three core elements: • Advancing diversity, equity, inclusion, and accessibility; • Contributing to energy equity, including community and labor engagement leading to negotiated agreements, as applicable; and • Investing in America's workforce, including job quality and workforce continuity.
Addendum	2 pages maximum	Applicants are required to describe succinctly the qualifications, experience, and capabilities of the proposed Project Team, including: • Whether the Principal Investigator (PI) and Project Team have the skill and expertise

		needed to successfully execute the project plan; • Whether the applicant has prior experience which demonstrates an ability to perform tasks of similar risk and complexity; • Whether the applicant has worked together with its teaming partners on prior projects or programs; • 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.

DOE makes an independent assessment of each Concept Paper based on the criteria in Section V.A.i of the FOA. DOE will encourage a subset of applicants to submit Full Applications. Other applicants will be discouraged from submitting a Full Application. See Section VI.A.ii.

D. Content and Form of the Full Application

Applicants must complete the following application forms found on the EERE Exchange website at https://eere-Exchange.energy.gov/.

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

All Full Application documents must be marked with the control number issued to the applicant.

i. Full Application Content Requirements

Each Full Application must be limited to a single concept. Full Applications must conform to the following requirements and must not exceed the stated page limits.

Component	File Format	Page Limit	File Name
Technical Volume— **Topics 2, 3, and 5**	PDF	15 pages	ControlNumber_LeadOrganization_TechnicalVolume
Technical Volume— **Topics 1, 4, and 6**	PDF	30 pages	ControlNumber_LeadOrganization_TechnicalVolume
Resumes	PDF	3 pages each	ControlNumber_LeadOrganization_Resumes
Letters of Commitment	PDF	1 page each	ControlNumber_LeadOrganization_LOCs
Community Partnership Documentation *(optional)*	PDF	1 page each (max 5 total)	ControlNumber_LeadOrganization_PartnerDocs
SF-424	PDF	n/a	ControlNumber_LeadOrganization_App424
Budget Justification Workbook	MS Excel	n/a	ControlNumber_LeadOrganization_Budget_Justification
Summary/Abstract for Public Release	PDF	1	ControlNumber_LeadOrganization_Summary
Summary Slide(s)	MS Power Point	2	ControlNumber_LeadOrganization_Slide
Subrecipient Budget Justification (if applicable)	MS Excel	n/a	ControlNumber_LeadOrganization_Subrecipient_Budget_Justification
DOE Work Proposal for FFRDC, if applicable (see DOE O 412.1A, Attachments 1 and 2)	PDF	n/a	ControlNumber_LeadOrganization_WP
Authorization from cognizant Contracting Officer for FFRDC (if applicable)	PDF	n/a	ControlNumber_LeadOrganization_FFRDCAuth
SF-LLL Disclosure of Lobbying Activities (required)	PDF	n/a	ControlNumber_LeadOrganization_SF-LLL
Foreign Entity Waiver Requests and Foreign Work Waiver Requests (if applicable)	PDF	n/a	ControlNumber_LeadOrganization_Waiver
Locations of Work	PDF	n/a	Control Number_LeadOrganization_LOW
R&D Community Benefits Plan— **Topics 2, 3, and 5**	PDF	5 pages	ControlNumber_LeadOrganization_CBenefits
R&D Community Benefits Plan— **Topics 1, 4, and 6**	PDF	10 pages	ControlNumber_LeadOrganization_CBenefits
Current and Pending Support	PDF	n/a	ControlNumber_LeadOrganization_CPS
Transparency of Foreign Connections	PDF	n/a	ControlNumber_LeadOrganization_TFC
Potentially Duplicative Funding Notice (if applicable)	PDF	n/a	ControlNumber_LeadOrganization_PDF

Note: The maximum file size that can be uploaded to the EERE Exchange website is 50MB. See Section IV.B.

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

ii. 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 Section V of the FOA. Save the Technical Volume in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_TechnicalVolume."

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

The Technical Volume to the Full Application may not be more than 15 pages for **Topics 2, 3, and 5** or 30 pages for **Topics 1, 4, and 6.** These page limits include the cover page, table of contents, and all citations, charts, graphs, maps, photos, or other graphics, and must include all of the information in the table below. The applicant should consider the weighting of each of the technical review criterion (see Section V of the FOA) when preparing the Technical Volume.

The Technical Volume should clearly describe and expand upon information provided in the Concept Paper and address specific requirements described in the Topic Area descriptions (Section I.B).

Technical Volume Content Requirements	
SECTION/PAGE LIMIT	**DESCRIPTION**
Cover Page	The cover page should include the project title, the specific FOA Topic Area being addressed (including Focus Area for Topics 2, 3, and 5), both the technical and business points of contact, names of all team member organizations, names of project managers, senior/key personnel and their organizations, the project location(s), and any 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 their organization, including the history, successes, and current research and development status (i.e., the technical baseline) relevant to the technical topic being addressed in the Full Application. • Project Goal: The applicant should explicitly identify the targeted improvements to the baseline technology and the critical success factors in achieving that goal, including the ways in which the proposed project location and related infrastructure, skilled workforce, community benefits, etc. will contribute to the success of the overall project. • 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. • Identify any potential long-term constraints project will have on community's access to natural resources (e.g., water) and tribal cultural resources. If applicable, describe a long-term cleanup strategy that ensures communities and neighborhoods remain healthy and safe and not burdened with cleanup costs and waste. • As applicable, the applicant should outline a climate resilience strategy that accounts for climate impacts and extreme weather patterns such as high winds (tornadoes and hurricanes), heat and freezing temperatures, drought, wildfire, and floods.
Technical Description, Innovation, and Impact (Approximately 30% of the Technical Volume)	Applicants should consult Section I.B for specific requirements listed in the Topic Area descriptions. In general, 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 FOA, including the potential to meet

	specific DOE technical targets or other relevant performance and/or manufacturing objectives. 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, 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. The impact on a domestic supply chain, such as building new stakeholder relationships, should also be described, if applicable. This section should also include preliminary, boundary-level, technoeconomic analysis, manufacturing analysis, and/or life cycle assessment if solicited in the topic description.
Workplan (Approximately 40% of the Technical Volume)	The Workplan should include a summary of the Project Objectives, Technical Scope, Work Breakdown Structure (WBS), Milestones, Go/No-Go decision points, and Project Schedule. The Workplan should contain the following information: • Project Objectives: The applicant should provide a clear and concise (high-level) statement of the goals and objectives of the project as well as the expected outcomes. • Technical Scope Summary: The applicant should provide a summary description of the overall work scope and approach to achieve the objective(s). The overall work scope is to be divided by performance periods that are separated by discrete, approximately annual decision points (see below for more information on Go/No-Go decision points). The applicant should describe the specific expected end result of each performance period, 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 (including milestones identified in the Community Benefits Plan), will accomplish the final project goal(s), and will produce all deliverables. The Workplan is to be structured with a hierarchy of performance period (approximately annual), task and subtasks, which is typical of a standard WBS for any project. The Workplan shall contain a concise description of the specific activities to be conducted over the life of the project. The description shall be a full explanation and disclosure of the project being proposed (i.e., a statement such as "we

will then complete a proprietary process" is unacceptable). It is the applicant's responsibility to prepare an adequately detailed task plan to describe the proposed project and the plan for addressing the objectives of this FOA.

- Milestone Summary: The applicant should provide a summary of appropriate milestones (including milestones identified in the Community Benefits Plan) throughout the project to demonstrate success. A milestone may be either a progress measure (which can be activity based) or a SMART technical milestone. SMART milestones should be Specific, Measurable, Achievable, Relevant, and Timely, and must demonstrate a technical achievement rather than simply completing a task. Unless otherwise specified in the FOA, the minimum requirement is that each project must have at least one milestone per quarter for the duration of the project with at least one SMART technical milestone per year (depending on the project, more milestones may be necessary to comprehensively demonstrate progress). The applicant should also provide how the milestone will be verified.
- Go/No-Go Decision Points (See Section VI.B.xv. for more information on the Go/No-Go Review): 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 to 18-month period) of the project. See Section VI.B.xiv and Section VI.B.xv. 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. Go/No-Go decision points are considered "SMART" and can fulfill the requirement for an annual SMART milestone.
- End of Project Goal: The applicant should provide a summary of the end of project goal(s). At a minimum, each project must have one SMART end of project goal.
- Project Schedule (Gantt Chart or similar): The applicant should provide a schedule for the entire project, including task and subtask durations, milestones, and Go/No-Go decision points.
- Buy America Requirements for Infrastructure Projects: Within the first 2 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 Appendix D 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, schedule delays, cost increases, and other supply chain risks. ○ 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. • *For Topics 1, 2, 4, and 5 only:* Market Impact 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 that includes community and labor engagement as applicable. ○ 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. ○ Identification of how the proposed technology, process, or project will impact domestic manufacturing capacity and supply chains.
Technical Qualifications and Resources (Approximately 20% of the Technical Volume)	The Technical Qualifications and Resources should contain the following information: • Describe the project team's unique qualifications and expertise, including those of key subrecipients. • Describe the project team's existing equipment and facilities, 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.

	• This section should also include relevant, previous work efforts, demonstrated innovations, and how these enable the applicant to achieve the project objectives.
	• Describe the time commitment of the key team members to support the project.
	• Describe the technical services to be provided by DOE/NNSA FFRDCs, if applicable.
	• Describe the skills, certifications, or other credentials of the construction and ongoing operations workforce, if applicable.
	• For multi-organizational projects, describe succinctly:
	  ○ The roles and the work to be performed by the Project Manager and senior/key personnel at the prime and sub levels;
	  ○ Business agreements between the applicant and sub;
	  ○ How the various efforts will be integrated and managed;
	  ○ Process for making decisions on technical direction;
	  ○ Publication arrangements;
	  ○ Intellectual Property issues; and
	  ○ Communication plans.

iii. Resumes

A resume provides information that can be used by reviewers to evaluate the individual's skills, experience, and potential for leadership within the scientific community. Applicants must submit a three-page resume for each Principal Investigator or Lead Project Manager and Senior/Key Personnel that include the following:

1. Contact Information;
2. Education and training: Provide institution, major/area, degree, and year for undergraduate, graduate, and postdoctoral training, and any other relevant certifications or credentials;
3. Research and Professional Experience: Beginning with the current position, list professional/academic positions in chronological order with a brief description. List all current academic, professional, or institutional appointments, foreign or domestic, at the applicant institution or elsewhere, whether or not remuneration is received, and, whether full-time, part-time, or voluntary;
4. Awards and honors;

5. A list of up to 10 publications most closely related to the proposed project. For each publication, identify the names of all authors (in the same sequence in which they appear in the publication), the article title, book or journal title, volume number, page numbers, year of publication, and website address if available electronically. Patents, copyrights, and software systems developed may be provided in addition to or substituted for publications. An abbreviated style such as the Physical Review Letters (PRL) convention for citations (list only the first author) may be used for publications with more than 10 authors;
6. Synergistic Activities: List up to five professional and scholarly activities related to the proposed effort; and
7. There should be no lapses in time over the past ten years or since age 18, which ever time period is shorter.

As an alternative to a resume, it is acceptable to use the biographical sketch format approved by the National Science Foundation (NSF). The biographical sketch format may be generated by the Science Experts Network Curriculum Vita (SciENcv), a cooperative venture maintained at https://www.ncbi.nlm.nih.gov/sciencv/, and is also available at https://nsf.gov/bfa/dias/policy/nsfapprovedformats/biosketch.pdf. The use of a format required by another agency is intended to reduce the administrative burden to researchers by promoting the use of common formats.

Save the resumes in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_Resumes."

iv. Letters of Commitment

Submit letters of commitment from all subrecipient and third-party cost share providers. If applicable, the letter must state that the third party is committed to providing a specific minimum dollar amount or value of in-kind contributions allocated to cost sharing. The following information for each third party contributing to cost sharing should be identified: (1) the name of the organization; (2) the proposed dollar amount to be provided; and (3) the proposed cost sharing type – (cash or in-kind contributions). Each letter must not exceed 1 page. Save the letters of commitment in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_LOCs."

Letters of support or endorsement for the project from entities that do not have a substantive role in the project are not accepted.

v. Community Partnership Documentation

In support of the Community Benefits Plan (particularly for Topics 1 and 4), applicants may submit documentation to demonstrate existing or planned partnerships with community entities, such as, organizations that work with local stakeholders most vulnerable to or affected by the project, such as organizations that carry out workforce development programs, labor unions, Tribal organizations, and community-based organizations that work with disadvantaged communities. The partnership documentation could be in the form of a letter on the partner's letterhead outlining the planned partnership signed by an officer of the entity, a Memorandum of Understanding, or other similar agreement. Such letters must state the specific nature of the partnership and must not be general letters of support. Each letter must not exceed 1 page. In total, the partnership documentation must not exceed 5 pages. Save the partnership documentation in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_PartnerDoc."

vi. SF-424: Application for Federal Assistance

Applicants must complete the SF-424 Application for Federal Assistance, which is available on EERE eXCHANGE at https://eere-eXCHANGE.energy.gov/. Complete all required fields in accordance with the instructions on the form. The list of certifications and assurances in Field 21 can be found at http://energy.gov/management/office-management/operational-management/financial-assistance/financial-assistance-forms, under Certifications and Assurances. Note: The dates and dollar amounts on the SF-424 are for the complete project period and not just the first project year, first phase or other subset of the project period. Save the SF-424 in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_424."

vii. Budget Justification Workbook

Applicants must complete the Budget Justification Workbook, which is available on EERE Exchange at https://eere-Exchange.energy.gov/. Applicants must complete each tab of the Budget Justification Workbook for the project as a whole, including all work to be performed by the prime recipient and its subrecipients and contractors. Applicants should include costs associated with implementing the various BIL-specific requirements (e.g., Buy America requirements for infrastructure projects, Davis Bacon, Community Benefits Plan, reporting, oversight) and with required annual audits and incurred cost proposals in their proposed budget documents. Such costs may be reimbursed as a direct or indirect cost. The "Instructions and Summary" included with the Budget Justification Workbook will auto-populate as the applicant enters information into the Workbook. Applicants must carefully read the "Instructions

and Summary" tab provided within the Budget Justification Workbook. Save the Budget Justification Workbook in a single Microsoft Excel file using the following convention for the title "ControlNumber_LeadOrganization_Budget_Justification."

viii. Summary for Public Release

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

ix. Summary Slides

Applicants must provide Summary Slide(s) summarizing the proposed project that include the following information:

- A technology summary;
- A description of the technology's impact;
- Proposed project goals;
- List of Go/No-go and other key milestones;
- Any key graphics (illustrations, charts and/or tables);
- The project's key idea/takeaway;
- Topline diversity, equity, workforce, and community benefits;
- Project title, prime recipient, subrecipients, Principal Investigator/Lead Project Manager, and senior/key personnel information; and
- Requested DOE funds and proposed applicant cost share.

A Summary Slide Template is provided for your convenience in the "Application Forms and Templates" section of EERE eXCHANGE at https://eere-eXCHANGE.energy.gov/. Save the Summary Slide (2-page limit) in a single Microsoft PowerPoint file using the following convention for the title "ControlNumber_LeadOrganization_Slide."

x. Subrecipient Budget Justification (if applicable)

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

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

If a DOE/NNSA FFRDC is to perform a portion of the work, the applicant must provide a DOE WP in accordance with the requirements in DOE Order 412.1A, Work Authorization System, Attachments 1 and 2, available at: https://www.directives.doe.gov/directives-documents/400-series/0412.1-BOrder-a-chg1-AdmChg. Save the WP in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_WP."

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

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

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

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

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

- An officer or employee of any federal agency;

- A member of Congress;
- An officer or employee of Congress; or
- An employee of a member of Congress.

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

xiv. Waiver Requests (if applicable)

Foreign Entity Participation
For projects selected under this FOA, all recipients and subrecipients must qualify as domestic entities. See Section III. To request a waiver of this requirement, the applicant must submit an explicit waiver request in the Full Application. Appendix C lists the information that must be included in a waiver request.

Performance of Work in the United States (Foreign Work Waiver)
As set forth in Section IV.J.iii., all work for the projects selected under this FOA must be performed in the United States. To request a waiver of this requirement, the applicant must submit an explicit waiver request in the Full Application. Appendix C lists the information that must be included in a foreign work waiver request.

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

xv. R&D Community Benefits Plan

The R&D Community Benefits Plan must set forth the applicant's approach to ensuring the Federal investments advance the following three objectives: (1) advance diversity, equity, inclusion, and accessibility (DEIA); (2) contribute to energy equity; and (3) invest in America's workforce. The below sections set forth the content requirements for the R&D Community Benefits Plan, which addresses each of the preceding objectives. Applicants must address all three sections.

The applicant's R&D Community Benefits Plan must include at least one Specific, Measurable, Assignable, Relevant, and Timely (SMART) milestone per budget period to measure progress on the proposed actions. These milestones should also be included the Work Plan in the Technical Volume and accounted for in the project budget. The R&D Community Benefits Plan will be evaluated as part of the technical review process, including the extent to which the team and

resources—including staff, facilities, capabilities, and budget—are capable of adequately implementing the plans outlined in the Community Benefits Plan. If EERE selects a project, EERE will incorporate the R&D Community Benefits Plan into the award and the recipient must implement its R&D Community Benefits Plan as part of carrying out its project. During the life of the EERE award, EERE will evaluate the recipient's progress, including as part of the Go/No-Go review process.

The plan should be specific to the proposed project and not a restatement of organizational policies. Applicants should describe the future implications or a milestone-based plan for identifying future implications of their research on energy equity, including, but not limited to, benefits for the U.S. workforce. These impacts may be uncertain, occur over a long period of time, and/or have many factors within and outside the specific proposed research. Applicants are encouraged to describe the influencing factors and the most likely workforce and energy equity implications of the proposed R&D if the research is successful. The applicant should also explain any ways that the proposed actions could contribute to the President's goal that 40% of the overall benefits of Federal investments in climate and energy will flow to disadvantaged communities (the Justice40 Initiative).[137] While some guidance and example activities are provided in Appendix F, applicants are encouraged to leverage promising practices and develop a plan that is tailored for their project.

The R&D Community Benefits Plan must not exceed five (5) pages for **Topics 2, 3, and 5** or ten (10) pages for **Topics 1, 4, and 6**. It must be submitted in PDF format using the following convention name for the title: "Control Number_LeadOrganization_CBP." This Plan must address the technical review criterion titled, "R&D Community Benefits Plan." See Section V. of the FOA.

The applicant's R&D Community Benefits Plan must address the following three sections:

1) Diversity, Equity, Inclusion, and Accessibility:

[137] Benefits include (but are not limited to) measurable direct or indirect investments or positive project outcomes that achieve or contribute to the following in disadvantaged communities: (1) a decrease in energy burden; (2) a decrease in environmental exposure and burdens; (3) an increase in access to low-cost capital; (4) an increase in high-quality job creation, the clean energy job pipeline, and job training for individuals; (5) increases in clean energy enterprise creation and contracting (e.g., minority-owned or disadvantaged business enterprises); (6) increases in energy democracy, including community ownership; (7) increased parity in clean energy technology access and adoption; and (8) an increase in energy resilience.

To build a clean and equitable energy economy, it is important that there are opportunities for people of all racial, ethnic, socioeconomic and geographic backgrounds, sexual orientation, gender identity, persons with disabilities, and those re-entering the workforce from incarceration. This section of the plan must demonstrate how DEIA is incorporated in the technical project objectives. This section must identify specific actions the applicant would undertake to help achieve DEIA that is integrated into the research goals and project teams. Submitting an institutional DEIA plan without specific integration into the project will be deemed insufficient.

2) Energy Equity:
This section must articulate the applicant's consideration of long-term equity implications of the research. It must identify how the specific project integrates equity considerations into the project design to support equitable outcomes should the innovation be successful. Like cost reductions and commercialization plans, the R&D Community Benefits Plan requires a description of the equity implications of the innovation if successful, including the extent to which the project would provide measurable benefits to disadvantaged communities.

3) Workforce Implications:
This section must articulate the applicant's consideration of long-term workforce impacts and opportunities of the research. It must identify how the project is designed and executed to include an understanding of the future workforce needs should the resulting innovation be successful.

See Appendix F for more guidance.

xvi. Current and Pending Support

Current and pending support is intended to allow the identification of potential duplication, overcommitment, potential conflicts of interest or commitment, and all other sources of support. As part of the application, the principal investigator or lead project manager and all senior/key personnel at the applicant and subrecipient level must provide a list of all sponsored activities, awards, and appointments, whether paid or unpaid; provided as a gift with terms or conditions or provided as a gift without terms or conditions; full-time, part-time, or voluntary; faculty, visiting, adjunct, or honorary; cash or in-kind; foreign or domestic; governmental or private-sector; directly supporting the individual's research or indirectly supporting the individual by supporting students, research staff, space, equipment, or other research expenses. All connections with foreign government-sponsored talent recruitment programs must be identified in current and pending support.

For every activity, list the following items:

- The sponsor of the activity or the source of funding;
- The award or other identifying number;
- The title of the award or activity. If the title of the award or activity is not descriptive, add a brief description of the research being performed that would identify any overlaps or synergies with the proposed research;
- The total cost or value of the award or activity, including direct and indirect costs and cost share. For pending proposals, provide the total amount of requested funding;
- The award period (start date – end date); and
- The person-months of effort per year being dedicated to the award or activity.

To identify overlap, duplication of effort, or synergistic efforts, append a description of the other award or activity to the current and pending support.

Details of any obligations, contractual or otherwise, to any program, entity, or organization sponsored by a foreign government must be provided on request to either the applicant institution or DOE. Supporting documents of any identified source of support must be provided to DOE on request, including certified translations of any document.

PIs and senior/key personnel must provide a separate disclosure statement listing the required information above regarding current and pending support. Each individual must sign and date their respective disclosure statement and include the following certification statement:

> I, [Full Name and Title], certify to the best of my knowledge and belief that the information contained in this Current and Pending Support Disclosure Statement is true, complete, and accurate. I understand that any false, fictitious, or fraudulent information, misrepresentations, half-truths, or omissions of any material fact, may subject me to criminal, civil or administrative penalties for fraud, false statements, false claims or otherwise. (18 U.S.C. §§ 1001 and 287, and 31 U.S.C. §§ 3729-3733 and 3801-3812). I further understand and agree that (1) the statements and representations made herein are material to DOE's funding decision, and (2) I have a responsibility to update the disclosures during the period of

performance of the award should circumstances change which impact the responses provided above.

The information may be provided in the format approved by the National Science Foundation (NSF), which may be generated by the Science Experts Network Curriculum Vita (SciENcv), a cooperative venture maintained at https://www.ncbi.nlm.nih.gov/sciencv/, and is also available at https://www.nsf.gov/bfa/dias/policy/nsfapprovedformats/cps.pdf. The use of a format required by another agency is intended to reduce the administrative burden to researchers by promoting the use of common formats. If the NSF format is used, the individual must still include a signature, date, and a certification statement using the language included in the paragraph above.

Save the Current and Pending Support in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_CPS."

Definitions:

Current and pending support – (a) All resources made available, or expected to be made available, to an individual in support of the individual's RD&D efforts, regardless of (i) whether the source is foreign or domestic; (ii) whether the resource is made available through the entity applying for an award or directly to the individual; or (iii) whether the resource has monetary value; and (b) includes in-kind contributions requiring a commitment of time and directly supporting the individual's RD&D efforts, such as the provision of office or laboratory space, equipment, supplies, employees, or students. This term has the same meaning as the term Other Support as applied to researchers in NSPM-33: For researchers, Other Support includes all resources made available to a researcher in support of and/or related to all of their professional RD&D efforts, including resources provided directly to the individual or through the organization, and regardless of whether or not they have monetary value (e.g., even if the support received is only in-kind, such as office/laboratory space, equipment, supplies, or employees). This includes resource and/or financial support from all foreign and domestic entities, including but not limited to, gifts provided with terms or conditions, financial support for laboratory personnel, and participation of student and visiting researchers supported by other sources of funding.

Foreign Government-Sponsored Talent Recruitment Program – An effort directly or indirectly organized, managed, or funded by a foreign government, or a foreign government instrumentality or entity, to recruit science and technology professionals or students (regardless of citizenship or national origin, or whether having a full-time or part-time position). Some foreign government-sponsored

talent recruitment programs operate with the intent to import or otherwise acquire from abroad, sometimes through illicit means, proprietary technology or software, unpublished data and methods, and intellectual property to further the military modernization goals and/or economic goals of a foreign government. Many, but not all, programs aim to incentivize the targeted individual to relocate physically to the foreign state for the above purpose. Some programs allow for or encourage continued employment at United States research facilities or receipt of federal research funds while concurrently working at and/or receiving compensation from a foreign institution, and some direct participants not to disclose their participation to United States entities. Compensation could take many forms including cash, research funding, complimentary foreign travel, honorific titles, career advancement opportunities, promised future compensation, or other types of remuneration or consideration, including in-kind compensation.

Senior/key personnel – an individual who contributes in a substantive, meaningful way to the scientific development or execution of a research, development and demonstration (RD&D) project proposed to be carried out with DOE award.[138]

xvii. Locations of Work

The applicant must complete the supplied template by listing the city, state, and zip code + 4 for each location where project work will be performed by the prime recipient or subrecipient(s). Save the completed template as a MS Excel file using the following convention for the title "ControlNumber_LeadOrganization_LOW."

xviii. Transparency of Foreign Connections

Applicants must identify the following as they relate to the proposed recipient and subrecipients. Include a separate disclosure for the applicant and each proposed subrecipient. U.S. National Laboratories, domestic government entities, and institutions of higher education are only required to respond to items 1, 2 and 9, and if applying as to serve as the prime recipient, must provide complete responses for project team members that are not U.S. National Laboratories, domestic government entities, or institutions of higher education.

1. Entity Name, website address and physical address;

[138] Typically, these individuals have doctoral or other professional degrees, although individuals at the masters or baccalaureate level may be considered senior/key personnel if their involvement meets this definition. Consultants, graduate students, and those with a postdoctoral role also may be considered senior/key personnel if they meet this definition.

2. The identity of all owners, project managers, PIs and senior/key personnel who are a party to any *Foreign Government-Sponsored Talent Recruitment Program* of a foreign country of risk (i.e., China, Iran, North Korea, and Russia);
3. The existence of any joint venture or subsidiary that is based in, funded by, or has a foreign affiliation with any foreign country of risk, including the People's Republic of China;
4. Any current or pending contractual or financial obligation or other agreement specific to a business arrangement, or joint venture-like arrangement with an enterprise owned by a foreign state or any foreign entity;
5. Percentage, if any, that the proposed recipient or subrecipient has foreign ownership or control;
6. Percentage, if any, that the proposed recipient or subrecipient is wholly or partially owned by an entity in a foreign country of risk;
7. The percentage, if any, of venture capital or institutional investment by an entity that has a general partner or individual holding a leadership role in such entity who has a foreign affiliation with any foreign country of risk;
8. Any technology licensing or intellectual property sales to a foreign country of risk, during the 5-year period preceding submission of the proposal;
9. Any foreign business entity, offshore entity, or entity outside the United States related to the proposed recipient or subrecipient;
10. Complete list of all directors (and board observers), including their full name, citizenship and shareholder affiliation, date of appointment, duration of term, as well as a description of observer rights as applicable;
11. Complete capitalization table for your entity, including all equity interests (including LLC and partnership interests, as well as derivative securities). Include both the number of shares issued to each equity holder, as well as the percentage of that series and all equity on a fully diluted basis. Identify the principal place of incorporation (or organization) for each equity holder. If the equity holder is a natural person, identify the citizenship(s). If the recipient or subrecipient is a publicly traded company, provide the above information for shareholders with an interest greater than five percent;
12. A summary table identifying all rounds of financing, the purchase dates, the investors for each round, and all the associated governance and information rights obtained by investors during each round of financing; and

13. An organization chart to illustrate the relationship between your entity and the immediate parent, ultimate parent, and any intermediate parent, as well as any subsidiary or affiliates. Identify where each entity is incorporated.

Save the information requested in a separate Word file using the following convention for the title "ControlNumber_LeadOrganization_TFC."

xix. Potentially Duplicative Funding Notice

If the applicant or project team member has other active awards of federal funds, the applicant must determine whether the activities of those awards potentially overlap with the activities set forth in its application to this FOA. If there is a potential overlap, the applicant must notify DOE in writing of the potential overlap and state how it will ensure any project funds (i.e., recipient cost share and federal funds) will not be used for identical cost items under multiple awards. Likewise, for projects that receive funding under this FOA, if a recipient or project team member receives any other award of federal funds for activities that potentially overlap with the activities funded under the DOE award, the recipient must promptly notify DOE in writing of the potential overlap and state whether project funds from any of those other federal awards have been, are being, or are to be used (in whole or in part) for one or more of the identical cost items under the DOE award. If there are identical cost items, the recipient must promptly notify the DOE Contracting Officer in writing of the potential duplication and eliminate any inappropriate duplication of funding.

Save the Potentially Duplicative Funding Notice in a single PDF file using the following convention for the title "ControlNumber_LeadOrganization_PDFN.pdf."

E. Content and Form of Replies to Reviewers Comments (Optional Submission)

DOE will provide applicants with reviewer comments following the evaluation of all eligible Full Applications. Applicants have a brief opportunity to prepare a short Reply to Reviewer Comments (Reply). The Reply must not exceed five (5) pages. If a Reply is more than five (5) pages in length, DOE will review only the first five (5) pages and disregard any additional pages. Applicants may use the Reply to respond to one or more comments or to supplement their Full Application. The Reply may include text, graphs, charts, or data.

DOE will post the reviewer comments in EERE Exchange. The expected submission deadline is on the cover page of the FOA; however, it is the applicant's responsibility to monitor EERE Exchange in the event that the

expected date changes. The deadline will not be extended for applicants who are unable to timely submit their Reply due to failure to check EERE Exchange or relying on the expected date alone. Applicants should anticipate having three to five business days to submit a Reply.

Applicants are not required to submit a Reply to Reviewer Comments. DOE will review and consider each eligible Full Application, even if no Reply is submitted or if the Reply is found to be ineligible.

F. Post Selection Information Requests

If selected for award negotiations, DOE reserves the right to require that selected applicants provide additional or clarifying information regarding the application submissions, the project, the project team, the award requirements, and any other matters related to anticipated award. The following is a non-exhaustive list of examples of information that may be required:

- Personnel proposed to work on the project and collaborating organizations (See Section VI.B.xx. Participants and Collaborating Organizations);
- Current and Pending Support (See Sections IV.D.xvi. and VI.B.xxi. Current and Pending Support);
- An Intellectual Property Management Plan (if applicable) describing how the project team/consortia members will handle intellectual property rights and issues between themselves while ensuring compliance with federal intellectual property laws, regulations, and policies in accordance with Section VI.B.xi. Intellectual Property Management Plan;
- A Data Management Plan (if applicable) describing how all research data displayed in publications resulting from the proposed work will be digitally accessible at the time of publications, in accordance with Section VI.B.xxiv.;
- Indirect cost information;
- Other budget information;
- Letters of Commitment from third parties contributing to cost share, if applicable;
- Name and phone number of the Designated Responsible Employee for complying with national policies prohibiting discrimination (See 10 CFR 1040.5);
- Information for the DOE Office of Civil Rights to process assurance reviews under 10 CFR 1040;
- Representation of Limited Rights Data and Restricted Software, if applicable;
- Information related to Davis-Bacon Act Requirements;

- Information related to any proposed Workforce and Community Agreement, as defined above in "R&D Community Benefits Plan" that applicants may have made with the relevant community; and
- Environmental Questionnaire, DOE F 540.

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

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

NOTE: Due to the high demand of UEI requests and SAM registrations, entity legal business name and address validations are taking longer than expected to process. Entities should start the UEI and SAM registration process as soon as possible. If entities have technical difficulties with the UEI validation or SAM registration process they should utilize the **HELP** feature on **SAM.gov**. SAM.gov will work entity service tickets in the order in which they are received and asks that entities not create multiple service tickets for the same request or technical issue. Additional entity validation resources can be found here: GSAFSD Tier 0 Knowledge Base - Validating your Entity.

H. Submission Dates and Times

All required submissions must be submitted in EERE Exchange no later than 5 p.m. ET on the dates provided on the cover page of this FOA.

I. Intergovernmental Review

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

J. Funding Restrictions

i. Allowable Costs

All expenditures must be allowable, allocable, and reasonable in accordance with the applicable federal cost principles. Pursuant to 2 CFR 910.352, the cost principles in the Federal Acquisition Regulations (48 CFR 31.2) apply to for-profit entities. The cost principles contained in 2 CFR Part 200, Subpart E apply to all entities other than for-profits.

ii. Pre-Award Costs

Applicants selected for award negotiations (selectee) must request prior written approval to charge pre-award costs. Pre-award costs are those incurred prior to the effective date of the federal award directly pursuant to the negotiation and in anticipation of the federal award where such costs are necessary for efficient and timely performance of the scope of work. Such costs are allowable only to the extent that they would have been allowable if incurred after the date of the federal award and **only** with the written approval of the federal awarding agency, through the DOE Contracting Officer.

Pre-award costs cannot be incurred prior to the Selection Official signing the Selection Statement and Analysis.

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

1. **National Environmental Policy Act (NEPA) Requirements Related to Pre-Award Costs**

   DOE's decision whether and how to distribute federal funds under this FOA is subject to NEPA. Applicants should carefully consider and should seek legal counsel or other expert advice before taking any action related to the proposed project that would have an adverse effect on the environment or limit the choice of reasonable alternatives prior to DOE completing the NEPA review process.

   DOE does not guarantee or assume any obligation to reimburse pre-award costs incurred prior to receiving written authorization from the Contracting Officer. If the applicant elects to undertake activities that DOE determines may have an adverse effect on the environment or limit the choice of

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

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

1. Requirement

All work performed under awards issued under this FOA must be performed in the United States. The prime recipient must flow down this requirement to its subrecipients.

2. Failure to Comply

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

3. Waiver

To seek a foreign work waiver, the applicant must submit a written waiver request to DOE. Appendix C lists the information that must be included in a request for a foreign work waiver.

Save the waiver request(s) in a single PDF file. The applicant does not have the right to appeal DOE's decision concerning a waiver request.

iv. Construction

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

For large construction projects), DOE may require a Project Labor Agreement (PLA). A PLA is a pre-hire agreement between a private entity (or entities) and a labor organization (or organizations) representing individuals who will be working on the construction project. Assessment of applicability will be conducted on a case-by-case basis.

v. Foreign Travel

If international travel is proposed for your project, please note that your organization must comply with the International Air Transportation Fair Competitive Practices Act of 1974 (49 U.S.C. § 40118), commonly referred to as the "Fly America Act," and implementing regulations at 41 CFR 301-10.131 through 301-10.143. The law and regulations require air transport of people or property to, from, between, or within a country other than the United States, the cost of which is supported under this award, to be performed by or under a cost-sharing arrangement with a United States flag carrier, if service is available. Foreign travel costs are allowable only with the written prior approval of the Contracting Officer assigned to the award.

vi. Equipment and Supplies

Property disposition may be required at the end of a project if the current fair market value of property exceeds $5,000. For-profit entity disposition requirements are set forth at 2 CFR 910.360. Property disposition requirements for other non-federal entities are set forth in 2 CFR 200.310 – 200.316. See section VI.B.xviii of the FOA for more information on property disposition or request for continued use.

vii. Buy America Requirements for Infrastructure Projects

Pursuant to the Build America Buy America Act, subtitle IX of BIL (Buy America, or "BABA"), federally assisted projects that involve infrastructure work, undertaken by applicable recipient types, require that:

- All iron, steel, and manufactured products used in the infrastructure work are produced in the United States; and
- 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 that term is 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 Appendix D of this FOA 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.

Please note that, based on implementation guidance from the Office of Management and Budget (OMB) issued on April 18, 2022, the Buy America requirements of the BIL do not apply to DOE projects in which the prime recipient is a for-profit entity; the requirements only apply to projects whose prime recipient is a "non-Federal entity," e.g., a State, local government, Indian tribe, Institution of Higher Education, or nonprofit organization. Subawards should conform to the terms of the prime award from which they flow; in other words, for-profit prime 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, prime recipients which are non-Federal entities must flow the Buy America requirements down to all subrecipients, even if those subrecipients are for-profit entities. Finally, for all applicants—both non-Federal entities and for-profit entities—DOE is including a Program Policy Factor that the Selection Official may consider in determining which Full Applications to select for award negotiations that considers whether the applicant has made a commitment to procure U.S. iron, steel, manufactured products, and construction materials in its project.

The DOE financial assistance agreement will require each recipient: (1) to fulfill the commitments made in its application regarding the procurement of U.S.-produced products and (2) to fulfill the commitments made in its application regarding the procurement of other key component metals and manufactured products domestically 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 Appendix D and the terms and conditions of an award.

Applicants are strongly encouraged to consult Appendix D for more information.

viii. Davis-Bacon Act Requirements

Projects awarded under this FOA will be funded under Division D of the Bipartisan Infrastructure Law. Accordingly, per Section 41101 of that law, all laborers and mechanics employed by the recipient, subrecipients, contractors or subcontractors in the performance of construction, alteration, or repair work funded in whole or in part under this FOA shall be paid wages at rates not less than those prevailing on similar projects in the locality, as determined by the Secretary of Labor in accordance with subchapter IV of chapter 31 of title 40, United States Code commonly referred to as the "Davis-Bacon Act" (DBA).

Applicants shall provide written assurance acknowledging the DBA requirements above, and confirming that the laborers and mechanics performing construction, alteration, or repair work on projects funded in whole or in part by awards made as a result of this FOA are paid or will be paid wages at rates not less than those prevailing on projects of a character similar in the locality as determined by subchapter IV of Chapter 31 of Title 40, United States Code (Davis-Bacon Act).

Applicants acknowledge that they will comply with all of the Davis-Bacon Act requirements, including but not limited to:

(1) ensuring that the wage determination(s) and appropriate Davis-Bacon clauses and requirements are flowed down to and incorporated into any applicable subcontracts or subrecipient awards.

(2) ensuring that if wage determination(s) and appropriate Davis-Bacon clauses and requirements are improperly omitted from contracts and subrecipient awards, the applicable wage determination(s) and clauses are retroactively incorporated to the start of performance.

(3) being responsible for compliance by any subcontractor or subrecipient with the Davis-Bacon labor standards.

(4) receiving and reviewing certified weekly payrolls submitted by all subcontractors and subrecipients for accuracy and to identify potential compliance issues.

(5) maintaining original certified weekly payrolls for 3 years after the completion of the project and must make those payrolls available to the DOE or the United States Department of Labor ("DOL") upon request, as required by 29 CFR 5.6(a)(2).

(6) conducting payroll and job-site reviews for construction work, including interviews with employees, with such frequency as may be necessary to assure compliance by its subcontractors and subrecipients and as requested or directed by the DOE.

(7) cooperating with any authorized representative of the DOL in their inspection of records, interviews with employees, and other actions undertaken as part of a DOL investigation.

(8) posting in a prominent and accessible place the wage determination(s) and DOL Publication: WH-1321, Notice to Employees Working on Federal or Federally Assisted Construction Projects.

(9) notifying the Contracting Officer of all labor standards issues, including all complaints regarding incorrect payment of prevailing wages and/or fringe benefits, received from the recipient, subrecipient, contractor, or subcontractor employees; significant labor standards violations, as defined in 29 CFR 5.7; disputes concerning labor standards pursuant to 29 CFR Parts 4, 6, and 8 and as defined in Federal Acquisition Regulation (FAR) 52.222-14; disputed labor standards determinations; DOL investigations; or legal or judicial proceedings related to the labor standards under this Contract, a subcontract, or subrecipient award.

(10) preparing and submitting to the Contracting Officer, the Office of Management and Budget Control Number 1910-5165, Davis Bacon Semi-Annual Labor Compliance Report, by April 21 and October 21 of each year. Form submittal will be administered through the iBenefits system (https://doeibenefits2.energy.gov), its successor system, or other manner of compliance as directed by the Contracting Officer.

Recipients of funding under this FOA will also be required to undergo Davis-Bacon Act compliance training and to maintain competency in Davis-Bacon Act compliance. The Contracting Officer will notify the recipient of any DOE sponsored Davis-Bacon Act compliance trainings. The DOL offers free Prevailing Wage Seminars several times a year that meet this requirement, at https://www.dol.gov/agencies/whd/government-contracts/construction/seminars/events.

For additional guidance on how to comply with the Davis-Bacon provisions and clauses, see https://www.dol.gov/agencies/whd/government-

contracts/construction and https://www.dol.gov/agencies/whd/government-contracts/protections-for-workers-in-construction.

DOE anticipates contracting with a third party for a Davis-Bacon Act electronic payroll compliance software application. Recipients of funding under this FOA must ensure the timely electronic submission of weekly certified payrolls through this software as part of its compliance with the Davis-Bacon Act unless a waiver is granted to a particular contractor or subcontractor because they are unable or limited in their ability to use or access. Applicants should indicate if a waiver will be sought.

ix. Lobbying

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

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

- An officer or employee of any federal agency;
- A Member of Congress;
- An officer or employee of Congress; or
- An employee of a Member of Congress.

x. Risk Assessment

Pursuant to 2 CFR 200.206, DOE will conduct an additional review of the risk posed by applications submitted under this FOA. Such risk assessment will consider:

1. Financial stability;
2. Quality of management systems and ability to meet the management standards prescribed in 2 CFR 200 as amended and adopted by 2 CFR 910;
3. History of performance;
4. Audit reports and findings; and
5. The applicant's ability to effectively implement statutory, regulatory, or other requirements imposed on non-federal entities.

DOE may make use of other publicly available information and the history of an applicant's performance under DOE or other federal agency awards.

Depending on the severity of the findings and whether the findings were resolved, DOE may elect not to fund the applicant.

In addition to this review, DOE must comply with the guidelines on government-wide suspension and debarment in 2 CFR Part 180, and must require non-federal entities to comply with these provisions. These provisions restrict federal awards, subawards and contracts with certain parties that are debarred, suspended or otherwise excluded from or ineligible for participation in federal programs or activities.

Further, as DOE invests in critical infrastructure and funds critical and emerging technology (CET) areas, DOE also considers possible vectors of undue foreign influence in evaluating risk. If high risks are identified and cannot be sufficiently mitigated, DOE may elect to not fund the applicant.

xi. Invoice Review and Approval

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

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

xii. Prohibition related to Foreign Government-Sponsored Talent Recruitment Programs

a. Prohibition

Persons participating in a *Foreign Government-Sponsored Talent Recruitment Program of a Foreign Country of Risk* are prohibited from participating in projects selected for federal funding under this FOA. Should an award result from this FOA, the recipient must exercise ongoing due diligence to reasonably ensure that no individuals participating on the DOE-funded project are participating in a *Foreign Government-Sponsored Talent Recruitment Program of a Foreign Country of Risk*. Consequences for violations of this prohibition will be determined according to applicable law, regulations, and policy. Further, the recipient must notify DOE within five (5) business days upon learning that an individual on the project team is or is believed to be participating in a foreign government talent recruitment program of a foreign country of risk. DOE may modify and add requirements related to this prohibition to the extent required by law.

b. Definitions

1. **Foreign Government-Sponsored Talent Recruitment Program.** An effort directly or indirectly organized, managed, or funded by a foreign government, or a foreign government instrumentality or entity, to recruit science and technology professionals or students (regardless of citizenship or national origin, or whether having a full-time or part-time position). Some foreign government-sponsored talent recruitment programs operate with the intent to import or otherwise acquire from abroad, sometimes through illicit means, proprietary technology or software, unpublished data and methods, and intellectual property to further the military modernization goals and/or economic goals of a foreign government. Many, but not all, programs aim to incentivize the targeted individual to relocate physically to the foreign state for the above purpose. Some programs allow for or encourage continued employment at United States research facilities or receipt of federal research funds while concurrently working at and/or receiving compensation from a foreign institution, and some direct participants not to disclose their participation to U.S. entities. Compensation could take many forms including cash, research funding, complimentary foreign travel, honorific titles, career advancement opportunities, promised future compensation, or other types of remuneration or consideration, including in-kind compensation.

2. **Foreign Country of Risk.** DOE has designated the following countries as foreign countries of risk: Iran, North Korea, Russia, and China. This list is subject to change.

xiii. Affirmative Action and Pay Transparency Requirements

All federally assisted construction contracts exceeding $10,000 annually will be subject to the requirements of Executive Order 11246:

(1) Recipients are prohibited from discriminating in employment decisions on the basis of race, color, religion, sex, sexual orientation, gender identity or national origin.

(2) Recipients must take affirmative action to ensure that equal opportunity is provided in all aspects of their employment. This includes flowing down the appropriate language to all subrecipients and contractors.

(3) Recipients are prohibited from taking adverse employment actions against applicants and employees for asking about, discussing, or sharing information about their pay or, under certain circumstances, the pay of their co-workers.

The Department of Labor's (DOL) Office of Federal Contractor Compliance Programs (OFCCP) uses a neutral process to schedule compliance evaluations. OFCCP's Technical Assistance Guide[139] should be consulted to gain an understanding of the requirements and possible required actions.

Additionally, for construction projects valued at $35 million or more and lasting more than one year, the recipients, subrecipients, contractors and subcontractors may be selected by OFCCP to participate in the *Mega Construction Project Program*. DOE, under relevant legal authorities including Sections 205 and 303(a) of Executive Order 11246, will require participation as a condition of the award. This program offers extensive compliance assistance with EO 11246. For more information regarding this program, see https://www.dol.gov/agencies/ofccp/construction/mega-program.

[139] See OFCCP's Technical Assistance Guide at: https://www.dol.gov/sites/dolgov/files/ofccp/Construction/files/ConstructionTAG.pdf?msclkid=9e397d68c4b111ec9d8e6fecb6c710ec. Also see the National Policy Assurances http://www.nsf.gov/awards/managing/rtc.jsp.

xiv. Foreign Collaboration Considerations

a. Consideration of new collaborations with foreign organizations and governments. The recipient will be required to provide DOE with advanced written notification of any potential collaboration with foreign organizations or governments in connection with its DOE-funded award scope. The recipient will then be required to await further guidance from DOE prior to contacting the proposed foreign organization or government regarding the potential collaboration or negotiating the terms of any potential agreement.

b. Existing collaborations with foreign organizations and governments. The recipient will be required to provide DOE with a written list of all existing foreign collaborations in which it has entered in connection with its DOE-funded award scope.

c. Description of collaborations that should be reported: In general, a collaboration will involve some provision of a thing of value to, or from, the recipient. A thing of value includes but may not be limited to all resources made available to, or from, the recipient in support of and/or related to the DOE award, regardless of whether or not they have monetary value. Things of value also may include in-kind contributions (such as office/laboratory space, data, equipment, supplies, employees, students). In-kind contributions not intended for direct use on the DOE award but resulting in provision of a thing of value from or to the DOE award must also be reported. Collaborations do not include routine workshops, conferences, use of the recipient's services and facilities by foreign investigators resulting from its standard published process for evaluating requests for access, or the routine use of foreign facilities by awardee staff in accordance with the recipient's standard polies and procedures.

V. Application Review Information

A. Technical Review Criteria

i. Concept Papers

Concept Papers are evaluated based on consideration of the following factors.

Concept Paper Criterion: Overall FOA Responsiveness and Viability of the Project (Weight: 100%)

This criterion involves consideration of the following factors:

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

ii. Full Applications

Applications will be evaluated against the technical review criteria shown below.

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, scalable, and/or enables increased manufacturing capacity;
- Degree to which the current state of the technology, challenges to be addressed, and the proposed advancement are clearly described and quantified;
- 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, including relevant data, calculations and discussion of prior work with analyses that support the viability of the proposed work;

Additional criteria for Topics 1, 2, 4, and 5 only

- Degree to which key manufacturing and supply chain challenges are considered for viable scale-up;
- Extent to which the application has the potential to increase the domestic electrolyzer or fuel cell supply chains.

Impact of Technology Advancement

- Extent to which the project supports the topic area objectives, required deliverables, and target specifications and metrics (please refer to the individual topic areas);
- Potential impact of the project on advancing the state-of-the-art;

Additional criteria for Topics 1, 2, 4, and 5 only

- Potential impact of the project on decreasing electrolyzer or fuel cell capital cost and increasing manufacturing throughput.

Criterion 2: Quality of Workplan (25%)
This criterion involves consideration of the following factors:

Research Approach, and Workplan

- Degree to which the approach and critical path have been clearly described and thoughtfully considered;
- Degree to which the task descriptions are clear, detailed, timely, and reasonable, resulting in a high likelihood that the proposed Workplan will succeed in meeting the project goals; and
- Clarity and relevance of plans to validate innovations and/or conduct complementary analysis activities, as described in the topic area descriptions.

Identification of 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;

Additional criteria for Topics 1, 4, and 5 only

- Demonstrated understanding of workforce continuity, scheduling, cost increase, and other potential supply chain risks and the quality of mitigation strategies to address them.

Project Management

- Adequacy of proposed project management systems including the ability to track scope, cost, and schedule progress and changes;
- The reasonableness of the budget and spend plan as detailed in the budget justification workbook for the proposed project and objectives.

- Adequacy, reasonableness, and soundness of the project schedule, as well as periodic Go/No-Go decisions prior to a budget period continuation application, interim milestones, and metrics to track progress.

Baseline, Metrics, and Deliverables

- The 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;

Additional criteria for Topics 1, 2, 4, and 5 only

- Extent to which the applicant provides a detailed description of how the team will collect data on primary resource consumption (e.g., electricity, fossil fuels/other resources, feedstock materials, water, etc.) for each manufacturing step relevant to the overall environmental impact of the manufacturing process.

Market Impact Plan *(applicable to Topics 1, 2, 4, and 5 only)*

- Identification of target market, competitors, and distribution channels for proposed technology along with known or perceived barriers to market penetration, including mitigation plan that includes community and labor engagement as applicable;
- Comprehensiveness of market impact 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, etc., and product distribution;
- Identification of how the proposed technology, process, or project will impact domestic manufacturing capacity and supply chains.

Criterion 3: Team and Resources (15%)

This criterion involves consideration of the following factors:

- The 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;
- The sufficiency of the existing facilities or infrastructure to support the work;

- The degree to which the proposed consortium/team demonstrates the ability to facilitate and expedite further demonstration, development and commercial deployment of the proposed technologies; and
- The level of participation by project participants as evidenced by letter(s) of commitment and how well they are integrated into the Workplan.

Criterion 4: R&D Community Benefits Plan (15%)

This criterion involves consideration of the following factors:

Diversity, Equity, Inclusion, and Accessibility (DEIA)

- Clear articulation of the project's goals related to diversity, equity, inclusion, and accessibility. These are four different, but related, concepts that should not be conflated. That is, you can achieve diversity without equity; all four are necessary for top scores;
- Quality of the project's DEIA goals, as measured by the goals' depth, breadth, likelihood of success, inclusion of appropriate and relevant SMART milestones, and overall project integration;
- Degree of applicant's commitment and ability to track progress towards meeting each of the diversity, equity, inclusion, and accessibility goals;
- Extent of engagement of organizations that represent disadvantaged communities as a core element of their mission, including MSIs, Minority Business Entities, and non-profit or community-based organizations.

Energy Equity

- Clear workplan tasks, staffing, research, and timeline for engaging energy equity stakeholders and/or evaluating the possible near and long-term implications of the project for the benefit of the American public, including, but not limited to the public health and public prosperity benefits;
- Approach, methodology, and expertise articulated in the plan for addressing energy equity and justice issues associated with the technology innovation, including plans for effective community engagement;
- Likelihood that the plan will result in improved understanding of distributional public benefits and costs related to the innovation if successful;
- Extent to which the Community Benefits Plan identifies: specific, measurable benefits for disadvantaged communities, how the benefits will flow to disadvantaged communities, and how negative environmental impacts affecting disadvantaged communities would be mitigated; and
- Extent to which the project would contribute to meeting the objective that 40% of the overall benefits of climate and clean energy investments flow to disadvantaged communities.

Workforce Implications

- Clear and comprehensive plan to mitigate workforce-related risks, as documented in the Project Safety Plan (see section VI.B.xiv) and the CBP;
- Clear and comprehensive plan for engaging workforce stakeholders and/or evaluating the possible near- and long-term implications of the project for the U.S. workforce;
- Approach and qualified personnel to document the knowledge, skills, and abilities of the workforce required for successful commercial deployment of innovations resulting from this research;
- Likelihood that the plan will result in improved understanding of the workforce implications related to the innovation if successful;

Additional criteria for Topics 1 and 4 only:

- Efforts to facilitate labor input across every phase of the project;
- Quality of partnerships with apprenticeship readiness programs or community-based workforce training and support organizations to train and engage local workforce and registered apprentices for construction and other activities.

iii. 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 Full Application.

B. Standards for Application Evaluation

Applications that are determined to be eligible will be evaluated in accordance with this FOA, by the standards set forth in EERE's Notice of Objective Merit Review Procedure (76 Fed. Reg. 17846, March 31, 2011) and the guidance provided in the "DOE Merit Review Guide for Financial Assistance," effective October 2021, which is available at: https://www.energy.gov/sites/default/files/2021-09/Guide to Financial Assistance- October 2021.pdf

C. Other Selection Factors

i. Program Policy Factors

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

- The degree to which the proposed project exhibits technological diversity when compared to the existing DOE project portfolio and other projects selected from the subject FOA;
- The degree to which the proposed project supports complementary efforts or projects, which, when taken together, will best achieve the research goals and objectives;
- The degree to which the proposed project, including proposed cost share, optimizes the use of available DOE 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 is likely to lead to increased high-quality employment and manufacturing in the United States;
- The degree to which the proposed project will accelerate transformational technological advances in areas that industry by itself is not likely to undertake because of technical and financial uncertainty;
- The degree to which the proposed project, or group of projects, represent a desired geographic distribution (considering past awards and current applications);
- The degree to which the proposed project incorporates applicant or team members from Minority Serving Institutions (e.g., HBCUs/Other MSIs); and demonstrates meaningful partnerships with Minority Business Enterprises, Minority Owned Businesses, Woman Owned Businesses, Veteran Owned Businesses, Tribal energy development organizations, Federally recognized Indian Tribes, Tribal organizations, Native Hawaiian community-based organizations, or territories or freely associated States; or entities located in economically distressed areas of the major natural gas-producing regions of the US;
- The degree to which the proposed project demonstrates plans for job creation, quality jobs, inclusive recruitment and hiring, supports worker rights, workplace safety and investments in worker training;

- The degree to which the proposed project, when compared to the existing DOE project portfolio and other projects to be selected from the subject FOA, contributes to the total portfolio meeting the goals reflected in the Community Benefits Plan criteria; and
- The degree to which the proposed project will employ procurement of U.S. iron, steel, manufactured products, and construction materials.

Additional program policy factors for Topics 4 and 5:

- The degree to which the proposed project increases efficiency and cost-effectiveness in the manufacturing process; and the use of resources, including existing energy and manufacturing infrastructure;
- The degree to which the proposed project supports domestic supply chains for materials and components;
- The degree to which the proposed project identifies and incorporates nonhazardous alternative materials for components and devices; and
- Projects that are located in economically distressed areas of the major natural gas-producing regions of the United States.

D. Evaluation and Selection Process

i. Overview

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

ii. Pre-Selection Interviews

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

DOE will arrange to meet with the invited applicants in person at DOE's offices or a mutually agreed upon location. DOE may also arrange site visits at certain

applicants' facilities. In the alternative, DOE may invite certain applicants to participate in a one-on-one conference with DOE via webinar, videoconference, or conference call.

DOE will not reimburse applicants for travel and other expenses relating to the pre-selection interviews, nor will these costs be eligible for reimbursement as pre-award costs.

Participation in pre-selection interviews with DOE does not signify that applicants have been selected for award negotiations.

iii. Pre-Selection Clarification

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

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

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

iv. Recipient Integrity and Performance Matters

DOE, prior to making a federal award with a total amount of federal share greater than the simplified acquisition threshold, is required to review and consider any information about the applicant that is in the designated integrity and performance system accessible through SAM (Responsibility/Qualification Reports, formerly known as Federal Awardee Performance and Integrity Information System (FAPIIS)), see 41 U.S.C. § 2313.

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

DOE will consider any written comments by the applicant, in addition to the other information in the designated integrity and performance system, in making a judgment about the applicant's integrity, business ethics, and record of performance under federal awards when completing the review of risk posed by applicants as described in 2 CFR 200.206.

v. Selection

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

E. Anticipated Notice of Selection and Award Negotiation Dates

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

VI. Award Administration Information

A. Award Notices

i. Ineligible Submissions

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

ii. Concept Paper Notifications

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

Exchange. DOE may include general comments provided from reviewers on an applicant's Concept Paper in the encourage/discourage notifications.

Applicants may submit a Full Application even if they receive a notification discouraging them from doing so. By discouraging the submission of a Full Application, DOE intends to convey its lack of programmatic interest in the proposed project. Such assessments do not necessarily reflect judgments on the merits of the proposed project. The purpose of the Concept Paper phase is to save applicants the considerable time and expense of preparing a Full Application that is unlikely to be selected for award negotiations.

iii. Full Application Notifications

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

iv. Applicants Selected for Negotiations

Successful applicants will receive written notification that they have been selected for award negotiations. Receipt of a notification letter selecting a Full Application for award negotiations does not authorize the applicant to commence performance of the project. If an application is selected for award negotiations, it is not a commitment by DOE to issue an award nor is it a guarantee of Federal Government funding. Applicants do not receive an award unless and until award negotiations are complete and the Contracting Officer executes the funding agreement, accessible by the prime recipient in FedConnect.

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

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

v. Alternate Selection Determinations

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

vi. Unsuccessful Applicants

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

B. Administrative and National Policy Requirements

i. Registration Requirements

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

1. **EERE Exchange**
   Register and create an account on EERE Exchange at https://eere-Exchange.energy.gov. This account will then allow the user to register for any open EERE FOAs that are currently in EERE Exchange. It is recommended that each organization or business unit, whether acting as a team or a single entity, use only one account as the contact point for each submission. Applicants should also designate backup points of contact so they may be easily contacted if deemed necessary. **This step is required to apply to this FOA.** The EERE Exchange registration does not have a delay; however, **the remaining registration requirements below could take several weeks to process and are necessary for a potential applicant to receive an award under this FOA.**

2. **System for Award Management**
   Register with the SAM at https://www.sam.gov. Designating an Electronic Business Point of Contact (EBiz POC) and obtaining a special password called

a Marketing Partner ID Number (MPIN) are important steps in SAM registration. Please update your SAM registration annually.

3. **FedConnect**
   Register in FedConnect at https://www.fedconnect.net. To create an organization account, your organization's SAM MPIN is required. For more information about the SAM MPIN or other registration requirements, review the FedConnect Ready, Set, Go! Guide at https://www.fedconnect.net/FedConnect/Marketing/Documents/FedConnect_Ready_Set_Go.pdf.
4. **Grants.gov**
   Register in Grants.gov (http://www.grants.gov) to receive automatic updates when Amendments to this FOA are posted. However, please note that Concept Papers and Full Applications will not be accepted through Grants.gov.

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

ii. Award Administrative Requirements

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

iii. Foreign National Participation

All applicants selected for an award under this FOA and project participants (including subrecipients and contractors) who anticipate involving foreign nationals in the performance of an award, may be required to provide DOE with specific information about each foreign national to satisfy requirements for foreign national participation. A "foreign national" is defined as any person who is not a United States citizen by birth or naturalization. The volume and type of information collected may depend on various factors associated with the award. DOE concurrence may be required before a foreign national can participate in the performance of any work under an award.

DOE may elect to deny foreign national's participation in the award. Likewise, DOE may elect to deny a foreign national's access to a DOE sites, information, technologies, equipment, programs or personnel.

iv. Subaward and Executive Reporting

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

v. National Policy Requirements

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

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

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

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

vii. Flood Resilience

Applications should indicate whether the proposed project location(s) is within a floodplain, how the floodplain was defined, and how future flooding will factor into the project's design. The base floodplain used for planning has been the 100-year floodplain, that is, a floodplain with a 1.0 percent chance of flooding in any given year. As directed by Executive Order 13690, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input (2015), Federal agencies, including DOE, continue to avoid development in a floodplain to the extent possible. When doing so is

not possible, Federal agencies are directed to "expand management from the current base flood level to a higher vertical elevation and corresponding horizontal floodplain to address current and future flood risk and ensure that projects funded with taxpayer dollars last as long as intended." The higher flood elevation is based on one of three approaches: climate-informed science (preferred), freeboard value, or 0.2 percent annual flood change (500-year floodplain). EO 13690 and related information is available at https://www.energy.gov/nepa/articles/eo-13690-establishing-federal-flood-risk-management-standard-and-process-further.

viii. Applicant Representations and Certifications

1. **Lobbying Restrictions**
   By accepting funds under this award, the prime recipient agrees that none of the funds obligated on the award shall be expended, directly or indirectly, to influence Congressional action on any legislation or appropriation matters pending before Congress, other than to communicate to Members of Congress as described in 18 U.S.C. § 1913. This restriction is in addition to those prescribed elsewhere in statute and regulation.

2. **Corporate Felony Conviction and Federal Tax Liability Representations**
   In submitting an application in response to this FOA, the applicant represents that:

   a. It is **not** a corporation that has been convicted of a felony criminal violation under any federal law within the preceding 24 months; and

   b. It is **not** a corporation that has any unpaid federal tax liability that has been assessed, for which all judicial and administrative remedies have been exhausted or have lapsed, and that is not being paid in a timely manner pursuant to an agreement with the authority responsible for collecting the tax liability.
   For purposes of these representations the following definitions apply:

   A Corporation includes any entity that has filed articles of incorporation in any of the 50 states, the District of Columbia, or the various territories of the United States [but not foreign corporations]. It includes both for-profit and nonprofit organizations.

3. **Nondisclosure and Confidentiality Agreements Representations**

In submitting an application in response to this FOA the applicant represents that:

a. It **does not and will not** require its employees or contractors to sign internal nondisclosure or confidentiality agreements or statements prohibiting or otherwise restricting its employees or contactors from lawfully reporting waste, fraud, or abuse to a designated investigative or law enforcement representative of a federal department or agency authorized to receive such information.

b. It **does not and will not** use any federal funds to implement or enforce any nondisclosure and/or confidentiality policy, form, or agreement it uses unless it contains the following provisions:

(1) *''These provisions are consistent with and do not supersede, conflict with, or otherwise alter the employee obligations, rights, or liabilities created by existing statute or Executive Order relating to (1) classified information, (2) communications to Congress, (3) the reporting to an Inspector General of a violation of any law, rule, or regulation, or mismanagement, a gross waste of funds, an abuse of authority, or a substantial and specific danger to public health or safety, or (4) any other whistleblower protection. The definitions, requirements, obligations, rights, sanctions, and liabilities created by controlling Executive Orders and statutory provisions are incorporated into this agreement and are controlling.''*

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

(3) Notwithstanding the provision listed in paragraph (a), a nondisclosure or confidentiality policy form or agreement that is to be executed by a person connected with the conduct of an intelligence or intelligence-related activity, other than an employee or officer of the United States government, may contain provisions appropriate to the particular activity for which such document is to be used. Such form or agreement shall, at a minimum, require that the person will not

disclose any classified information received in the course of such activity unless specifically authorized to do so by the United States government. Such nondisclosure or confidentiality forms shall also make it clear that they do not bar disclosures to Congress, or to an authorized official of an executive agency or the Department of Justice, that are essential to reporting a substantial violation of law.

ix. Statement of Federal Stewardship

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

x. Statement of Substantial Involvement

DOE has substantial involvement in work performed under awards made as a result of this FOA. 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 as a whole. Substantial involvement includes, but is not limited to, 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.

xi. Intellectual Property Management Plan (IPMP)

A signed IPMP will be required for Topic Area 6 at the time of award due to the consortium arrangement. Other Topics Areas may also require an IPMP, to be determined by DOE at the time of award.

If an IPMP is required, the award will set forth the treatment of and obligations related to intellectual property rights between DOE and the individual members. The IPMP should describe how the members will handle intellectual property rights and issues between themselves while ensuring compliance with federal intellectual property laws, regulations, and policies (see Sections VIII.J.-VIII.N. of this FOA for more details on applicable federal intellectual property laws and regulations). Guidance regarding the contents of IPMP is available from DOE upon request.

The following is a non-exhaustive list of examples of items that the IPMP may cover:

- The treatment of confidential information between members (e.g., the use of NDAs);
- The treatment of background intellectual property (e.g., any requirements for identifying it or making it available);
- The treatment of inventions made under the award (e.g., any requirements for disclosing to the other members on an application, filing patent applications, paying for patent prosecution, and cross-licensing or other licensing arrangements between the members);
- The treatment of data produced, including software, under the award (e.g., any publication process or other dissemination strategies, copyrighting strategy or arrangement between members);
- Any technology transfer and commercialization requirements or arrangements between the members;
- The treatment of any intellectual property issues that may arise due to a change in membership of the consortia or team; and
- The handling of disputes related to intellectual property between the members.

xii. Subject Invention Utilization Reporting

To ensure that prime recipients and subrecipients holding title to subject inventions are taking the appropriate steps to commercialize subject inventions, DOE may require that each prime recipient holding title to a subject invention submit annual reports for ten (10) years from the date the subject invention was disclosed to DOE on the utilization of the subject invention and efforts made by prime recipient or their licensees or assignees to stimulate such utilization. The reports must include information regarding the status of development, date of first commercial sale or use, gross royalties received by the prime recipient, and such other data and information as DOE may specify.

xiii. Intellectual Property Provisions

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

xiv. Reporting

Reporting requirements are identified on the Federal Assistance Reporting Checklist, attached to the award agreement.

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

- Quarterly Financial and Technical Reports
- Final Technical Report
- Yearly participation at the DOE Hydrogen Program Merit Review and Peer Evaluation (AMR) meeting, typically held in Washington, D.C.
- Yearly participation in one Joint Technical Team Meeting between U.S. DRIVE and the 21st Century Truck Partnership
- DOE may request that material samples, components, and/or prototype systems resulting from the R&D effort be sent for independent, standardized testing at a facility specified by DOE, as appropriate
- Work with independent system and/or cost analysis projects within DOE portfolio for independent performance and model validation as appropriate
- **Project Safety Plan**: Safe practices in the production, storage, distribution, and use of hydrogen are essential for the widespread acceptance of hydrogen and fuel cell technologies. The recipient must comply with the following requirements:
    1. The recipient is required to coordinate with the Hydrogen Safety Panel (HSP), a resource of the DOE Hydrogen and Fuel Cells Program, throughout the project life cycle. Examples of opportunities for HSP involvement include participation in post- award project kickoff meetings, project design and document reviews, risk assessments, and pre-startup reviews prior to beginning field demonstrations. To minimize project impacts, these engagements should be coordinated with regularly scheduled project activities rather than be unique efforts and should be based on discussions with HSP.
    2. All projects are required to submit safety plans. Guidance for the creation of the Safety Plan can be found at https://h2tools.org/sites/default/files/Safety_Planning_for_Hydrogen_and_Fuel_Cell_Projects.pdf. The Safety Plan should cover the full scope of the project, including work by the prime as well as any

subrecipients, and should be complete before the work is started. The Safety Plan is due to DOE within 90 days after the award is signed unless alternative timing is approved due to project constraints. The HSP will review the Safety Plan and provide feedback to the Recipient (through DOE) within approximately 30 days of receipt. The Recipient will then have 30 days to respond to the HSP's feedback (e.g., either by incorporating comments into the Plan or by providing rationale for not incorporating comments) and resubmit a revised Safety Plan to DOE.

3. DOE may request HSP involvement in site visits or via teleconferences. If a safety-focused site visit/teleconference is requested, the HSP will provide a written site visit report to the recipient for review and comment and may conduct a follow-up interview with the recipient and their project team. All such HSP reports are also provided to DOE.

Additional reporting requirements apply to projects funded by BIL. As part of tracking progress toward key departmental goals – ensuring justice and equity, investing in the American workforce, boosting domestic manufacturing, reducing greenhouse gas emissions, and advancing a pathway to private sector deployment – DOE may require specific data collection. Examples of data that may be collected include:

- New manufacturing production, or recycling capacity
- Jobs data including:
    - Number and types of jobs provided, wages and benefits paid.
    - Demographics of workforce including local hires.
    - Efforts to minimize risks of labor disputes and disruptions.
    - Contributions to training; certificates and training credentials received by employees; ratio of apprentice-to-journey level workers employed.
    - Number of trainings completed, trainees placed in full-time employment, or number of trainings with workforce partnerships involving employers, community-based organizations, or labor unions.
- Justice and Equity data, including:
    - Minority Business Enterprises, Minority Owned Businesses, Woman Owned Businesses and Veteran Owned Businesses acting as vendors and sub-contractors for bids on supplies, services and equipment.
    - Value, number, and type of partnerships with MSIs.
    - Stakeholder engagement events, consent-based siting activities.
    - Other relevant indicators from the Community Benefits Plan.

- Number and type of energy efficient and clean energy equipment installed
- Funding leveraged, follow-on-funding, Intellectual Property (IP) Generation and IP Utilization

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

xv. Go/No-Go Review

Each project selected under this FOA will be subject to a periodic project evaluation referred to as a Go/No-Go Review. A Go/No-Go Review is a risk management tool and a project management best practice to ensure that, for the current phase or period of performance, technical success is definitively achieved and potential for success in future phases or periods of performance is evaluated, prior to actually beginning the execution of future phases. At the Go/No-Go decision points, DOE will evaluate project performance, project schedule adherence, the extent milestone objectives are met, compliance with reporting requirements, and overall contribution to the program goals and objectives. Federal funding beyond the Go/No-Go decision point (continuation funding) is contingent upon (1) availability of federal funds appropriated by Congress for the purpose of this program; (2) the availability of future-year budget authority; (3) recipient's technical progress compared to the Milestone Summary Table stated in Attachment 1 of the award; (4) recipient's submittal of required reports; (5) recipient's compliance with the terms and conditions of the award; (6) DOE's Go/No-Go decision; (7) the recipient's submission of a continuation application[140]; and (8) written approval of the continuation application by the Contracting Officer.

As a result of the Go/No-Go Review, DOE may, at its discretion, authorize the following actions: (1) continue to fund the project, contingent upon the availability of funds appropriated by Congress for the purpose of this program and the availability of future-year budget authority; (2) recommend redirection

[140] A continuation application is a non-competitive application for an additional budget period within a previously approved project period. At least ninety (90) days before the end of each budget period, the recipient must submit its continuation application, which includes the following information:

i. A progress report on the project objectives, including significant findings, conclusions, or developments, and an estimate of any unobligated balances remaining at the end of the budget period. If the remaining unobligated balance is estimated to exceed 20 percent of the funds available for the budget period, explain why the excess funds have not been obligated and how they will be used in the next budget period.
ii. A detailed budget and supporting justification if there are changes to the negotiated budget, or a budget for the upcoming budget period was not approved at the time of award.
iii. A description of any planned changes from the SOPO and/or Milestone Summary Table.

of work under the project; (3) place a hold on federal funding for the project, pending further supporting data or funding; or (4) discontinue funding the project because of insufficient progress, change in strategic direction, or lack of funding.

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

xvi. Conference Spending

The recipient shall not expend any funds on a conference not directly and programmatically related to the purpose for which the grant or cooperative agreement was awarded that would defray the cost to the United States government of a conference held by any Executive branch department, agency, board, commission, or office for which the cost to the United States government would otherwise exceed $20,000, thereby circumventing the required notification by the head of any such Executive Branch department, agency, board, commission, or office to the Inspector General (or senior ethics official for any entity without an Inspector General), of the date, location, and number of employees attending such conference.

xvii. Uniform Commercial Code (UCC) Financing Statements

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

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

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

xviii. 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 projects selected for award under this FOA, the recipient 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 Contracting 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 where 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 at 2 CFR 910.360. Property disposition requirements for other non-federal entities are set forth in 2 CFR 200.310 – 200.316.

xix. Implementation of Executive Order 13798, Promoting Free Speech and Religious Liberty

States, local governments, or other public entities may not condition sub-awards in a manner that would discriminate, or disadvantage sub-recipients based on their religious character.

xx. Participants and Collaborating Organizations

If selected for award negotiations, the selected applicant must submit a list of personnel who are proposed to work on the project, both at the recipient and subrecipient level and a list of proposed collaborating organizations prior to

award. Recipients will have an ongoing responsibility to notify DOE of changes to the personnel and collaborating organizations, and submit updated information during the life of the award.

xxi. Current and Pending Support

If selected for award negotiations, within 30 days of the selection notice, the selectee must submit 1) current and pending support disclosures and resumes for any new PIs or senior/key personnel, and 2) updated disclosures if there have been any changes to the current and pending support submitted with the application. Throughout the life of the award, the recipient has an ongoing responsibility to submit 1) current and pending support disclosure statements and resumes for any new PI and senior/key personnel, and 2) updated disclosures if there are changes to the current and pending support previously submitted to DOE. Also See Section IV.D.xvi.

xxii. U.S. Manufacturing Commitments

A primary objective of DOE's multi-billion dollar research, development, and demonstration investments is to cultivate new research and development ecosystems, manufacturing capabilities, and supply chains for and by United States industry and labor. Therefore, in exchange for receiving taxpayer dollars to support an applicant's project, the applicant must agree to a U.S. Competitiveness provision requiring that any products embodying any subject invention or produced through the use of any subject invention will be manufactured substantially in the United States unless the Recipient can show to the satisfaction of DOE that it is not commercially feasible. Award terms, including the specific U.S. Competitiveness Provision applicable to the various types of recipients and projects, are available at https://www.energy.gov/gc/standard-intellectual-property-ip-provisions-financial-assistance-awards.

Please note that a subject invention is any invention conceived or first actually reduced to practice in performance of work under an award. An invention is any invention or discovery which is or may be patentable. The recipient includes any awardee, recipient, sub-awardee, or sub-recipient.

As noted in the U.S. Competitiveness Provision, if an entity cannot meet the requirements of the U.S. Competitiveness Provision, the entity may request a modification or waiver of the U.S. Competitiveness Provision. For example, the entity may propose modifying the language of the U.S. Competitiveness Provision in order to change the scope of the requirements or to provide more specifics on the application of the requirements for a particular technology. As

another example, the entity may request that the U.S. Competitiveness Provision be waived in lieu of a net benefits statement or United States manufacturing plan. The statement or plan would contain specific and enforceable commitments that would be beneficial to the United States economy and competitiveness. Examples of such commitments could include manufacturing specific products in the United States, making a specific investment in a new or existing United States manufacturing facility, keeping certain activities based in the United States or supporting a certain number of jobs in the United States related to the technology. DOE may, in its sole discretion, determine that the proposed modification or waiver promotes commercialization and provides substantial United States economic benefits, and grant the request. If granted, DOE will modify the award terms and conditions for the requesting entity accordingly.

More information and guidance on the waiver and modification request process can be found in the DOE Financial Assistance Letter on this topic, available at https://www.energy.gov/management/pf-2022-09-fal-2022-01-implementation-doe-determination-exceptional-circumstances-under. Additional information on DOE's Commitment to Domestic Manufacturing for DOE-funded R&D is available at https://www.energy.gov/gc/us-manufacturing.

The U.S. Competitiveness Provision is implemented by DOE pursuant to a Determination of Exceptional Circumstances (DEC) under the Bayh-Dole Act and DOE Patent Waivers. See Section VIII.J Title to Subject Inventions of this FOA for more information on the DEC and DOE Patent Waivers.

xxiii. Interim Conflict of Interest Policy for Financial Assistance

The DOE interim Conflict of Interest Policy for Financial Assistance (COI Policy)[141] is applicable to all non-Federal entities applying for, or that receive, DOE funding by means of a financial assistance award (e.g., a grant, cooperative agreement, or technology investment agreement) and, through the implementation of this policy by the entity, to each Investigator who is planning to participate in, or is participating in, the project funded wholly or in part under the DOE financial assistance award. The term "Investigator" means the PI and any other person, regardless of title or position, who is responsible for the purpose, design, conduct, or reporting of a project funded by DOE or proposed for funding by DOE. Recipients must flow down the requirements of the interim COI Policy to any subrecipient non-federal entities. Further, for DOE funded projects, the

[141] DOE's interim COI Policy can be found at PF 2022-17 FAL 2022-02 Department of Energy Interim Conflict of Interest Policy Requirements for Financial Assistance.

recipient must include all financial conflicts of interest (FCOI) (i.e., managed and unmanaged/ unmanageable) in their initial and ongoing FCOI reports.

It is understood that non-federal entities and individuals receiving DOE financial assistance awards will need sufficient time to come into full compliance with DOE's interim COI Policy. To provide some flexibility, DOE allows for a staggered implementation. Specifically, prior to award, applicants selected for award negotiations must: ensure all Investigators complete their significant financial disclosures; review the disclosures; determine whether a FCOI exists; develop and implement a management plan for FCOIs; and provide DOE with an initial FCOI report that includes all FCOIs (i.e., managed and unmanaged/ unmanageable). Recipients will have 180 days from the date of the award to come into full compliance with the other requirements set forth in DOE's interim COI Policy. Prior to award, the applicant must certify that it is, or will be within 180 days of the award, compliant with all requirements in the COI Policy.

xxiv. Data Management Plan (DMP)

Each applicant whose Full Application is selected for award negotiations will be required to submit a DMP during the award negotiations phase. A DMP explains how, when appropriate, data generated in the course of the work performed under a DOE award will be shared and preserved to validate the results of the proposed work or how the results could be validated if the data is not shared or preserved. The DMP must provide a plan for making all research data displayed in publications resulting from the proposed work digitally accessible at the time of publications. All successful applicants will be requested to share pertinent data of manufacturing or recycling processes with national laboratories, such as Argonne National Laboratory's GREET team, to inform comprehensive life cycle assessments.

xxv. Fraud, Waste and Abuse

The mission of the DOE Office of Inspector General (OIG) is to strengthen the integrity, economy and efficiency of the Department's programs and operations including deterring and detecting fraud, waste, abuse and mismanagement. The OIG accomplishes this mission primarily through investigations, audits, and inspections of DOE activities to include grants, cooperative agreements, loans, and contracts.

The OIG maintains a Hotline for reporting allegations of fraud, waste, abuse, or mismanagement. To report such allegations, please visit https://www.energy.gov/ig/ig-hotline.

Additionally, recipients of DOE awards must be cognizant of the requirements of 2 CFR 200.113 Mandatory disclosures, which states:

> The non-Federal entity or applicant for a Federal award must disclose, in a timely manner, in writing to the Federal awarding agency or pass-through entity all violations of Federal criminal law involving fraud, bribery, or gratuity violations potentially affecting the Federal award. Non-Federal entities that have received a Federal award including the term and condition outlined in appendix XII of 2 CFR Part 200 are required to report certain civil, criminal, or administrative proceedings to SAM (currently FAPIIS). Failure to make required disclosures can result in any of the remedies described in 2 CFR 200.339. (See also 2 CFR part 180, 31 U.S.C. § 3321, and 41 U.S.C. § 2313.) [85 FR 49539, Aug. 13, 2020]

Applicants and subrecipients (if applicable) are encouraged to allocate sufficient costs in the project budget to cover the costs associated for personnel and data infrastructure needs to support performance management and program evaluation needs including but not limited to independent program and project audits to mitigate risks for fraud, waste, and abuse.

xxvi. Human Subjects Research

Research involving human subjects, biospecimens, or identifiable private information conducted with DOE funding is subject to the requirements of DOE Order 443.1C, Protection of Human Research Subjects, 45 CFR Part 46, Protection of Human Subjects (subpart A which is referred to as the "Common Rule"), and 10 CFR Part 745, Protection of Human Subjects. Additional information on the DOE Human Subjects Research Program can be found at: HUMAN SUBJECTS Human Subjects Pr... | U.S. DOE Office of Science (SC) (osti.gov).

xxvii. Cybersecurity Plan

In accordance with BIL section 40126, applicants selected for award negotiations must submit an acceptable cybersecurity plan to DOE prior to receiving funding.[142] These plans are intended to foster a cybersecurity-by-design approach for BIL efforts. The Department will also use these plans to ensure effective integration and coordination across its research, development, and demonstration programs. A cybersecurity plan is NOT required as part of the

[142] 42 U.S.C. § 18725.

application submission for this FOA, but all projects selected under this FOA will be required to submit a cybersecurity plan during the award negotiation phase.

The Department recommends using open guidance and standards such as the National Institute of Standards and Technology's (NIST) Cybersecurity Framework (CSF) and the DOE Cybersecurity Capability Maturity Model (C2M2).[143] The cybersecurity plan created pursuant to BIL section 40126 should document any deviation from open standards, as well as the utilization of proprietary standards where the awardee determines that such deviation is necessary.

- Cybersecurity plans should be commensurate to the threats and vulnerabilities associated with the proposed efforts and demonstrate the cybersecurity maturity of the project.
- Cybersecurity plans may cover a range of topics relevant to the proposed project, e.g., software development lifecycle, third-party risks, and incident reporting.
- At a minimum, cybersecurity plans should address questions noted in BIL section 40126 (b) 'Contents of Cybersecurity Plan'.[144]

A draft version of supplementary guidance on the cybersecurity plan requirement will be available at https://www.energy.gov/ceser/bipartisan-infrastructure-law-implementation.

VII. Questions/Agency Contacts

Upon the issuance of a FOA, DOE personnel are prohibited from communicating (in writing or otherwise) with applicants regarding the FOA except through the established question and answer process as described below. Specifically, questions regarding this

[143] NERC critical infrastructure protection (CIP) standards for entities responsible for the availability and reliability of the bulk electric system. NIST IR 7628: 2 Smart grid cyber security strategy and requirements. NIST SP800-53, Recommended Security Controls for Federal Information Systems and Organizations: Catalog of security controls in 18 categories, along with profiles for low-, moderate-, and high-impact systems. NIST SP800-82, Guide to Industrial Control Systems (ICS) Security. NIST SP800-39, Integrated Enterprise-Wide Risk Management: Organization, mission, and information system view. AMI System Security Requirements: Security requirements for advanced metering infrastructure. ISO (International Organization for Standardization) 27001, Information Security Management Systems: Guidance on establishing governance and control over security activities (this document must be purchased). IEEE (Institute of Electrical and Electronics Engineers) 1686-2007, Standard for Substation Intelligent Electronic Devices (IEDs) Cyber Security Capabilities (this document must be purchased). DOE Cybersecurity Capability Maturity Model (C2M2).

[144] 42 U.S.C. § 18725.

FOA must be submitted to: HFTOBILFOA@ee.doe.gov. Questions must be submitted not later than 3 business days prior to the application due date and time. Please note, feedback on individual concepts will not be provided through Q&A.

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

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

VIII. Other Information

A. FOA Modifications

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

B. Government Right to Reject or Negotiate

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

C. Commitment of Public Funds

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

D. Treatment of Application Information

Applicants should not include business sensitive (e.g., commercial or financial information that is privileged or confidential), trade secrets, proprietary, or otherwise confidential information in their application unless such information is necessary to convey an understanding of the proposed project or to comply with a requirement in the FOA. Applicants are advised to not include any critically sensitive proprietary detail.

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

If an applicant chooses to submit business sensitive, trade secrets, proprietary, or otherwise confidential information, the applicant must provide **two copies** of the submission (e.g., Concept Paper, Full Application). The first copy should be marked, "non-confidential" with the information believed to be confidential deleted. The second copy should be marked "confidential" and must clearly and conspicuously identify the business sensitive, trade secrets, proprietary, or otherwise confidential information and must be marked as described below. Failure to comply with these marking requirements may result in the disclosure of the unmarked information under the FOIA or otherwise. The government is not liable for the disclosure or use of unmarked information and may use or disclose such information for any purpose as authorized by law.

The cover sheet of the Full Application, and other applicant submission must be marked as follows and identify the specific pages business sensitive, trade secrets, proprietary, or otherwise confidential information:

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

In addition, (1) the header and footer of every page that contains business sensitive, trade secrets, proprietary, or otherwise confidential information must be marked as follows: "Contains Business Sensitive, Trade Secrets, Proprietary,

or Otherwise Confidential Information Exempt from Public Disclosure," and (2) every line or paragraph containing such information must be clearly marked with double brackets or highlighting. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

E. Evaluation and Administration by Non-Federal Personnel

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

F. Notice Regarding Eligible/Ineligible Activities

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

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

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

H. Requirement for Full and Complete Disclosure

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

- The termination of award negotiations;
- The modification, suspension, and/or termination of a funding agreement;
- The initiation of debarment proceedings, debarment, and/or a declaration of ineligibility for receipt of federal contracts, subcontracts, and financial assistance and benefits; and
- Civil and/or criminal penalties.

I. Retention of Submissions

DOE expects to retain copies of all Full Applications and other submissions. No submissions will be returned. By applying to DOE for funding, applicants consent to DOE's retention of their submissions.

J. Title to Subject Inventions

Ownership of subject inventions is governed pursuant to the authorities listed below:

- Domestic Small Businesses, Educational Institutions, and Nonprofits: Under the Bayh-Dole Act (35 U.S.C. § 200 et seq.), domestic small businesses, educational institutions, and nonprofits may elect to retain title to their subject inventions;
- All other parties: The Federal Non-Nuclear Energy Act of 1974, 42. U.S.C. § 5908, provides that the government obtains title to new inventions unless a waiver is granted (see below);
- Class Patent Waiver: DOE has issued a class waiver that applies to this FOA. Under this class waiver, domestic large businesses may elect title to their subject inventions similar to the right provided to the domestic small businesses, educational institutions, and nonprofits by law. In order to avail itself of the class waiver, a domestic large business must agree that any products embodying or produced through the use of a subject invention first created or reduced to practice under this program will be substantially manufactured in the United States.
- Advance and Identified Waivers: For an applicant not covered by a Class Patent Waiver or the Bayh-Dole Act, the applicant may request a patent waiver that will cover subject inventions that may be invented under the award, in advance of or within 30 days after the effective date of the award. Even if an advance waiver is not requested or the request is denied, the recipient will have a continuing right under the award to request a waiver for identified inventions, i.e., individual subject inventions that are disclosed to DOE within the timeframes set forth in the award's intellectual property data terms and conditions. Any patent waiver that may be granted is subject to certain terms and conditions in 10 CFR 784.
- DEC: On June 07, 2021, DOE approved a DETERMINATION OF EXCEPTIONAL CIRCUMSTANCES (DEC) UNDER THE BAYH-DOLE ACT TO FURTHER PROMOTE DOMESTIC MANUFACTURE OF DOE SCIENCE AND ENERGY TECHNOLOGIES. In accordance with this DEC, all awards, including sub-awards, under this FOA shall include the U.S. Competitiveness Provision in accordance with Section VI.B.xxi. U.S. Manufacturing Commitments of this FOA. A copy of the DEC can

be found at https://www.energy.gov/gc/determination-exceptional-circumstances-decs. Pursuant to 37 CFR 401.4, any nonprofit organization or small business firm as defined by 35 U.S.C. § 201 affected by any DEC has the right to appeal it by providing written notice to DOE within 30 working days from the time it receives a copy of the determination.

- DOE may issue and publish on the website above further DECs prior to the issuance of awards under this FOA. DOE may require additional submissions or requirements as authorized by any applicable DEC.

K. Government Rights in Subject Inventions

Where prime recipients and subrecipients retain title to subject inventions, the United States government retains certain rights.

Government Use License

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

March-In Rights

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

DOE may exercise its march-in rights only if it determines that such action is necessary under any of the four following conditions:

- The owner or licensee has not taken or is not expected to take effective steps to achieve practical application of the invention within a reasonable time;
- The owner or licensee has not taken action to alleviate health or safety needs in a reasonably satisfied manner;
- The owner has not met public use requirements specified by federal statutes in a reasonably satisfied manner; or
- The United States manufacturing requirement has not been met.

Any determination that march-in rights are warranted must follow a fact-finding process in which the recipient has certain rights to present evidence and

witnesses, confront witnesses and appear with counsel and appeal any adverse decision. To date, DOE has never exercised its march-in rights to any subject inventions.

L. Rights in Technical Data

Data rights differ based on whether data is first produced under an award or instead was developed at private expense outside the award.

"Limited Rights Data": The United States 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 United States 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 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.

M. Copyright

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

N. Export Control

The United States government regulates the transfer of information, commodities, technology, and software considered to be strategically important to the United States to protect national security, foreign policy, and economic interests without imposing undue regulatory burdens on legitimate international trade. There is a network of federal agencies and regulations that govern exports

that are collectively referred to as "Export Controls." All recipients and subrecipients are responsible for ensuring compliance with all applicable United States Export Control laws and regulations relating to any work performed under a resulting award.

The recipient must immediately report to DOE any export control violations related to the project funded under the DOE award, at the recipient or subrecipient level, and provide the corrective action(s) to prevent future violations.

O. Prohibition on Certain Telecommunications and Video Surveillance Services or Equipment

As set forth in 2 CFR 200.216, recipients and subrecipients are prohibited from obligating or expending project funds (federal funds and recipient cost share) to procure or obtain; extend or renew a contract to procure or obtain; or enter into a contract (or extend or renew a contract) to procure or obtain equipment, services, or systems that uses *covered telecommunications equipment or services* as a substantial or essential component of any system, or as critical technology as part of any system. As described in Section 889 of Public Law 115-232, *covered telecommunications equipment* is telecommunications equipment produced by Huawei Technologies Company or ZTE Corporation (or any subsidiary or affiliate of such entities).

See Public Law 115-232, Section 889, 2 CFR 200.216, and 2 CFR 200.471 for additional information.

P. Personally Identifiable Information (PII)

All information provided by the applicant must to the greatest extent possible exclude PII. The term "PII" refers to information which can be used to distinguish or trace an individual's identity, such as their name, social security number, biometric records, alone, or when combined with other personal or identifying information which is linked or linkable to a specific individual, such as date and place of birth, mother's maiden name. (See OMB Memorandum M-17-12 dated January 3, 2017, found at MEMORANDUM FOR HEADS OF EXECUTIVE DEPARTMENTS AND AGENCIES (whitehouse.gov)).

By way of example, applicants must screen resumes to ensure that they do not contain PII such as personal addresses, personal landline/cell phone numbers, and personal emails. **Under no circumstances should Social Security Numbers (SSNs) be included in the application**. Federal agencies are prohibited from the collecting, using, and displaying unnecessary SSNs. (See, the Federal Information

Security Modernization Act of 2014 (Pub. L. No. 113-283, Dec 18, 2014; 44 U.S.C. § 3551).

Q. Annual Independent Audits

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

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

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

APPENDIX A – COST SHARE INFORMATION

Cost Sharing or Cost Matching

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

How Cost Sharing Is Calculated

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

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

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

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

What Qualifies For Cost Sharing

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

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

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

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

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

General Cost Sharing Rules on a DOE Award

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

(B) Valuing and documenting contributions

(1) Valuing recipient's property or services of recipient's employees. Values are established in accordance with the applicable cost principles, which mean that amounts chargeable to the project are determined on the basis of costs incurred. For real property or equipment used on the project, the cost principles authorize depreciation or use charges. The full value of the item may be applied when the item will be consumed in the performance of the award or fully depreciated by the end of the award. In cases where the full value of a donated capital asset is to be applied as cost sharing or matching, that full value must be the lesser or the following:

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

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

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

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

(4) Valuing property donated by third parties.

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

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

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

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

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

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

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

APPENDIX B – SAMPLE COST SHARE CALCULATION FOR BLENDED COST SHARE PERCENTAGE

The following example shows the math for calculating required cost share for a project with $2,000,000 in federal funds with four tasks requiring different non-federal cost share percentages:

Task	Proposed Federal Share	Federal Share %	Recipient Share %
Task 1 (R&D)	$1,000,000	80%	20%
Task 2 (R&D)	$500,000	80%	20%
Task 3 (Demonstration)	$400,000	50%	50%
Task 4 (Outreach)	$100,000	100%	0%

Federal share ($) divided by federal share (%) = Task Cost

Each task must be calculated individually as follows:

Task 1
$1,000,000 divided by 80% = $1,250,000 (Task 1 Cost)
Task 1 Cost minus federal share = non-federal share
$1,250,000 - $1,000,000 = $250,000 (non-federal share)

Task 2
$500,000 divided 80% = $625,000 (Task 2 Cost)
Task 2 Cost minus federal share = non-federal share
$625,000 - $500,000 = $125,000 (non-federal share)

Task 3
$400,000 / 50% = $800,000 (Task 3 Cost)
Task 3 Cost minus federal share = non-federal share
$800,000 - $400,000 = $400,000 (non-federal share)

Task 4
Federal share = $100,000
Non-federal cost share is not mandated for outreach = $0 (non-federal share)

The calculation may then be completed as follows:

Tasks	$ Federal Share	% Federal Share	$ Non-Federal Share	% Non-Federal Share	Total Project Cost
Task 1	$1,000,000	80%	$250,000	20%	$1,250,000
Task 2	$500,000	80%	$125,000	20%	$625,000
Task 3	$400,000	50%	$400,000	50%	$800,000
Task 4	$100,000	100%	$0	0%	$100,000
Totals	$2,000,000		$775,000		$2,775,000

Blended Cost Share %
Non-federal share ($775,000) divided by Total Project Cost ($2,775,000) = 27.9% (non-federal)
Federal share ($2,000,000) divided by Total Project Cost ($2,775,000) = 72.1% (federal)

APPENDIX C – WAIVER REQUESTS FOR: 1. FOREIGN ENTITY PARTICIPATION; AND 2. FOREIGN WORK

1. Waiver for Foreign Entity Participation

Many of the technology areas that DOE funds fall in the category of critical and emerging technologies (CETs). CETs are a subset of advanced technologies that are potentially significant to United States national and economy security.[145] For projects selected under this FOA, all recipients and subrecipients must be organized, chartered, or incorporated (or otherwise formed) under the laws of a state or territory of the United States; have majority domestic ownership and control; and have a physical location for business operations in the United States. To request a waiver of this requirement, an applicant must submit an explicit waiver request in the Full Application.

Waiver Criteria

Foreign entities seeking to participate in a project funded under this FOA must demonstrate to the satisfaction of DOE that:

a. Its participation is in the best interest of the United States industry and United States economic development;
b. The project team has appropriate measures in place to control sensitive information and protect against unauthorized transfer of scientific and technical information;
c. Adequate protocols exist between the United States subsidiary and its foreign parent organization to comply with export control laws and any obligations to protect proprietary information from the foreign parent organization;
d. The work is conducted within the United States and the entity acknowledges and demonstrates that it has the intent and ability to comply with the U.S. Competitiveness Provision (see Section VI.B.xxi.); and
e. The foreign entity will satisfy other conditions that may be deemed necessary by DOE to protect United States government interests.

Content for Waiver Request

A Foreign Entity waiver request must include the following:

a. Information about the entity: name, website, point of contact, physical address, and proposed type of involvement in the project;

[145] See, Critical and Emerging Technologies List Update (whitehouse.gov).

b. Country of incorporation, the extent of the ownership/level control by foreign entities, whether the entity is state owned or controlled, a summary of the ownership breakdown of the foreign entity and the percentage of ownership/control by foreign entities, foreign shareholders, foreign state or foreign individuals;
c. The rationale for proposing a foreign entity participate (must address criteria above);
d. A description of the project's anticipated contributions to the United States economy;
    - How the project will benefit United States research, development and manufacturing, including contributions to employment in the United States and growth in new markets and jobs in the United States;
    - How the project will promote domestic American manufacturing of products and/or services;
e. A description of how the foreign entity's participation is essential to the project;
f. A description of the likelihood of Intellectual Property (IP) being created from the work and the treatment of any such IP; and
g. Countries where the work will be performed (Note: if any work is proposed to be conducted outside the United States, the applicant must also complete a separate request foreign work waiver).

DOE may also require:

- A risk assessment with respect to IP and data protection protocols that includes the export control risk based on the data protection protocols, the technology being developed and the foreign entity and country. These submissions could be prepared by the project lead (if not the prime recipient), but the prime recipient must make a representation to DOE as to whether it believes the data protection protocols are adequate and make a representation of the risk assessment – high, medium or low risk of data leakage to a foreign entity.
- Additional language be added to any agreement or subagreement to protect IP, mitigate risk or other related purposes.

DOE may require additional information before considering the waiver request.

DOE's decision concerning a waiver request is not appealable.

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

As set forth in Section IV.J.iii., all work under funding under this FOA must be performed in the United States. To seek a waiver of the Performance of Work in the United States

requirement, the applicant must submit an explicit waiver request in the Full Application. A separate waiver request must be submitted for each entity proposing performance of work outside of the United States.

Overall, a waiver request must demonstrate to the satisfaction of DOE that it would further the purposes of this FOA and is otherwise in the economic interests of the United States to perform work outside of the United States. A request for a foreign work waiver must include the following:

1. The rationale for performing the work outside the United States ("foreign work");
2. A description of the work proposed to be performed outside the United States;
3. An explanation as to how the foreign work is essential to the project;
4. A description of the anticipated benefits to be realized by the proposed foreign work and the anticipated contributions to the United States economy;
5. The associated benefits to be realized and the contribution to the project from the foreign work;
6. How the foreign work will benefit the United States, including manufacturing, contributions to employment in the United States and growth in new markets and jobs in the United States;
7. How the foreign work will promote manufacturing of products and/or services in the United States;
8. A description of the likelihood of Intellectual Property (IP) being created from the foreign work and the treatment of any such IP;
9. The total estimated cost (DOE and recipient cost share) of the proposed foreign work;
10. The countries in which the foreign work is proposed to be performed; and
11. The name of the entity that would perform the foreign work. Information about the entity(ies) involved in the work proposed to be conducted outside the United States. (i.e., entity seek a waiver and the entity(ies) that will conduct the work).

DOE may require additional information before considering the waiver request.

DOE's decision concerning a waiver request is not appealable.

APPENDIX D – REQUIRED USE OF AMERICAN IRON, STEEL, MANUFACTURED PRODUCTS, AND CONSTRUCTION MATERIALS BUY AMERICA REQUIREMENTS FOR INFRASTRUCTURE PROJECTS

A. Definitions

For purposes of the Buy America requirements, based both on the statute and OMB Guidance Document dated April 18, 2022, the following definitions apply:

Construction materials includes an article, material, or supply—other than an item of primarily iron or steel; a manufactured product; cement and cementitious materials; aggregates such as stone, sand, or gravel; or aggregate binding agents or additives[146]—that is or consists primarily of:

- non-ferrous metals;
- plastic and polymer-based products (including polyvinylchloride, composite building materials, and polymers used in fiber optic cables);
- glass (including optic glass);
- lumber; or
- drywall.

Infrastructure includes, at a minimum, the structures, facilities, and equipment for, in the United States, roads, highways, and bridges; public transportation; dams, ports, harbors, and other maritime facilities; intercity passenger and freight railroads; freight and intermodal facilities; airports; water systems, including drinking water and wastewater systems; electrical transmission facilities and systems; utilities; broadband infrastructure; and buildings and real property. Infrastructure includes facilities that generate, transport, and distribute energy.

Moreover, according to the OMB guidance document:

> When determining if a program has infrastructure expenditures, Federal agencies should interpret the term "infrastructure" broadly and consider the definition provided above as illustrative and not exhaustive. When determining if a particular construction project of a type not listed in the definition above constitutes "infrastructure," agencies should consider whether the project will serve a public function, including whether the project is publicly owned and operated, privately operated on behalf of the public, or is a place of public accommodation, as opposed to a project that is privately owned and not open to the public. Projects with the former qualities have greater indicia of infrastructure, while projects with the latter quality have fewer. Projects consisting solely of the

[146] BIL, § 70917(c)(1).

purchase, construction, or improvement of a private home for personal use, for example, would not constitute an infrastructure project.

The Agency, not the applicant, will have the final say as to whether a given project includes infrastructure, as defined herein. Accordingly, in cases where the "public" nature of the infrastructure is unclear, but the other relevant criteria are met DOE strongly recommends that applicants complete their full application with the assumption that Buy America requirements will apply to the proposed project.

Project means the construction, alteration, maintenance, or repair of infrastructure in the United States.

B. Buy America Requirements for Infrastructure Projects ("Buy America" requirements)
In accordance with Section 70914 of the BIL, none of the project funds (includes federal share and recipient cost share) may be used for a project for infrastructure unless:

(1) all iron and steel used in the project are produced in the United States--this means all manufacturing processes, from the initial melting stage through the application of coatings, occurred in the United States;

(2) all manufactured products used in the project are produced in the United States—this means the manufactured product was manufactured in the United States; and the cost of the components of the manufactured product that are mined, produced, or manufactured in the United States is greater than 55 percent of the total cost of all components of the manufactured product, unless another standard for determining the minimum amount of domestic content of the manufactured product has been established under applicable law or regulation; and

(3) all construction materials[147] are produced in the United States—this means that all manufacturing processes for the construction material occurred in the United States.

The Buy America requirements only apply to articles, materials, and supplies that are consumed in, incorporated into, or affixed to an infrastructure project. As such, it does not apply to tools, equipment, and supplies, such as temporary scaffolding, brought to the construction site and removed at or before the completion of the infrastructure project. Nor does the Buy America requirements apply to equipment and furnishings, such as movable chairs, desks, and portable computer equipment, that are used at or within the finished infrastructure project, but are not an integral part of the structure or permanently affixed to the infrastructure project.

[147] Excludes cement and cementitious materials, aggregates such as stone, sand, or gravel, or aggregate binding agents or additives.

These requirements must flow down to all sub-awards, all contracts, subcontracts, and purchase orders for work performed under the proposed project, except where the prime recipient is a for-profit entity. Based on guidance from the OMB, the Buy America requirements of the BIL do not apply to DOE projects in which the prime recipient is a for-profit entity; the requirements only apply to projects whose prime recipient is a State, local government, Indian tribe, Institution of Higher Education, or nonprofit organization.

For additional information related to the application and implementation of these Buy America requirements, please see OMB Memorandum M-22-11, issued April 18, 2022: https://www.whitehouse.gov/wp-content/uploads/2022/04/M-22-11.pdf

Note that for all applicants—both non-Federal entities and for-profit entities—DOE is including a Program Policy Factor that the Selection Official may consider in determining which Full Applications to select for award negotiations that considers whether the applicant has made a commitment to procure U.S. iron, steel, manufactured products, and construction materials in its project.

C. Waivers

The DOE financial assistance agreement will require each recipient: (1) to fulfill the commitments made in its application regarding the procurement of U.S.-produced products and (2) to fulfill the commitments made in its application regarding the procurement of other key component metals and manufactured products domestically that are deemed available in sufficient and reasonably available quantities or of a satisfactory quality at the time of award negotiation.

In limited circumstances, DOE may waive the application of the Buy America requirements where DOE determines that:

(1) applying the Buy America requirements would be inconsistent with the public interest;

(2) the types of iron, steel, manufactured products, or construction materials are not produced in the United States in sufficient and reasonably available quantities or of a satisfactory quality; or

(3) the inclusion of iron, steel, manufactured products, or construction materials produced in the United States will increase the cost of the overall project by more than 25 percent.

If an applicant or recipient is seeking a waiver of the Buy America requirements, it may submit a waiver request after it has been notified of its selection for award negotiations. A waiver request must include:

- A detailed justification for the use of "non-domestic" iron, steel, manufactured products, or construction materials to include an explanation as to how the non-domestic item(s) is essential to the project
- A certification that the applicant or recipient made a good faith effort to solicit bids for domestic products supported by terms included in requests for proposals, contracts, and nonproprietary communications with potential suppliers
- Applicant/Recipient name and Unique Entity Identifier (UEI)
- Total estimated project cost, DOE and cost-share amounts
- Project description and location (to the extent known)
- List and description of iron or steel item(s), manufactured goods, and construction material(s) the applicant or recipient seeks to waive from Domestic Content Procurement Preference requirement, including name, cost, country(ies) of origin (if known), and relevant Product Services Code (PSC) and North American Industry Classification System (NAICS) code for each
- Waiver justification including due diligence performed (e.g., market research, industry outreach) by the applicant or recipient
- Anticipated impact if no waiver is issued

DOE may require additional information before considering the waiver request.

Waiver requests are subject to public comment periods of no less than 15 days and must be reviewed by the Made in America Office. There may be instances where an award qualifies, in whole or in part, for an existing waiver described at DOE Buy America Requirement Waiver Requests - Department of Energy, https://www.energy.gov/management/doe-buy-america-requirement-waiver-requests.

DOE's decision concerning a waiver request is not appealable.

APPENDIX E – DEFINITION OF TECHNOLOGY READINESS LEVELS

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

APPENDIX F – R&D COMMUNITY BENEFITS PLAN GUIDANCE

The DOE is committed to pushing the frontiers of science and engineering; catalyzing high-quality domestic clean energy jobs through research, development, demonstration, and deployment; and ensuring energy equity and energy justice[148] for disadvantaged communities. Therefore, and in accordance with the Administration's priority to empower workers and harness opportunities to create good union jobs as stated in EO 14008 (Tackling the Climate Crisis at Home and Abroad),[149] it is important to consider the impacts of the successful commercial deployment of any innovations resulting from this FOA on current and future workforce. All applicants to this FOA for all Topics (1-6) are required to submit a separate R&D Community Benefits Plan (CBP) as part of their application.

The goal of the three-section R&D Community Benefits Plan is to allow the application to illustrate engagement in critical thought about implications of how the proposed work will benefit the broadest swaths of American people and lead to broadly shared prosperity, including for workers and disadvantaged communities.[150] In addition, for Topic 4 of the FOA, BIL 40314 Clean Hydrogen Manufacturing and Recycling program (EPAct Section 815) specifically prioritizes projects that operate in partnership with Tribal energy development organizations, Indian Tribes, Tribal organizations, Native Hawaiian community-based organizations, or territories or freely associated States; or are located in economically distressed areas of the major natural gas-producing regions of the United States. The sections of the R&D Community Benefits Plans are considered together because there may be significant overlap between audiences considered in workforce and disadvantaged communities.

Example DEIA, Energy Equity, and Workforce Plan Elements

Outlined below are examples of activities that applicants might consider when developing their R&D Community Benefits Plan. Applicants are not required to implement any of these specific examples and should propose the Plan that best fits their research goals, institutional environment, team composition, and other factors. Creativity is encouraged.

DEIA

DOE strongly encourages applicants to involve individuals and entities from disadvantaged communities. Tapping all the available talent requires intentional approaches and yields broad benefits.

[148] At DOE, we define energy justice as "the goal of achieving equity in both the social and economic participation in the energy system, while also remediating social, economic, and health burdens on those disproportionately harmed by the energy system" (Initiative for Energy Justice, 2019). Aligned with that document, the remainder of this document refers to this as, 'energy equity,' and is meant to encompass energy justice as well as DOE's efforts related to Justice40. https://www.energy.gov/diversity/articles/how-energy-justice-presidential-initiatives-and-executive-orders-shape-equity.

[149] EO 14008, "Tackling the Climate Crisis at Home and Abroad," January 27, 2021.

[150] See footnote 2 for guidance on the definition and tools to locate and identify disadvantaged communities.

Equity extends beyond diversity to include equitable treatment. Equitable access to opportunity for members of the project team is paramount. This includes ensuring that all members of the team, including students, are paid a living wage, provided appropriate working conditions, and provided appropriate benefits. In the execution of their project plan, applicants are asked to describe efforts in diversity, equity, inclusion, and accessibility. In this context, efforts toward DEIA are defined as:[151]

1) the practice of including the many communities, identities, races, ethnicities, backgrounds, abilities, cultures, and beliefs of the American people,
2) the consistent and systematic fair, just, and impartial treatment of all individuals, including protecting workers rights and adhering to Equal Employment Opportunity laws,
3) the recognition, appreciation, and use of the talents and skills of employees of all backgrounds, and
4) the provision of accommodations so that all people, including people with disabilities, can fully and independently access facilities, information and communication technology, programs, and services.

Successful plans will not only describe how the project team seeks to increase DEIA, but will describe the overall approaches to retention, engagement, professional development, and career advancement. Specifically, they will demonstrate clear approaches to ensure all team members' strengths are meaningfully leveraged and all members are provided opportunities and paths for career development, especially including paths for interns and trainees to secure permanent positions. Diversity should be considered at all levels of the project team, not just leveraging early career individuals to meet diversity goals.

DOE strongly encourages applicants to consider partnerships as a means of promoting diversity, equity, inclusion, accessibility, justice, and workforce participation. Minority Serving Institutions, Minority Business Enterprises, Minority Owned Businesses, Disability Owned Business, Women Owned Businesses, Native American-owned Businesses, Veteran Owned Businesses, or entities located in an underserved community that meet the eligibility requirements are encouraged to lead these partnerships as the prime applicant or participate on an application as a proposed partner to the prime applicant. See section I.B.iii of the FOA for information on the Teaming Partner list for this FOA, which is being made available to assist applicants in identifying potential partners.

[151] Office of the President (November 2021). Government-wide Strategic Plan to Advance Diversity, Equity, Inclusion, and Accessibility in the Federal Workforce. https://www.whitehouse.gov/wp-content/uploads/2021/11/Strategic-Plan-to-Advance-Diversity-Equity-Inclusion-and-Accessibility-in-the-Federal-Workforce-11.23.21.pdf.

When crafting the DEIA section of the Plan, applicants should describe the ways in which they will act to promote each of the four DEIA efforts above into their investigation. It is important to note that diversity, equity, inclusion, and accessibility are four different, but related, concepts that should not be conflated. That is, you can achieve diversity without equity; all four must be addressed. Applicants could discuss how the proposed investigation could contribute to training and developing a diverse scientific workforce. Applicants could describe the efforts they plan to take, or will continue to take, to create an inclusive workplace, free from retaliation, harassment, and discrimination. Applicants could outline any barriers to creating an equitable and inclusive workplace and address the ways in which the team will work to overcome these barriers within the bounds of the specific research project. The plan could detail specific efforts to inform project team members in any capacity of their labor rights and rights under Equal Employment Opportunity laws, and their free and fair chance to join a union. Note that this inclusion of informing project team members is also incorporated into awards through the National Policy Assurances.

Equal treatment of workers, including students, is necessary but overcoming institutional bias requires intentionally reducing sometimes hidden barriers to equal opportunity. Applicants could consider measures like childcare, transportation, flexible schedules, paid parental leave, pay transparency, and other supports to ensure that societal barriers are not hindering realization of DEIA intentions. Some of these considerations may result in common approaches in different sections of the plan, and that is acceptable, as long as the submission is not a singular approach to all sections.

EERE especially encourages applicants to form partnerships with diverse and often underrepresented institutions, such as Minority Serving Institutions including Tribal Colleges and Universities, labor unions, and community colleges that otherwise meet the eligibility requirements. Underrepresented institutions that meet the eligibility requirements are encouraged to lead these partnerships as the prime applicant. The DEIA section of the Plan could include engagement with underrepresented institutions to broaden the participation of disadvantaged communities and/or with local stakeholders, such as residents and businesses, entities that carry out workforce development programs, labor unions, local government, and community-based organizations that represent, support, or work with disadvantaged communities. Applicants should ensure there is transparency, accountability, and follow-through when engaging with community members and stakeholders.

Specific examples include:

- Building collaborations and partnerships with researchers and staff at Minority Serving Institutions
- Addressing barriers identified in climate surveys to remove inequities
- Providing anti-bias training and education in the project design and implementation teams
- Offering training, mentorship, education, and other support to students and early/mid-career professionals from disadvantaged communities
- Providing efforts toward improving a workplace culture of inclusion
- Developing technology and technology integration innovations to meet the needs of disadvantaged communities
- Creating partnerships with local communities, especially under-resourced and disadvantaged communities
- Voluntary recognition of a union and informing employees of their rights, regardless of their classification
- Making research products and engagement materials accessible in a greater variety of formats to increase accessibility of research outputs
- Implementing training or distributing materials to reduce stigma towards individuals with disabilities
- Designing technologies that strategically fit within the existing workforce for installation and maintenance of the potential innovation

Energy Equity

The Energy Equity section should articulate how project proposals will drive equitable access to, participation in, and distribution of the benefits produced from successful technology innovations to disadvantaged communities and groups. Intentional inclusion of energy equity requires evaluating the anticipated long-term costs and benefits that will accrue to disadvantaged groups as a result of the project, and how research questions and project plans are designed for and support historically disadvantaged communities' engagement in clean energy decisions. Similar to potential cost reductions or groundbreaking research findings resulting from the research, energy equity and justice benefits may be uncertain, occur over a long period of time, and have many factors within and outside the specific proposed research influencing them.

Applicants should describe the influencing factors, and the most likely energy equity implications of the proposed research. Applicants should describe any long-term constraints the proposed technology may pose to communities' access to natural resources and Tribal Cultural resources. There may be existing equity research available to use and cite in this description, or the applicant could describe milestone-based efforts toward developing that understanding through this innovation.

These near and long term outcomes may include, but are not limited to: a decrease in the percent of income a household spends on energy costs (energy burden[152]); an increase in access to low-cost capital; a decrease in environmental exposure and burdens; increases in clean energy enterprise creation and contracting (e.g., women or minority-owned business enterprises); increased parity in clean energy technology access and adoption; increases in energy democracy, including community ownership; and an increase in energy resilience.

Specific examples include:

- Describing how a successful innovation will support economic development in diverse geographic or demographic communities
- Creating a plan to engage equity and justice stakeholders in evaluating the broader impacts of the innovation or in the development of the research methodology, including opportunities to provide benefits for disadvantaged communities
- Describing how the proposed research strategy and methodology was informed by input from a wide variety of stakeholders
- Conducting an assessment of the equity and justice implications of the outcomes of the specific R&D if the innovation is successful (including anticipated benefits or negative impacts when deployed at scale).
- Developing a community engagement plan to facilitate community input, social buy-in, and accountability, to address community concerns and ensure the equitable distribution of benefits and the mitigation of potential harms.

Workforce

The Workforce section of the R&D Community Benefits Plan should articulate the future workforce implications of the innovation or a milestone-driven plan for understanding those implications. This includes documenting the knowledge, skills, and abilities (KSAs) that would be required of workers installing, maintaining, and operating the technology that may be derivative of the applicant's R&D, as well as the training pathways and their accessibility for workers to acquire the necessary skills. There may be field-specific or relevant existing research that could be cited in this section. In addition, applicants could detail the process they will use to evaluate long-term impacts on jobs, including job growth or job loss, a change in job quality, disruptions to existing industry and resulting changes to relationships between employers and employees and improvements or reductions in the ability of workers to organize for collective representation, and anything else that could result in changes to regional or national labor markets.

[152] Energy burden is defined as the percentage of gross household income spent on energy costs: https://www.energy.gov/eere/slsc/low-income-community-energy-solutions.

The Plan should also describe the applicant's current and future approach to investing in workforce education and training of both new and incumbent workers and ensuring jobs are of sufficient quality to attract and retain skilled workers needed to deploy and operate the technology at scale, including opportunities for collective bargaining.

For additional support with developing the Workforce section of a R&D Community Benefits Plan, please refer to the DOE's Community Benefits Plan Frequently Asked Questions (FAQs) webpage (https://www.energy.gov/bil/community-benefits-plan-frequently-asked-questions-faqs). This new resource, though created primarily for demonstration and deployment projects funded by the Bipartisan Infrastructure Law (BIL), may be useful for R&D projects which is the main subject of this FOA template.

Applicants will find section 2 of the FAQ ("Investing in America's Workforce") particularly helpful for understanding key federal policies, terms and concepts, as well as workforce development strategies relevant to examination of the workforce implications of applicants' proposed research.

Specific examples include:

- Outlining the challenges and opportunities for commercializing the technology in the US
- Conducting an assessment of the workforce implications of the outcomes of the specific R&D if the innovation is successful or a plan with dedicated budget and expertise (staffing or subawardee) to evaluate the potential equity implications of successful innovation outcomes
- Creating a plan and milestones for assessing how a successful innovation will have implications for job savings or loss, either at the macroeconomic level or within specific industries
- Describing how the project will support training of workforce to address needs of successful innovation and plans to offer pre-apprenticeship or registered apprenticeship programs, as applicable
- Voluntary recognition of a union and informing employees of their rights, regardless of their classification or plans to develop policies that would ensure worker voice
- Creating a plan to evaluate how a successful innovation will result in potential workforce shifts between industries or geographies.

Other examples, especially relevant for FOA Topics 1 and 4 (which are expected to develop and demonstrate manufacturing technologies and processes suitable for near-term commercial scale-up), include:

- Co-creation of open-source workforce training materials or industry-recognized credentials with one or more community colleges, training institutions, HBCUs or other MSIs
- Engaging with relevant labor organizations, government, education, apprenticeship-readiness programs and training institutions to identify training priorities for an electrolyzer and fuel cell manufacturing workforce
- Characterization of the quality of the jobs that will be offered (for example classification as employees, wages, benefits, and opportunities for progression)
- Development of recruitment and retention strategies that prioritize disadvantaged and/or underutilized populations
- Creation of community awareness sessions in collaboration with local governments and community-based organizations
- Work with communities to understand challenges and opportunities with technology commercialization
- Plans to hold outreach events with community/disadvantaged community organizations.

Inclusion of SMART milestones

EERE requires that the applicant's R&D Community Benefits Plan include one Specific, Measurable, Achievable, Relevant and Timely (SMART) milestone for each budget period, and major milestones and the associated budget must be integrated into the overall project narrative and workplan in the Technical Volume. An exemplar SMART milestone clearly answers the following questions:

- What needs to be accomplished?
- What measures and deliverables will be used to track progress toward accomplishment?
- What evidence suggests that the accomplishment is achievable?
- Why choose this milestone?
- When will the milestone be reached?

APPENDIX G – LIST OF ACRONYMS

A	Ampere
AEM	Anion Exchange Membrane
AOI	Areas of Interest
BABA	Build America Buy America Act
BIL	Bipartisan Infrastructure Law
BOP	Balance-of-Plant
BPP	Bipolar Plate
C2M2	Cybersecurity Capability Maturity Model
CET	Critical and Emerging Technology
CEJST	Climate and Economic Justice Screening Tool
CFR	Code of Federal Regulations
COI	Conflict of Interest
CRADA	Cooperative Research and Development Agreement
CSF	Cybersecurity Framework
DBA	Davis-Bacon Act
DEC	Determination of Exceptional Circumstances
DEIA	Diversity, Equity, Inclusion, and Accessibility
DMP	Data Management Plan
DOE	Department of Energy
DOI	Digital Object Identifier
DOL	Department of Labor
EERE	Energy Efficiency and Renewable Energy
EOL	End-of-Life
EPAct	Energy Policy Act
FAPIIS	Federal Awardee Performance and Integrity Information System
FAQ	Frequently Asked Questions
FAR	Federal Acquisition Regulation
FCOI	Financial Conflicts of Interest
FCTT	Fuel Cell Technical Team
FFATA	Federal Funding and Transparency Act of 2006
FOA	Funding Opportunity Announcement
FOIA	Freedom of Information Act
FFRDC	Federally Funded Research and Development Center
FY	Fiscal Year
GDL	Gas Diffusion Layer
GHG	Greenhouse Gas
GW	Gigawatt
HBCUs	Historically Black Colleges and Universities
HDFC	Heavy Duty Fuel Cell
HDV	Heavy-Duty Vehicle

HFTO	Hydrogen and Fuel Cell Technologies Office
THE	High Temperature Electrolysis
IP	Intellectual Property
IPMP	Intellectual Property Management Plan
kg	Kilogram
kW	Kilowatt
LA	Liquid Alkaline
LCA	Life Cycle Analysis
LTE	Low Temperature Electrolysis
M2FCT	Million Mile Fuel Cell Truck
M&O	Management and Operating
MDV	Medium-Duty Vehicle
MEA	Membrane Electrode Assembly
MMT	Million Metric Tons
MPIN	Marketing Partner ID Number
MSI	Minority-Serving institution
MW	Megawatt
NAICS	North American Industry Classification System
NDA	Non-Disclosure Acknowledgement
NEPA	National Environmental Policy Act
NIST	National Institute of Standards and Technology
NNSA	National Nuclear Security Agency
NSF	National Science Foundation
OEM	Original Equipment Manufacturer
OER	Oxygen Evolution Reaction
OFCCP	Office of Federal Contractor Compliance Programs
OIG	Office of Inspector General
OMB	Office of Management and Budget
O-SOEC	Oxide-Conducting Solid Oxide Electrolysis Cell
OSS	Open-Source Software
OSTI	Office of Scientific and Technical Information
OTA	Other Transactions Authority
PEM	Proton Exchange Membrane
PEMFC	Proton Exchange Membrane Fuel Cell
PFSA	Perfluorosulfonic Acid
PGM	Platinum Group Metal
PI	Principal Investigator
PII	Personal Identifiable Information
POC	Point of Contact
PRL	Physical Review Letters
PSC	Product Services Code
P-SOEC	Proton-Conducting Solid Oxide Electrolysis Cell
PTL	Porous Transport Layer

R&D	Research and Development
RD&D	Research, Development, and Demonstration
RDD&D	Research, Development, Demonstration, and Deployment
SAM	System for Award Management
SciENcv	Science Experts Network Curriculum Vita
SMART	Specific, Measurable, Achievable, Relevant, and Timely
SOEC	Solid Oxide Electrolyzer Cell
SPOC	Single Point of Contact
STEM	Science, Technology, Engineering, and Mathematics
TAA	Technical Assistance Agreement
TCO	Total Cost of Ownership
TRL	Technology Readiness Level
UCC	Uniform Commercial Code
UEI	Unique Entity Identifier
V	Volt
WBS	Work Breakdown Structure
WP	Work Proposal

APPENDIX H - CONGRESSIONAL AUTHORIZATION

Statutory Requirements – BIL Section 40314 (Additional Clean Hydrogen Programs):

- **EPAct Sec. 815. CLEAN HYDROGEN MANUFACTURING AND RECYCLING, and**
- **EPAct Sec. 816. CLEAN HYDROGEN ELECTROLYSIS PROGRAM**

SEC. 40314. ADDITIONAL CLEAN HYDROGEN PROGRAMS.

Title VIII of the Energy Policy Act of 2005 (42 U.S.C. 16151 et seq.) is amended—

(1) by redesignating sections 813 through 816 as sections 818 through 821, respectively; and

(2) by inserting after section 812 the following:

…

SEC. 815. CLEAN HYDROGEN MANUFACTURING AND RECYCLING.

(a) CLEAN HYDROGEN MANUFACTURING INITIATIVE

(1) IN GENERAL.—In carrying out the programs established under sections 805 and 813, the Secretary shall award multiyear grants to, and enter into contracts, cooperative agreements, or any other agreements authorized under this Act or other Federal law with, eligible entities (as determined by the Secretary) for research, development, and demonstration projects to advance new clean hydrogen production, processing, delivery, storage, and use equipment manufacturing technologies and techniques.

(2) PRIORITY.—In awarding grants or entering into contracts, cooperative agreements, or other agreements under paragraph (1), the Secretary, to the maximum extent practicable, shall give priority to clean hydrogen equipment manufacturing projects that--

(A) increase efficiency and cost-effectiveness in-

(i) the manufacturing process; and

(ii) the use of resources, including existing energy infrastructure;

(B) support domestic supply chains for materials and components;

(C) identify and incorporate nonhazardous alternative materials for components and devices;

(D) operate in partnership with tribal energy development organizations, Indian Tribes, Tribal organizations, Native Hawaiian community-based organizations, or territories or freely associated States; or

(E) are located in economically distressed areas of the major natural gas-producing regions of the United States.

(3) EVALUATION.—Not later than 3 years after the date of enactment of the Infrastructure Investment and Jobs Act, and not less frequently than once every 4 years thereafter, the Secretary shall conduct, and make available to the public and the relevant committees of Congress, an independent review of the progress of the projects carried out through grants awarded, or contracts, cooperative agreements, or other agreements entered into, under paragraph (1).

(b) CLEAN HYDROGEN TECHNOLOGY RECYCLING RESEARCH, DEVELOPMENT, AND DEMONSTRATION PROGRAM.

(1) IN GENERAL.—In carrying out the programs established under sections 805 and 813, the Secretary shall award multiyear grants to, and enter into contracts, cooperative agreements, or any other agreements authorized under this Act or other Federal law with, eligible entities for research, development, and demonstration projects to create innovative and practical approaches to increase the reuse and recycling of clean hydrogen technologies, including by-

(A) increasing the efficiency and cost-effectiveness of the recovery of raw materials from clean hydrogen technology components and systems, including enabling technologies such as electrolyzers and fuel cells;

(B) minimizing environmental impacts from the recovery and disposal processes;

(C) addressing any barriers to the research, development, demonstration, and commercialization of technologies and processes for the disassembly and recycling of devices used for clean hydrogen production, processing, delivery, storage, and use;

(D) developing alternative materials, designs, manufacturing processes, and other aspects of clean hydrogen technologies;

(E) developing alternative disassembly and resource recovery processes that enable efficient, cost-effective, and environmentally responsible disassembly of, and resource recovery from, clean hydrogen technologies; and

(F) developing strategies to increase consumer acceptance of, and participation in, the recycling of fuel cells.

(2) DISSEMINATION OF RESULTS.—The Secretary shall make available to the public and the relevant committees of Congress the results of the projects carried out through grants awarded, or contracts, cooperative agreements, or other agreements entered into, under paragraph (1), including any educational and outreach materials developed by the projects.

(c) AUTHORIZATION OF APPROPRIATIONS.—There is authorized to be appropriated to the Secretary to carry out this section $500,000,000 for the period of fiscal years 2022 through 2026.

SEC. 816. CLEAN HYDROGEN ELECTROLYSIS PROGRAM

(a) DEFINITIONS.—In this section:

(1) ELECTROLYSIS.—The term 'electrolysis' means a process that uses electricity to split water into hydrogen and oxygen.

(2) ELECTROLYZER.—The term 'electrolyzer' means a system that produces hydrogen using electrolysis.

(3) PROGRAM.—The term 'program' means the program established under subsection (b).

(b) ESTABLISHMENT.—Not later than 90 days after the date of enactment of the Infrastructure Investment and Jobs Act, the Secretary shall establish a research, development, demonstration, commercialization, and deployment program for purposes of commercialization to improve the efficiency, increase the durability, and reduce the cost of producing clean hydrogen using electrolyzers.

(c) GOALS.—The goals of the program are—

(1) to reduce the cost of hydrogen produced using electrolyzers to less than $2 per kilogram of hydrogen by 2026; and

(2) any other goals the Secretary determines are appropriate.

(d) DEMONSTRATION PROJECTS.—In carrying out the program, the Secretary shall fund demonstration projects--

(1) to demonstrate technologies that produce clean hydrogen using electrolyzers; and

(2) to validate information on the cost, efficiency, durability, and feasibility of commercial deployment of the technologies described in paragraph (1).

(e) Focus.—The program shall focus on research relating to, and the development, demonstration, and deployment of—

(1) low-temperature electrolyzers, including liquid-alkaline electrolyzers, membrane-based electrolyzers, and other advanced electrolyzers, capable of converting intermittent sources of electric power to clean hydrogen with enhanced efficiency and durability;

(2) high-temperature electrolyzers that combine electricity and heat to improve the efficiency of clean hydrogen production;

(3) advanced reversible fuel cells that combine the functionality of an electrolyzer and a fuel cell;

(4) new highly active, selective, and durable electrolyzer catalysts and electro-catalysts that—

(A) greatly reduce or eliminate the need for platinum group metals; and

(B) enable electrolysis of complex mixtures with impurities, including seawater;

(5) modular electrolyzers for distributed energy systems and the bulk-power system (as defined in section 215(a) of the Federal Power Act (16 U.S.C. 824o(a)));
(6) low-cost membranes or electrolytes and separation materials that are durable in the presence of impurities or seawater;
(7) improved component design and material integration, including with respect to electrodes, porous transport layers and bipolar plates, and balance-of-system components, to allow for scale-up and domestic manufacturing of electrolyzers at a high volume;
(8) clean hydrogen storage technologies;
(9) technologies that integrate hydrogen production with—
    (A) clean hydrogen compression and drying technologies;
    (B) clean hydrogen storage; and
    (C) transportation or stationary systems; and
(10) integrated systems that combine hydrogen production with renewable power or nuclear power generation technologies, including hybrid systems with hydrogen storage.

(f) GRANTS, CONTRACTS, COOPERATIVE AGREEMENTS.—
(1) GRANTS.—In carrying out the program, the Secretary shall award grants, on a competitive basis, to eligible entities for projects that the Secretary determines would provide the greatest progress toward achieving the goal of the program described in subsection (c).
(2) CONTRACTS AND COOPERATIVE AGREEMENTS.—In carrying out the program, the Secretary may enter into contracts and cooperative agreements with eligible entities and Federal agencies for projects that the Secretary determines would further the purpose of the program described in subsection (b).
(3) ELIGIBILITY; APPLICATIONS.—
    (A) IN GENERAL.—The eligibility of an entity to receive a grant under paragraph (1), to enter into a contract or cooperative agreement under paragraph (2), or to receive funding for a demonstration project under subsection (d) shall be determined by the Secretary.
    (B) APPLICATIONS.—An eligible entity desiring to receive a grant under paragraph (1), to enter into a contract or cooperative agreement under paragraph (2), or to receive funding for a demonstration project under subsection (d) shall submit to the Secretary an application at such time, in such manner, and containing such information as the Secretary may require.

(g) AUTHORIZATION OF APPROPRIATIONS.—There is authorized to be appropriated to the Secretary to carry out the program $1,000,000,000 for the period of fiscal years 2022 through 2026, to remain available until expended.