RFI on Clean Hydrogen Manufacturing, Recycling, and Electrolysis

RFI # DE-FOA-0002698

DATE: February 15, 2022
SUBJECT: Request for Information (RFI)

Description

The U.S. Department of Energy's (DOE) Hydrogen and Fuel Cell Technologies Office (HFTO) seeks input on priority areas that will advance domestic manufacturing and recycling of clean hydrogen technologies, including fuel cells, storage equipment, and other hydrogen related components as specified below; and on priority areas that will advance electrolyzer technologies for affordable clean hydrogen production, in alignment with the Bipartisan Infrastructure Law (BIL) [1] and the mission of DOE's Hydrogen Energy Earthshot to reach the goal of $1 per 1 kilogram in 1 decade ("1 1 1").[2] This RFI was developed in coordination with the Advanced Manufacturing Office. This RFI is issued to obtain feedback on the status of and opportunities for technologies that support goals in BIL section 40314, amending the Energy Policy Act of 2005 (EPACT). The BIL added a new section 815 on clean hydrogen manufacturing and recycling research, development, and demonstration (RD&D) and a new section 816 for the establishment of the Clean Hydrogen Electrolysis Program to EPACT. The EPACT Sec. 815 activities are grouped into a Clean Hydrogen Manufacturing Initiative (815a) focused on enhancing domestic manufacturing of clean hydrogen use, storage, and related equipment and a Clean Hydrogen Technology Recycling RD&D Program (815b) that covers recycling of equipment for clean hydrogen processing, delivery, storage, and use, including fuel cells.[3] The Clean Hydrogen Electrolysis Program in section 816 expands on DOE's existing, comprehensive Program on electrolysis and is a research, development, demonstration, commercialization, and deployment program aimed at improving efficiency, increasing durability, and reducing capital costs of electrolyzers, thus facilitating the commercialization of clean hydrogen electrolyzer technology.[4]

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[1] https://www.congress.gov/117/bills/hr3684/generated/BILLS-117hr3684enr.html#toc-HEBC9C466B73E4FE7887D369791CDD207
[2] The U.S Department of Energy's Hydrogen Energy Earthshot, or Hydrogen Shot: https://www.energy.gov/eere/fuelcells/hydrogen-shot
[3] Pub.L. 109-58, Title VIII, § 815(a) and (b), as added Pub.L.117-58, Div. D, Title III, § 40314(2), Nov. 15, 2021.
[4] Pub.L. 109-58, Title VIII, § 816(b), as added Pub.L.117-58, Div. D, Title III, § 40314(2), Nov. 15, 2021.

DOE does not intend to publish information collected through this RFI; input will be used to develop and refine the programs.

Background

On November 15, 2021, President Joseph R. Biden, Jr. signed the Infrastructure Investment and Jobs Act (Public Law 117-58), also known as the Bipartisan Infrastructure Law. The BIL is a once-in-a-generation investment in infrastructure, which will grow a more sustainable, resilient, and equitable economy through enhancing U.S. competitiveness in the world, creating good jobs, ensuring stronger access to these economic benefits for underserved communities. The BIL appropriates more than $62 billion to DOE[5] to deliver a more equitable clean energy future for the American people by:

- Investing in American manufacturing and workers.
- Expanding access to energy efficiency and clean energy for families, communities, and businesses.
- Delivering reliable, clean, and affordable power to more Americans.
- Building the technologies of tomorrow through clean energy demonstrations.

As part of this effort, the BIL authorizes appropriations of $9.5 billion for clean hydrogen programs and initiatives for the five (5) year period encompassing fiscal years (FYs) 2022 through 2026, including $1 billion for the Clean Hydrogen Electrolysis Program, $500 million for the Clean Hydrogen Manufacturing Initiative and the Clean Hydrogen Technology Recycling RD&D Program, and $8 billion for the development of Regional Clean Hydrogen Hubs (which are covered in a separate RFI issued by DOE [see RFI # DE-FOA-0002664]). In addition, Section 40314 of the BIL amends EPAct 2005 to add "Section 814 – National Clean Hydrogen Strategy and Roadmap." Under this section, DOE shall develop a technologically and economically feasible national strategy and roadmap to facilitate widescale production, processing, delivery, storage, and use of clean hydrogen. DOE will use this roadmap to carry out its hydrogen research, development, demonstration, and deployment programs.

Purpose

The purpose of this RFI is to solicit feedback and other guidance from industry, academia, research laboratories, government agencies, community groups, labor unions, energy users, environmental justice organizations, economic development organizations, and other stakeholders regarding the clean hydrogen manufacturing, recycling, and electrolysis research, development, and demonstration topics/questions listed below, as well as any critical barriers

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[5] 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

and activities that are relevant but not directly addressed in this RFI. This RFI focuses on hydrogen and related technologies, such as electrolyzers, fuel cells, and storage tanks. These technologies can play a key role in decarbonizing multiple sectors and will support the Biden Administration's goal to achieve a carbon-free electric grid by 2035 and a net zero emissions economy by 2050.[6]

The RFI is divided into three parts: Part I covers topics relating to the Clean Hydrogen Manufacturing Initiative and Clean Hydrogen Recycling RD&D Program, Part II covers topics related to the Clean Hydrogen Electrolysis Program, and Part III covers topics relating to new Buy American and related employment considerations that are broader in scope. Respondents are welcome to provide responses to all parts of the RFI and may answer as many or as few questions as they wish. Please include the question numbers (3c, A2, etc.) in your responses. <u>If possible, please copy and paste the RFI question sections to use as a template for your response. This permits reviewers to efficiently organize and understand your key input.</u>

Part I: Clean Hydrogen Manufacturing and Recycling

Background

The Hydrogen and Fuel Cell Technologies Office is leading the clean hydrogen manufacturing and recycling RD&D in response to EPACT section 815 (as added by BIL section 40314). To meet the requirements of the legislation, the scope of these activities for the Clean Hydrogen Manufacturing Initiative will give priority to clean hydrogen equipment manufacturing projects that: increase efficiency and cost-effectiveness in the manufacturing process and the use of resources, including existing energy infrastructure; support domestic supply chains for materials and components; identify and incorporate nonhazardous alternative materials for components and devices; operate in partnership with tribal energy development organizations, Indian Tribes, Tribal organizations, Native Hawaiian community-based organizations, territories or freely associated States; or are located in economically distressed areas of the major natural gas-producing regions of the United States.[7]

In regard to the Clean Hydrogen Technology RD&D Program, practical and innovative approaches to increase the reuse and recycling of clean hydrogen technologies will be developed, including by: increasing the efficiency and cost-effectiveness of the recovery of raw

[6] See https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/. A near-term target for a 50-52% reduction in U.S. greenhouse gas emissions by 2030 was also announced in April 2021: https://www.whitehouse.gov/briefing-room/statements-releases/2021/04/22/fact-sheet-president-biden-sets-2030-greenhouse-gas-pollution-reduction-target-aimed-at-creating-good-paying-union-jobs-and-securing-u-s-leadership-on-clean-energy-technologies/.

[7] Pub.L. 109-58, Title VIII, § 815(a)(2), as added Pub.L. 117-58, Div. D, Title III, § 40314(2), Nov. 15, 2021.

materials from clean hydrogen technology components and systems, including enabling technologies such as electrolyzers and fuel cells; minimizing environmental impacts from the recovery and disposal processes; 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; developing alternative materials, designs, manufacturing processes, and other aspects of clean hydrogen technologies; 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 developing strategies to increase consumer acceptance of, and participation in, the recycling of fuel cells.[8]

For over two decades, HFTO[9] has led RD&D activities to enable the commercial viability and adoption of hydrogen and fuel cell technologies that would benefit multiple applications across sectors. HFTO funding has led to over 1,100 U.S. patents and more than 30 technologies that have been commercialized,[10] ranging from components such as membranes, to complete systems such as fuel cells, electrolyzers, and storage tanks. Commercialized systems include fuel cells for use in specific applications such as forklifts, backup power units, and stationary power, as well as transportation applications such as vehicles, buses, and the emerging infrastructure needed to support them. There are currently over 170MW of domestic polymer electrolyte membrane electrolyzers,[11] and the market is growing. As clean hydrogen technology deployments continue to increase, investments in manufacturing supply chains and in capturing end-of-life value of the clean hydrogen equipment can enable sustainability and expedite further private sector adoption and market penetration of the technologies.

The Clean Hydrogen Manufacturing Initiative and Clean Hydrogen Technology Recycling RD&D activities described in section 40314 of the BIL include multiple topics, including objectives to advance new equipment manufacturing technologies and techniques for clean hydrogen processing, delivery, storage, and use equipment, as well as materials and component recycling processes. The efforts aim at strengthening the domestic supply chain and are aligned with BIL and DOE clean hydrogen technology targets including $2/kg for hydrogen by 2026,[12] and

[8] Pub.L. 109-58, Title VIII, § 815(b)(1), as added Pub.L. 117-58, Div. D, Title III, § 40314(2), Nov. 15, 2021.
[9] Note that the Office name changed from Hydrogen, Fuel Cells and Infrastructure Technologies (HFCIT) to Fuel Cell Technologies Office (FCTO) and subsequently to Hydrogen and Fuel Cell Technologies Office (HFTO) to be consistent with its congressional budget chapter name.
[10] 2019 Patent Analysis for the U.S. Department of Energy Hydrogen and Fuel Cell Technologies Office
[11] Arjona, V., Buddhavarapu, P. "Electrolyzer Capacity Installations in the United States." U.S. Department of Energy Hydrogen and Fuel Cells Program Record, 2021. DOE Hydrogen Program Record 20009: Electrolyzer Capacity Installations in the United States (energy.gov) (As of June 2021).
[12] Pub.L. 109-58, Title VIII, § 816(c)(1), as added Pub.L.117-58, Div. D, Title III, § 40314(2), Nov. 15, 2021.

$80/kW for fuel cells[13] and $9/kWh for storage tanks by 2030.[14] The RD&D activities will enable the development and demonstration of manufacturing/recycling technologies that would lower cost and enhance efficiency for making clean hydrogen technology systems, supporting market competitiveness for these technologies. It will also alleviate dependence on imports, strengthen the domestic supply chain, and address environmental concerns related to the production and disposal of materials (e.g, perfluoronated membranes).

Questions related to Clean Hydrogen Manufacturing and Recycling

Respondents are welcome to provide responses to all parts this section and may answer as many or as few questions as they wish. Please use the underlined, lettered topics as headings in your response to the greatest extent possible and include the question number (e.g., A3, C2, etc.) in the body of your responses. This permits reviewers to efficiently organize and understand your input.

Clean Hydrogen Equipment Manufacturing

A) Increasing efficiency and cost effectiveness of the manufacturing process or in the use of resources:
   1. What additional manufacturing rates or efficiencies are required to meet projected demand for clean hydrogen storage and use equipment (fuel cells, storage tanks, etc.)?
   2. What are the most-costly or resource-intensive manufacturing processes in domestically produced components that can be addressed by RD&D?
   3. Are there promising existing/emerging lab-scale processes that increase efficiency and cost effectiveness that would benefit from scale-up development and demonstration and how much funding would be required?
   4. Are there other mature or emerging related technologies with manufacturing processes that can complement or be modified for fuel cell, hydrogen storage, and related clean hydrogen technologies? Please specify and discuss what modifications are required to produce clean hydrogen equipment. If available, provide information on feasibility and funding required.
   5. What existing energy infrastructure can be leveraged to reduce equipment manufacturing costs? What steps should be taken to reduce environmental impacts from repurposing existing energy infrastructure, especially in disadvantaged communities?
   6. What steps in the manufacturing process would benefit from automation, and what are the RD&D needs? How might automation impact job creation?

[13] https://www.hydrogen.energy.gov/pdfs/hydrogen-program-plan-2020.pdf

[14] DOE Hydrogen and Fuel Cells Program Record 19006: Hydrogen Class 8 Long Haul Truck Targets, https://www.hydrogen.energy.gov/pdfs/19006_hydrogen_class8_long_haul_truck_targets.pdf

7. What best practices need to be developed/demonstrated for material and component handling, roll-to-roll manufacturing techniques, in-line diagnostics and quality control/ assurance methods, and reduction of manufacturing defects to ensure high-throughput production of clean hydrogen technologies components? What steps must be taken immediately to advance manufacturing QC/QA for fuel cell, storage, and other clean H_2 equipment?
8. Would a consortium for advanced manufacturing for process validation and demonstration benefit the Hydrogen Equipment Manufacturing community? Which type of equipment specifically would benefit?
9. Are there diversity, equity, or inclusion (DEI) issues within the current clean energy equipment manufacturing community and what are suggestions for addressing those through this initiative?
10. What areas are lacking standards for equipment interoperability, such as compatibility between manufacturers and availability of commercial off the shelf (COTS) components?
11. What specific areas should DOE prioritize under EPACT section 815 funding of $500M over 5 years, given the funding available in EPACT section 816 ($1B over 5 years) focused primarily on electrolysis?

B) Supporting domestic supply chains for materials and components

1. What clean hydrogen components have limited or no domestic manufacturers? What are the most critical components that should be manufactured in the U.S.?
2. Would the US supply base benefit from building domestic reserves for clean hydrogen critical materials (e.g., Pt, Ir, etc) and what amounts would need to be stockpiled?
3. What system (e.g., stacks and balance of plant (BOP) including power electronics) and stack components would benefit from standardization?
4. What are the steps needed to design manufacturing processes with recyclability and critical material reclamation in mind?
5. What regulations, codes, standards, and safety protocols pose barriers to this growth?

6. What tools should be utilized to ensure strong work opportunities for local residents in the construction and long-term operations of manufacturing projects, especially in disadvantaged communities and in communities that have experienced job losses due to economic transition? Discuss creation of clear workforce education and training pathways, including registered apprenticeships,[15] into high quality jobs.

C) <u>Identifying and incorporating nonhazardous alternative materials for components and devices, and developing alternative materials, designs, manufacturing processes, and other aspects of clean hydrogen technologies</u>

1. Describe any existing or potential hazards associated with conventional clean hydrogen technology manufacturing materials (e.g., perfluoronated polymers) and identify potential materials to replace them that should receive additional RD&D investments. What is the technological maturity of the alternative material(s) in components?
2. Are there alternative materials that could be further developed that would address supply chain vulnerabilities? If so, please specify and please state the priority for funding under this initiative.
3. What opportunities exist to replace components with more easily recyclable materials (e.g., aluminum alloys)?
4. What opportunities exist to alter design and manufacturing processes of fuel cells, storage tanks, or other clean hydrogen equipment for simpler disassembly and recovery?
5. What opportunities exist in system component refurbishment? Are there lifetime prognostics needed and how could R&D address these?
6. What standardized testing methodologies need to be developed to enable development/utilization of alternative materials for components/devices?

D) <u>Operating in partnership with tribal energy development organizations, Indian Tribes, Tribal Organizations, and Native Hawaiian community orgs/territories/freely associated States</u>

1. How can these Native communities and organizations benefit from domestic clean hydrogen manufacturing and other activities outlined in EPACT section 815? Please be as specific as possible (e.g., by establishing a consortium, utilizing or building up manufacturing facilities).

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[15] "A Registered Apprenticeship Program (RAP) is a proven model of apprenticeship that has been validated by the U.S. Department of Labor or a State Apprenticeship Agency." Registered Apprenticeship is the term used for apprenticeship programs that have a formal structure, in which employers have established learning standards that meet national and state quality expectations. When individuals successfully complete a Registered Apprenticeship program, they receive a national credential that is recognized anywhere in the industry." https://www.apprenticeship.gov/employers/registered-apprenticeship-program; https://www.dol.gov/sites/dolgov/files/ETA/apprenticeship/pdfs/Pre_Apprenticeship_GuideforWomen.pdf

2. Please highlight opportunities to partner with these communities and organizations and specify the capabilities currently available or may be made available.
3. What barriers exist in developing partnerships with native communities and how can they be addressed?

E) Clean hydrogen technology manufacturing opportunities in economically distressed areas of major natural gas producing regions and equity, environmental and energy justice strategies, including significant and meaningful community engagement plans
   1. Please give input on how the Justice40[16] policy priorities can be achieved through Clean Hydrogen Manufacturing and Recycling to ensure that 40% of the overall benefits of projects will flow to disadvantaged communities (DACs).
   2. Please identify relevant manufacturing activities that exist in "regions of the United States with the greatest natural gas resources,"[17] or that could leverage existing manufacturing facilities for new manufacturing of clean hydrogen technologies.
   3. What workforce development infrastructure is needed to support high-paying union jobs and registered apprenticeship programs in these areas?
   4. How should communities and labor unions be involved in the process of selecting manufacturing facility type and location?

Approaches to Increase the Reuse and Recycling of Clean Hydrogen Technologies

F) Increasing efficiency/cost effectiveness of recovery of raw materials from clean hydrogen components and systems, including electrolyzers and fuel cells
   1. What are the current state-of-the-art recovery and recycling processes for clean hydrogen equipment (e.g., electrolyzers, fuel cells, storage, etc.)?
   2. What are the most valuable components or materials in these technologies, and what are the key barriers in demonstrating the recovery and recycling processes at scale?
   3. What are the greatest inefficiencies/greatest costs in recovery of fuel cell and electrolyzer components (platinum group metals from catalysts, nickel, electrolyte materials, bipolar plates, graphite, etc.), as well as for materials used for hydrogen storage systems (e.g., carbon fiber)? What opportunities exist to address them at R&D scale?
   4. Please comment on the value of forming a clean hydrogen manufacturing and recycling center that includes industry, national labs, labor unions, environmental justice organizations, community-based organizations, and academia.

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[16] The Justice40 initiative, established by E.O. 14008, states that 40% of the overall benefits of certain federal investments should flow to disadvantaged communities (DACs). The Justice40 Interim Guidance provides a broad definition of DACs (Page 2): https://www.whitehouse.gov/wp-content/uploads/2021/07/M-21-28.pdf
17 42 USC 16161a(c)(3)(D)

G) Addressing barriers to RD&D and commercialization for disassembly and recycling technology and processes for clean H_2 technologies, including environmental impacts
   1. What disassembly and recovery processes are key limitations in recycling the most desirable elements of clean hydrogen technologies (metals, ionomers, carbon fibers, etc.)?
   2. How does degradation during the lifetime affect the end-of-life value of cell membrane materials, catalysts, storage components, and related components? Are there second life uses for hydrogen technologies/systems without requiring full disassembly?
   3. What standards development is necessary to enable: safe disassembly/recycling of hydrogen technologies system components, second life uses, or other safety concerns?
   4. What are existing or potential future adverse environmental impacts of recovery and disposal processes? How are adverse impacts currently measured or monitored and which materials/processes/components result in the largest environmental impact?
   5. What opportunities exist to minimize impacts (e.g., incentivize recovery of material rather than dispose of it, alter designs or materials to requires less intensive recovery processes, etc.)?
   6. How can environmental impacts related to manufacturing, such as air and water quality, water use, and other negative impacts be minimized for disadvantaged communities (DACs) in particular? What communities are most impacted by the environmental impacts of disassembly and recovery processes and how can DOE support meaningful and sustained engagement with them?

H) Developing strategies to increase consumer acceptance of/participation in recycling of fuel cells
   1. Although broad consumer recycling programs such as for batteries and household products may not be applicable for most hydrogen technologies, what are the most effective strategies for potential recycling programs? What scale will they be most effective at, and what are the cost and policy drivers that could yield success?
   2. Would establishing a comprehensive materials management system (leasing programs, and deposit and return incentives for critical materials or other components) benefit material/component recyclability?
   3. What other mechanisms such as remuneration, prizes, national lab testing and collaboration, may be used to further accelerate progress? Please provide details.

Other Relevant Topics

- Please provide background and feedback on topics that support the above subject areas but were not specifically requested. Please begin with a concise description of why it is relevant to topics in Part I.

Part II: Clean Hydrogen Electrolysis Program

Background

A Clean Hydrogen Electrolysis Program (designated "the Program" in this section of the document) is being created in response to EPACT section 816 (as added by BIL section 40314). DOE has a long-established hydrogen research, development, and demonstration program which includes efforts to improve electrolyzer efficiency, durability and to reduce the hydrogen production cost. EPACT section 816(c) established the goal of the new Program to reduce the cost of clean hydrogen produced using electrolyzers to less than $2 per kilogram of hydrogen by 2026. To achieve this goal, the DOE's Hydrogen and Fuel Cell Technologies Office will leverage its already existing electrolysis program and will further refine and expand its efforts through stakeholder input, such as through this RFI. As outlined in EPACT section 816(b), the Clean Hydrogen Electrolysis Program will involve comprehensive research, development, demonstration, and deployment efforts. These efforts will be undertaken to improve the efficiency, increase the durability, and reduce the cost of electrolyzers. In carrying out the program, EPACT section 816(b) also states that demonstration projects of clean hydrogen electrolyzers shall be used to validate information on the cost, efficiency, durability, and feasibility of commercial deployment.[18]

As defined in EPACT section 816 (added by BIL section 40314), an electrolyzer is a system that produces hydrogen by means of using electricity to split water into hydrogen and oxygen.[19] Electrolyzer technologies covered by the Program include liquid alkaline electrolyte, low-temperature membrane-based electrolyte (e.g., proton exchange membrane [PEM], and alkaline exchange membrane [AEM]), high-temperature ceramic electrolyte (e.g., solid oxide electrolysis cells [SOEC]), and other advanced electrolyzer technologies. Improved electrolyzer stack (e.g., catalysts, membranes, bipolar plates) and system (e.g., power supply/controls, H_2 drying and purification, water purification) components are included. Also of interest are reversible fuel cells and technologies that integrate hydrogen production with compression, storage, transportation, or stationary systems, and renewable or nuclear power generation technologies. Please see EPACT section 816 (added by BIL section 40314) for a complete description of the Clean Hydrogen Electrolysis Program.

Questions related to the Clean Hydrogen Electrolysis Program

Respondents are welcome to provide responses to all parts of this section and may answer as many or as few questions as they wish. <u>Please use the underlined numbered statements/questions as headings in your response to the greatest extent possible</u> (e.g., 1a, 3b,

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[18] Pub.L. 109-58, Title VIII, § 816(d), as added Pub.L.117-58, Div. D, Title III, § 40314(2), Nov. 15, 2021.
[19] Pub.L. 109-58, Title VIII, § 816(a)(2), as added Pub.L.117-58, Div. D, Title III, § 40314(2), Nov. 15, 2021.

etc.) in the body of your responses. This permits reviewers to efficiently organize and understand your input.

1) Electrolyzers including, low-temperature electrolyzers (i.e. liquid alkaline or membrane-based); high-temperature electrolyzers that combine electricity and heat to improve the efficiency of clean hydrogen production; advanced reversible fuel cells that combine the functionality of an electrolyzer and a fuel cell; and other advanced electrolyzers, capable of converting intermittent sources of electric power to clean hydrogen with enhanced efficiency and durability.[20] Please state the specific electrolyzer technology your response relates to.
   a. What innovations in materials (such as novel compositions, structures, and designs) are needed to improve electrolyzer technology to generate clean hydrogen at $2/kg by 2026 assuming a cost of electricity of $30/MWh or less?
   b. What electricity cost should the program assume for hydrogen production in 2026 and 2030?
   c. What is the cost reduction potential of novel electrolyzer technologies that can tolerate direct use of impure water (e.g., tap water, brackish water, etc.)? What other implications of using impure water need to be considered (such as efficiency, maintenance, etc.), and what specific material innovations are required?
   d. What demonstration projects could enable and/or validate progress towards the $2/kg goal?
   e. What metrics and methods could enable and/or validate progress towards the $2/kg goal?
   f. What are the potential human and environmental impacts of scaling this specific electrolyzer technology, especially on disadvantaged communities (DACs)?

2) Improved component design and material integration, including with respect to catalysts, electrodes, porous transport layers, bipolar plates, and balance-of-system components, to allow for scale-up and domestic manufacturing of electrolyzers at a high volume.[21] Please state the specific component and electrolyzer technology your response relates to.
   a. What are the most promising opportunities for minimizing or eliminating iridium content in PEM electrolyzers?
   b. What are under-explored, yet promising, classes of materials that could result in enhanced electrolyzer performance and durability, including in the presence of impure water?

[20] Pub.L. 109-58, Title VIII, § 816(e)(1-3), as added Pub.L.117-58, Div. D, Title III, § 40314(2), Nov. 15, 2021.
[21] Pub.L. 109-58, Title VIII, § 816(e)(7), as added Pub.L.117-58, Div. D, Title III, § 40314(2), Nov. 15, 2021.

   c. What are the most critical barriers/needs for integrating the various cell/stack components into a stack from performance, durability, cost, and manufacturability perspectives?
   d. What are the trade-offs between ideal component structure or design and manufacturing cost?
   e. What further development is needed in balance-of-system components beyond the stack (including compressors, gas dryers, power electronics, etc.) to reduce the overall system cost and how much funding would be required for appropriate projects in each area?

3) Modular electrolyzers for distributed energy systems and the bulk-power system.[22]
   a. What benefits and value can electrolyzers provide to distributed energy systems and the bulk power system (e.g., energy storage, frequency stabilization, etc.) and what module sizes are of most interest (e.g., in MW) for a given application of interest?
   b. Are there specific demonstrations (scale, operation strategy, location in energy/power system, etc.) that can validate these benefits?

4) Clean hydrogen storage technologies.[23] Responses should include if they are for specific end-use applications or for general electrolyzer installations.
   a. What hydrogen storage requirements (e.g., capacity, pressure, cost) will be needed with future electrolyzer installations? Please be as specific as possible.
   b. Are there specific types of hydrogen storage needs, such as buffer storage able to undergo frequent cycling, or long duration storage with low-cycling frequency and at what scale (e.g., number of tonnes or kg of hydrogen stored per day)?
   c. What are the most important attributes for hydrogen storage, e.g., cost, system size/compactness, round-trip efficiency? Please state specific targets if available.
   d. Are there codes and standards that are either lacking for, or inhibiting to, storage needs?

5) Technologies that integrate hydrogen production with clean hydrogen compression and drying technologies, clean hydrogen storage, transportation or stationary systems, and renewable power or nuclear power generation technologies.[24] Please note the technology or technologies discussed in the response.
   a. What prior demonstrations of integrated systems have been successfully completed, or attempted with limited success? For the latter, please describe the challenges or barriers to success, and what remaining or unfinished demonstrations would be most

[22] Pub.L. 109-58, Title VIII, § 816(e)(5), as added Pub.L.117-58, Div. D, Title III, § 40314(2), Nov. 15, 2021.
[23] Pub.L. 109-58, Title VIII, § 816(e)(8), as added Pub.L.117-58, Div. D, Title III, § 40314(2), Nov. 15, 2021.
[24] Pub.L. 109-58, Title VIII, § 816(e)(9-10), as added Pub.L.117-58, Div. D, Title III, § 40314(2), Nov. 15, 2021.

valuable, including amount of funding required and for what scale of demonstration. Include the resulting positive and negative impacts to the geographic location surrounding the integrated systems being showcased, especially with respect to the Justice40 policy priorities for disadvantaged communities.[25]

b. How can demonstrations be best used to accelerate commercialization of electrolyzer produced hydrogen?
   i. Who should be the target audience for electrolyzer demonstrations (e.g., utilities, end users, disadvantaged communities, investors, other)?
   ii. How should demonstration projects be formulated to maximize their impact in accelerating acceptance and use of electrolyzer-produced hydrogen and what funding is required and at what scale?
   iii. How can demonstrations for the integration of hydrogen production with existing manufacturing processes and infrastructure accelerate commercialization/acceptance? Please provide specific examples and funding required.
c. What electrolyzer, distribution, storage, and end-use technologies should be prioritized in demonstration projects? Please describe specific technologies and:
   i. How the demonstration will validate information on cost, efficiency, durability, and/or feasibility of the technology, and state the methods/metrics used for validation. How does the proposed demonstration differ from previous demonstrations?
   ii. The scale of the demonstration (e.g., rated power capacity, hydrogen production rate) and funding required.
   iii. Intended operation strategy (e.g., steady state, dynamic, etc.) and end-use of the hydrogen produced.
   iv. Have there been similar demonstrations before and how would the proposed one be different?
   v. Any safety and building regulations, codes, and standards that present barriers to demonstration projects, in addition to ideas on how those barriers can be overcome.

6) <u>Of focus areas (1)-(5) listed above, please rate their importance on a scale of 1-5, with 1 being least important and 5 the most important.</u>

[25] The Justice40 initiative, established by E.O. 14008, states that 40% of the overall benefits of certain federal investments should flow to disadvantaged communities (DACs). The Justice40 Interim Guidance provides a broad definition of DACs (Page 2): https://www.whitehouse.gov/wp-content/uploads/2021/07/M-21-28.pdf

7) Domestic manufacturing of commercial electrolyzer materials, components, stacks, and systems
   a. What regulations, standards, and safety protocols pose barriers to this growth?
   b. What workforce development activities are needed to accelerate domestic electrolyzer manufacturing and where could registered apprenticeships provide highest value?
   c. What are the most important factors considered when conducting manufacturing site selection and capacity? How will diversity, equity, inclusion, and environmental justice principles be incorporated into manufacturing site selection?
   d. What are the greatest needs with respect to advancing electrolyzer manufacturing capacity to the GW-scale for the different electrolyzer technologies and how much funding would be required to achieve GW scale manufacturing capacity and in what time frame? (Please state if detailed response already given in Part I of this RFI.)
   e. Are there certain manufacturing-related activities that are ideal for carrying out at the national labs and are there other activities that are best left to industry to address?

8) National testing facilities
   a. How would the establishment of national stack-level and system-level testing facilities provide value and/or accelerate the deployment of MW- and GW-scale electrolyzer systems?
   b. If you have used electrolyzer test facilities before, what capabilities have you found beneficial and what were the limitations of those test facilities?
   c. What scale, or range of scales, are needed in testing facilities?
   d. What capabilities would the ideal testing facility possess?
   e. What is the value of having multiple, diverse testing facilities (e.g., different geographical locations, capabilities, etc.)?

9) Environmental justice, diversity, equity, and inclusion
   a. What are specific ideas and opportunities for including disadvantaged and tribal communities and addressing environmental justice, diversity, equity, and inclusion in carrying out the research and development goals, electrolyzer system research and demonstration projects?
   b. In gathering feedback on program priorities, how can DOE better engage disadvantaged and tribal communities and address environmental justice, diversity, equity, and inclusion?
   c. What other ways can the Clean Hydrogen Electrolysis Program meet the Justice40 policy priorities?
   d. Please comment on required investments in workforce education and training, including registered apprenticeships and quality pre-apprenticeship programs, to support access

to high quality jobs, including for workers displaced from fossil industries and other industrial or resource-dependent industries in decline.

10) Program structure
   a. Given the H2NEW,[26] HydroGEN,[27] and ElectroCat[28] Consortia established by HFTO, what additional gaps need to be addressed in establishing the Clean Hydrogen Electrolysis Program? Is this best done by expanding or modifying these existing consortia or establishing new consortia? Provide any suggestions as appropriate and benefits of the proposed approach.
   b. What other mechanisms such as prizes, competitions, or financing, may be used to further accelerate progress? How might these encourage new partners and researchers to bring their perspectives to the field?

Other Relevant Topics

- Please provide background and feedback on topics that support the above subject areas but were not specifically requested. Please begin with a concise description of why it is relevant to the Program.

Part III: Additional Questions

Background

As part of the new Buy American requirements,[29] agencies funding infrastructure projects are required to begin applying and enforcing that domestic preference requirement on May 14, 2022, 180 days after passage of the BIL.[30] Agencies will also be responsible for processing any waiver requests to that requirement. Waivers may be granted pursuant to three justifications:

- Applying the domestic content procurement preference would be inconsistent with the public interest;
- The types of iron, steel, manufactured products, or construction materials are not produced in the United States[31] in sufficient and reasonably available quantities or of a satisfactory quality; or

[26] The HFTO N2NEW Consortium on Hydrogen from Next-generation Electrolyzers of Water: https://h2new.energy.gov/
[27] The HFTO HydroGEN Consortium on Advanced Water Splitting Materials: https://h2awsm.org/
[28] The HFTO ElectroCat Consortium on PGM-free Electrocatalysts: https://www.electrocat.org/
[29] New Buy American requirements are located in Division G – Other Authorizations; Title IX – Build America, Buy America of the Infrastructure Investment and Jobs Act, Public Law 117-58, which was enacted into law on November 15, 2021. https://www.congress.gov/bill/117th-congress/house-bill/3684
[30]Pub.L.117-58, Div. G, Title IX, Part I, § 70914(a), Nov. 15, 2021.
[31] Sec. 70912(6) defines "Produced in the United States" to mean "(A) in the case of iron or steel products, that all manufactured processes, from the initial melting stage through the application of coatings, occurred in the United

- The inclusion of iron, steel, manufactured products, or construction materials produced in the United States will increase the cost of the overall projects by more than 25 percent.[32]

Questions related to the new Buy American requirements
Respondents may answer as few or as many of the questions below as they wish. Please use the underlined numbered statements/questions as headings in your response to the greatest extent possible (e.g., 1a, 3b, etc.) in the body of your responses. This permits reviewers to efficiently organize and understand your input.

1. Does any of the work for which you expect to apply for DOE Financial Assistance involve the construction, alteration, maintenance, or repair of any of the following:
    a. Roads, highways, and bridges;
    b. Public transportation;
    c. Dams, ports, harbors, and other maritime facilities;
    d. Intercity passenger and freight railroads;
    e. Airports;
    f. Water systems, including drinking water and wastewater systems;
    g. Electrical transmission facilities and systems;
    h. Utilities;
    i. Broadband infrastructure; and
    j. Buildings and real property.

2. If your response to question 1 is yes, will this work require any Iron or Steel?
    a. If yes, in the absence of any requirement to do so, would you seek to procure these goods domestically?
        i. If your answer to 2a is no, what circumstances are present that lead you to this response? For example, is it due to scarcity of these products domestically, or cost?

3. If your response to question 1 is yes, will this work require any manufactured products?

States; (B) in the case of manufactured products, that (i) the manufactured product was manufactured in the United States; and (ii) 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 (C) in the case of construction materials, that all manufacturing processes for the construction material occurred in the United States." Pub.L.117-58, Div. G, Title IX, Part I, § 70912(6), Nov. 15, 2021.

[32] Pub.L.117-58, Div. G, Title IX, Part I, § 70914(b), Nov. 15, 2021.

a. If yes, in the absence of any requirement to do so would you seek to procure these goods domestically?
    i. If your answer to 3a is no, what circumstances are present that lead you to this response? For example, is it due to scarcity of these manufactured goods domestically, or cost?

4. If your response to question 1 is yes, will this work require any construction materials?
    a. If yes, in the absence of any requirement to do so, would you seek to procure these goods domestically?
        i. If your answer to 4a is no, what circumstances are present that led you to this response? For example, is it due to a lack of availability of these manufactured goods domestically, or cost?

5. Please identify any manufactured goods which are crucial to work in your industry focused on infrastructure[33] which you would not typically seek to procure domestically. For each, please specify to the best of your ability whether you would avoid seeking to procure these items domestically due to scarcity or cost.

6. If possible, please provide: (a) an estimate of the cost of construction work associated with the project[34], if any; and (b) an estimate of the number of non-construction jobs you would hire for (specifying whether permanent, temporary, full time, or part time), as well as any information you can provide on the types of jobs these would be (assembly, maintenance, administrative, supervisory, etc.).

7. Would you consider working with local coalitions to find ways to match regional workforce resources with the project's hiring needs?

Supporting Documents

Supporting documents for this RFI can be found on EERE Exchange at https://eere-Exchange.energy.gov/. Input is greatly desired from stakeholders across the hydrogen and fuel cell community and other relevant sectors.

[33] "Infrastructure includes at a minimum, the structures, facilities, and equipment in the United States for: roads, highways, and bridges; public transportation; dams, ports, harbors, and other maritime facilities; intercity passenger and freight railroads; airports; water systems, including drinking water and wastewater systems; electrical transmission facilities and systems; utilities; Broadband infrastructure; and buildings and real property." Pub.L.117-58, Div. G, Title IX, Part I, § 70912(5), Nov. 15, 2021.
[34] Project is defined as "construction, alteration, maintenance, or repair of infrastructure in the United States." Pub.L.117-58, Div. G, Title IX, Part I, § 70912(7), Nov. 15, 2021.

Disclaimer and Important Notes

This RFI is not a Funding Opportunity Announcement (FOA); therefore, EERE is not accepting applications at this time. EERE may issue a FOA in the future based on or related to the content and responses to this RFI; however, EERE may also elect not to issue a FOA. There is no guarantee that a FOA will be issued as a result of this RFI. Responding to this RFI does not provide any advantage or disadvantage to potential applicants if EERE chooses to issue a FOA regarding the subject matter. Final details, including the anticipated award size, quantity, and timing of EERE funded awards, will be subject to Congressional appropriations and direction.

Any information obtained as a result of this RFI is intended to be used by the Government on a non-attribution basis for planning and strategy development; this RFI does not constitute a formal solicitation for proposals or abstracts. Your response to this notice will be treated as information only. EERE will review and consider all responses in its formulation of program strategies for the identified materials of interest that are the subject of this request. EERE will not provide reimbursement for costs incurred in responding to this RFI. Respondents are advised that EERE is under no obligation to acknowledge receipt of the information received or provide feedback to respondents with respect to any information submitted under this RFI. Responses to this RFI do not bind EERE to any further actions related to this topic.

Confidential Business Information

Pursuant to 10 CFR 1004.11, any person submitting information that he or she believes to be confidential and exempt by law from public disclosure should submit via email, postal mail, or hand delivery two well-marked copies: one copy of the document marked "confidential" including all the information believed to be confidential, and one copy of the document marked "non-confidential" with the information believed to be confidential deleted. Submit these documents via email or on a CD, if feasible. DOE will make its own determination about the confidential status of the information and treat it according to its determination.

Evaluation and Administration by Federal and Non-Federal Personnel

Federal employees are subject to the non-disclosure requirements of a criminal statute, the Trade Secrets Act, 18 USC 1905. The Government may seek the advice of qualified non-Federal personnel. The Government may also use non-Federal personnel to conduct routine, nondiscretionary administrative activities. The respondents, by submitting their response, consent to the Office providing their response to non-Federal parties. Non-Federal parties given access to responses must be subject to an appropriate obligation of confidentiality prior to being given the access. Submissions may be reviewed by support contractors and private consultants.

Request for Information Response Guidelines

Responses to this RFI must be submitted electronically to H2RFI@ee.doe.gov no later than **5:00 p.m. (ET) on March 29, 2022.** If possible, **please copy and paste the RFI questions and use them as a template for your response**. Responses must be provided as attachments to an email. It is recommended that attachments with file sizes exceeding 25 MB be compressed (i.e., zipped) to ensure message delivery. Responses must be provided as a Microsoft Word (*.docx) or Adobe Acrobat (*.pdf) attachment to the email. Only electronic responses will be accepted.

EERE will not respond to individual submissions or publicly publish a compendium of responses. A response to this RFI will not be viewed as a binding commitment to develop or pursue the project or ideas discussed.

Respondents are requested to provide the following information at the start of their response to this RFI:

- Company/institution name
- Company/institution contact
- Contact's address, phone number, and e-mail address.

This is a Request for Information (RFI) only. EERE will not pay for information provided under this RFI and no project will be supported as a result of this RFI. This RFI is not accepting applications for financial assistance or financial incentives. EERE may or may not issue a Funding Opportunity Announcement (FOA) based on consideration of the input received from this RFI.