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Re: Response to Request for Information on Clean Hydrogen Manufacturing, Recycling, and Electrolysis

The National Venture Capital Association (NVCA) unites the U.S. venture ecosystem to support the formation of high-growth companies and ensure the United States remains the most competitive environment in the world for entrepreneurs. We convene venture investors and entrepreneurs to shape public policy priorities, develop new industry initiatives, provide premier research, and organize professional development opportunities.

Particular to climate, we have created the NVCA Climate & Sustainability Working Group, which brings together venture capitalists and entrepreneurs working on solutions to the climate crisis to focus on the regulatory and legislative issues critical to the growth of a new energy economy. This working group serves as a forum to discuss major issues in climate technology with policymakers. The members of this group invest across investment stages from seed through growth into a broad range of technologies that impact climate change.

We appreciate the opportunity to respond to this Request for Information from the Department of Energy Hydrogen and Fuel Cell Technologies Office on Clean Hydrogen Manufacturing, Recycling, and Electrolysis. As with most other frontier technologies, venture capital plays a critical and unique role in discovering, commercializing, and scaling a broad range climate-related technology, including clean energy sources and battery storage, transportation, infrastructure and mobility, carbon capture, manufacturing, and agriculture and sustainability.

In 2021, 827 U.S.-based climate tech startups raised $27.27 billion in VC funding, more than double 2020's record of $12.7 billion invested. Given the importance of speed in getting the economy to carbon-neutral, this wave of young companies will play a major role in the country's effort to address the climate crisis.

Hydrogen holds enormous potential to decarbonize the energy, industrial and transportation sectors. Startups in this space are rising to the challenge and developing innovative technologies at a rapid pace. Effective public private partnerships which create space for leading edge ideas to challenge traditional business models and approaches will be key to unlocking the full potential of hydrogen in the energy transition.

Below are perspectives of our members and their portfolio companies on a range of topics included in the RFI which concern hydrogen startups.

Clean Hydrogen Equipment Manufacturing

A) Increasing efficiency and cost effectiveness of the manufacturing process or in the use of resources:

   10. What areas are lacking standards for equipment interoperability, such as compatibility between manufacturers and availability of commercial off the shelf (COTS) components?

Supply chain interoperability issues have created significant challenges at the scale-up phase. Investments in and new standards around integrated supply chains can help various technologies work together more cohesively. Individual technology providers often struggle to understand and align their product strategies with market needs. For example, companies need to be able to verify that compressors work with electrolyzers, that trailers work with compressors, and that storage systems are available. Furthermore, standards for electrolyzer stack layout, materials of construction and piping would increase compatibility of off the shelf components.

Ultimately, the end customers prioritize top-level cost, reliability, performance, and safety. Technologies have to work together within the supply chain to deliver the customer value proposition that makes a project bankable and scalable.

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.?

High storage pressures ranging from 550 to 1000 bar are necessary to boost energy density of hydrogen in order to be price competitive with other fuels. Storage of gaseous hydrogen at high pressures is required at the site of hydrogen generation, which includes renewable energy power plants, at fueling stations, in transportation of hydrogen, and in the form of fuel tanks for hydrogen powered vehicles. Thus, the requirement for high pressure hydrogen storage is ubiquitous in a hydrogen economy.

Currently, the construction of these cylinders requires hydrogen resistant steel liners that must be imported from Asia and Europe, steel wire imported from Japan, the wire wound in Bristol, VA, tested in specialized facilities located in California and then shipped to the final customer. In addition, there are regulatory oversight costs at each stage of the process. This complicated supply chain is the primary barrier to commercialization. The current cost of producing these cylinders is about $1,200 per KG hydrogen stored. These costs can be substantially reduced by consolidating these steps into fewer locations and by developing a facility to produce in bulk for an international market.

Furthermore, electrolyzer stacks have limited domestic manufacturing in large sizes. Expanding domestic capacity for electrolyzer stack production would lower costs and create supply certainty.

> 2. Would the U.S. 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?

Similar to how the U.S. keeps strategic reserves of other energy sources such as oil, the nation would benefit from having strategic reserves of Platinum, Lithium and other rare earth metals used in the production of hydrogen and batteries. Building domestic reserves and treating these critical materials as a strategic national asset would align our energy security protocols with our changing energy mixture of domestic energy sources and alleviate supply obstacles exacerbated by geopolitical instability and associated challenges.

> 3. What system (e.g., stacks and balance of plant (BOP) including power electronics) and stack components would benefit from standardization?

All components within the stack and BOP will benefit from standardization. The development of modular, standard hydrogen production facilities will decrease costs and schedule and improve reliability.

<u>Clean Hydrogen Electrolysis Program</u>

1) <u>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</u>.[1] 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?

DOE should maintain a flexible approach to new concepts in technology that achieve $2/kg. Prescriptive solutions which allocate funding only for established technologies will lock out next generation innovations, many of which are still in the lab stage, slowing the pace of innovation in this critical field. Support for new technologies will be key to achieving the $2/kg target.

[1] 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.

In utilizing polymer electrolyte membrane (PEM) electrolyzers, improved stack efficiencies, decreased fabrication labor costs and utilization of new materials other than rare earth metals is needed.

b. What electricity cost should the program assume for hydrogen production in 2026 and 2030?

Electrical costs vary widely depending on what area of the country is being evaluated.

d. What demonstration projects could enable and/or validate progress towards the $2/kg goal?

Demonstration projects that utilize the next generation of PEM membrane could have a higher efficiency and lower cost than the current generation.

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.[2] 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?

Strong demand for and limited supply of iridium has driven costs significantly higher in recent months. Startups are developing innovations to reduce the intensity of iridium required in platinum group metals (PGM) catalysts. Creating space for this innovation is critical for controlling costs and creating long-term supply certainty. DOE should support innovation around PGM catalysts in particular.

Additionally, DOE should support non-PGM approaches to move away from the inherent cost and availability issues that will prevent scaling.

4) Clean hydrogen storage technologies.[3] 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?

Standardized pressurized storage containers will improve the economics of hydrogen production at rates lower than 30 tons per day.

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)?

[2] Pub.L. 109-58, Title VIII, § 816(e)(7), as added Pub.L.117-58, Div. D, Title III, § 40314(2), Nov. 15, 2021.
[3] Pub.L. 109-58, Title VIII, § 816(e)(8), as added Pub.L.117-58, Div. D, Title III, § 40314(2), Nov. 15, 2021.

Buffer storage is operationally advantageous. The amount of storage will depend upon the application that the hydrogen will be used for and how the hydrogen is transported. Hydrogen pipelines allow for a degree of buffer storage naturally.

d. Are there codes and standards that are either lacking for, or inhibiting to, storage needs?

There are no specific codes and standards for hydrogen storage. DOE should develop a hydrogen storage standard which would improve efficiency and lower costs.

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.[4] Please note the technology or technologies discussed in the response.

c. What electrolyzer, distribution, storage, and end-use technologies should be prioritized in demonstration projects?

DOE should allocate funding in partnership with end-users that are otherwise reluctant to demonstrate concept and cost. The end-users include producers and users of Ammonia, Steel, Glass, Marine Fuel, and E-fuels. For example, ferries are an end-use marine fuel and short-haul rail is an end-use for hydrogen fuels. Demonstration projects will prove viability and create greater market opportunities for these technologies to be incorporated in novel ways, ultimately advancing decarbonization solutions in critical products.

8) National testing facilities

a. What scale, or range of scales, are needed in testing facilities?

DOE should provide access to electrolysis testing facilities at the 10-30MW level. This will help startups test new technologies at a smaller scale and enable viable frontier solutions to bridge the lab to market divide.

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.

Carbon Intensity vs. Color

Advancing a harmonized approach to carbon intensity calculations, and moving toward this standard instead of color designations, would create more certainty and attract customers prioritizing carbon intensity. DOE should direct support towards the end-state decarbonization methods (e.g., green hydrogen over blue) by focusing on the carbon intensity of the resulting

[4] 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.

hydrogen instead of the color. The carbon intensity should account for full life-cycle calculated inclusive of fugitive emissions from the natural gas industry and inclusive of embodied emissions associated with renewable electricity sources.

In addition to fugitive emissions from methane, total lifecycle emissions should include embodied emissions associated with renewable electricity sources. A good reference is the international panel on climate change guidelines here.

Conversion & Utilization of Natural Gas Pipelines

The U.S. has an extensive network of approximately three million miles of natural gas pipelines and more than 1,600 miles of dedicated hydrogen pipeline. Hydrogen produced through clean pathways can be injected into natural gas pipelines, and the resulting blends can be used to generate heat and power with lower emissions than using natural gas alone.

DOE should provide clear guidelines on converting and utilizing existing natural gas pipeline infrastructure with hydrogen. The lack of a clear regulatory structure of interstate hydrogen pipelines has created challenges in expanding transportation of hydrogen in natural gas pipelines.

Furthermore, DOE should encourage the sharing of natural gas safety guidelines when operating with hydrogen. These guidelines been developed over time by industrial gas producers and are proprietary. Sharing guidelines and best practices can also speed up permitting and commissioning timelines.

Non-Electrolysis Pathways

Innovations in non-electrolysis pathways such as ammonia splitting, pyrolysis, and the photocatalytic pathway have led to numerous advantages in cost and efficiency. DOE should allocate funding and support for non-electrolysis pathways.

Conclusion

We appreciate the Department of Energy Hydrogen and Fuel Cell Technologies Office for considering our comments. We hope that the opinions expressed in this filing serve to offer a unique perspective as the Office implements Clean Hydrogen Manufacturing, Recycling, and Electrolysis programs. We would be pleased to provide any additional material that may be helpful.