Regional Clean Hydrogen Hubs Implementation Strategy (RFI DE-FOA-0002664)
Los Alamos National Laboratory
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This response from Los Alamos National Laboratory (LANL) is largely based on outcomes and lessons learned from the Intermountain West Energy Sustainability & Transitions (I-WEST) project, which is led by LANL and sponsored by the US Department of Energy. I-WEST is developing a regional technology roadmap to transition six US states—Arizona, Colorado, Montana, New Mexico, Utah, and Wyoming—to a carbon-neutral energy economy by 2035.

I-WEST findings have high relevance to DOE's objectives for the H2Hubs. Not only is I-WEST investigating clean hydrogen as potential pathway for energy transition, it is doing so with a regional focus and place-based approach. Parts of the I-WEST project can serve as a model for establishing the regional H2Hubs—particularly the Phase 1-Planning stages. I-WEST is analyzing the decarbonization potential and energy resources, infrastructure, and workforce in the Intermountain West region.

Through its outreach to regional stakeholders—ranging from technology developers and deployers to Sovereign Nations to state-level leaders and economic developers—I-WEST prioritizes societal readiness over technology readiness. This has resulted in a number of key findings that address DOE's goals for an equitable energy transition and can help inform the diversity, equity, and inclusion objectives of the H2Hubs.

More information about I-WEST is available online at www.iwest.org.

Category 1: Regional Clean Hydrogen Hub Provisions and Requirements

1a. What should qualify as 'close proximity' in context of the hub requirements?
Based on information gathered from numerous H_2 production project leaders in the Intermountain West region, particularly those projects that are more mature and on a shorter timeline to deployment, proximity to existing infrastructure is of high importance. For example, two large H_2 production projects (Libertad Power Project and Escalante H_2 Power) in New Mexico will leverage existing infrastructure (e.g., natural gas transport pipeline, grid access, road/rail network) and utilize potential geologic CO_2 storage opportunities in close proximity to their project sites to keep their costs low and lessen overall impact.

Infrastructure for H_2 transportation has been identified by Intermountain West stakeholders as one of the critical needs, as it has similarly been flagged in other regions. Utilities in the I-WEST region are exploring the use of existing natural gas pipeline infrastructure to transport H_2, which can benefit a hub in getting H_2 produced to a site of utilization.

In addition to the need to transport H_2, hubs will almost certainly need to transport CO_2 that is captured as part of the H_2 production process—primarily to sites of CO_2 storage but also to sites for utilization. This CO_2 pipeline infrastructure could be local networks when storage sites are nearby, or regional networks to move CO_2 longer distances when local storage options are unavailable. For example, the Permian Basin (west TX, eastern NM, and southern CO) have large-scale CO_2 pipeline systems in operation that could be expanded for regional or national transport.

Beyond pipeline infrastructure, there are additional considerations. For land transportation, direct connection to major road or rail transportation infrastructure could be advantageous (e.g., in a hub placed in a few miles radius of an interstate or a major railway). Additionally, adjacency to major ports could be a factor for transportation via ships.

The possibility of using H_2 to generate electricity should be considered, which would necessitate close proximity to an H_2-fueled power plant. Given increasing capacity, perhaps a hub would best be located close to existing power infrastructure (high voltage transmission lines/network in a relatively central location within a major power grid for best utilization), or close to planned high-capacity transmission corridors.

1b. What existing facilities and infrastructure, including pipelines and storage facilities, could be most easily leveraged by the H2Hubs?

The long-term storage and transport of H_2 are known issues; however, strategies to use salt domes as storage could be viable for some geographic locations. For example, the Intermountain Power Project (UT) is planning to use salt caverns in Utah with an estimated 5500 million-ton capacity for H_2 storage. In the absence of suitable underground storage, chemicals such as methanol, ammonia, or dimethyl ether (DME) can be used as H_2 carriers to overcome the storage and transport issues of gaseous or liquid H_2. There are project developers with existing propane pipelines in the Intermountain West region (Suburban Propane) who are currently teaming with companies to provide blended DME-propane fuel to decarbonize the propane sector with initial market penetration in Southern California.

Across the Intermountain West, companies with existing natural gas pipelines are interested in providing the necessary infrastructure to serve grown H_2 markets; for example, Williams (WY) which handles 30% of the natural gas in the US.

It is anticipated that a significant portion of the H_2 produced in the Intermountain West region in the near future will be blue H_2, which will rely on carbon-dioxide capture and storage (CCS). The Intermountain West could be a prime region for testing and demonstrating CO_2 capture and storage in the context of the full process-chain for blue H_2. It has existing infrastructure and expertise that could be leveraged, as well as regional storage options, including the re-pressurization of depleted, naturally occurring CO_2 deposits.

Given the abundance of natural gas in parts of the Intermountain West region, there is significant interest in developing projects for producing H_2 using steam methane reforming technology. A number of project developers, including Newpoint Gas LLC (working on converting the Escalante coal-fired power plant into an H_2 power plant in northern New Mexico) and Libertad (working on developing a h H_2 production facility in the Four Corners region) have indicated that having access to proven CO_2 storage resource will be essential for reducing their carbon intensity and will be critical for growing an H_2 based economy in the four corners region.

1c. What types of new 'connective infrastructure' will be needed by the H2Hubs (e.g., pipelines, storage, etc.)?

In addition to fuel cell vehicles, the fuel cell transportation sector requires a reliable H_2 supply infrastructure, including filling stations. Integrating on-site electrolyzers into new filling stations that supply H_2 on demand offers an early market expansion strategy for fuel-cell vehicles by developing the supply and demand of H_2 in parallel. I-WEST stakeholders recognize that this strategy is unlikely to be adopted first by the general population, and the necessary catalyst for first-stage market adoption could potentially be conversion of existing government as well as commercial vehicle fleets from internal combustion engines to fuel cell vehicles.

Organizations and commercial entities with large vehicle fleets such as airports, USPS, FedEx, Amazon, and local as well as state governments were identified as pivotal players to the broader adoption of H_2-based fuel cell vehicles. National labs and military bases are also important early adopters for both clean power and fuel cell vehicles for their GSA fleet and heavy-duty vehicles. DOE and DoD could collaborate to encourage/incentivize the conversion of their base/lab infrastructure to be a regional accelerator for H_2 demand.

1d. What supportive activities would make the hydrogen hubs successful and sustainable (e.g., workforce development, community-based organization engagement, domestic manufacturing, labor standards, etc.)?

A key factor in commercially realizing a carbon-neutral strategy is the ability to get affordable financing and grants. Early-stage financing is extremely difficult to get, with approximately 1% of startups being funded. Mid-stage financing is equally challenging because to get mid-stage public financing the companies are required to hit around 50% of the expected revenue.

At community-based workshops focused on learning about grass-roots-level concerns, priorities, and ideas regarding energy transition across six Intermountain West states, stakeholders consistently expressed the need for a targeted education initiative. This need was discussed in the context of retraining fossil fuel-related professionals to develop new knowledge, skills, and abilities. It was also discussed in the context of providing age-appropriate and non-technical information about energy transition so that the problems and potential solutions are easy to understand.

Moreover, education was discussed in the context of communities learning about opportunities to partake in the energy transition; for example, by informing landowners who may benefit from energy projects hosted on their underutilized land. Furthermore, stakeholders discussed the need for learning opportunities to understand the feasibility, risks, strengths, and weaknesses associated with various solutions, such as H_2 production and utilization.

2a. What CO2 equivalent emissions should be met within the project and its supply chain? What strategies are available for, and how can DOE incentivize, the H2Hubs to reduce emissions not only at the point of production but also including upstream emissions? What challenges are there in measuring CO2 equivalent emissions?

While H_2 is a clean fuel, the CO_2 released from H_2 production via both steam methane reforming (SMR) and fugitive methane emissions (resulting during the production of natural gas) are significant greenhouse gas sources. Integrated carbon capture and sequestration (CCS) is a potential path-forward for mitigating the CO_2 emissions from the SMR process. Also, water electrolysis is rapidly emerging as an H_2 production technology for CO_2-free H_2 production via integration with renewable solar and wind power sources. In the Intermountain West region, it is anticipated that the pathways for H_2 production to meet the existing industrial and emerging transportation sector needs in the near future (next 5 years) will constitute a combination of H_2 production from fossil fuels and water electrolysis.

The use of methane as a feedstock for H_2 production is a focal point of many emerging projects in the Four Corners area, specifically. Several points in process-chain for the production of H_2 will require CO_2 handling and as such will be central to H_2 project deployment. In I-WEST workshops organized to engage with H_2 project teams, stakeholders identified CO_2 capture to be integral to their business plan and a necessary part of process operations. At one end, gas-processing facilities (which would provide natural gas feedstocks) have many GHG related emissions, which H_2 project teams recognize as central to their business plan. One part of this involves CO_2 directly, inasmuch as regional resources can contain significant CO_2 in the produced natural gas, and this will need to be captured and stored. At the other end of the H_2 production chain, these projects recognize the need to capture the CO_2 produced by the converted hydrocarbon and potentially produced by the energy used in the conversion process. In general, these project teams recognize that capture technology is likely to be based on amine technology or membrane technology. Integration of these technologies into the H_2 production process (gas plant to H_2 generation) will be needed, and the integration of CO_2 storage with these smaller distributed sources will also be key. The Four Corners could be a prime region for testing and demonstrating CO_2 capture and storage in the context of the full process-chain for blue H_2. It has existing infrastructure and expertise that could be leveraged and regional storage options, including the re-pressurization of depleted, naturally occurring CO_2 deposits.

2d. What policies, infrastructure, or other considerations could be put in place to enable the H2Hubs to develop into a national clean hydrogen network in the future?

As noted under #1, CO_2 storage is likely to be central to clean H_2 networks in the future. Infrastructure investments on CO_2 pipelines is one strategy to facilitate this by moving CO_2 to regions/locations where it can be stored. However, many regions (like the Intermountain West) project sufficient local storage options, which would moderate the need for pipeline investments. These local options could be enabled by clear and streamlined pathways to permitting, by extension of timelines for tax credits associated with CO_2 storage, and by clarification of legal factors such as pore-space ownership and long-term liability.

Generally, requiring the hubs to have an identified storage option locally would save resources and reduce risk. Alternatively, regional hubs could consider having multiple locations—one where all the H_2 generated is utilized locally and one where it can be stored on site or nearby.

2e. How should the H2Hubs be asked to measure progress toward the administration's goal of transforming the economy by 2050 to achieve net-zero emissions goals? Please be as specific as possible.

Meaningful progress toward net-zero emissions goals rests on *regionally relevant* technologies for decarbonization. Through extensive stakeholder engagement at the community and state levels, the I-WEST project has gathered strong evidence that a place-based approach is essential to ensuring the long-term sustainability of any energy transition strategy and that a one-size-fits-all approach will not be effective. The I-WEST project is prioritizing the unique geography, natural resources, economies, and societal readiness of the Intermountain West region as it develops a roadmap for transitioning the region to carbon neutral economies. The H2Hubs should be asked to take a similar approach in which goals and metrics to measure progress are developed with input from regional stakeholders and tailored to the region. Furthermore, using the I-WEST project as a blue print, the H2Hubs should be asked to develop goals and metrics to measure progress on non-technical factors that could ultimately determine the long-term sustainability of an H_2 economy. I-WEST has consistently found that an energy transition strategy must address needs in five key areas: technology, infrastructure, economy, societal readiness, and policy.

3a. Should DOE require a minimum level of hydrogen production per regional clean hydrogen hub, and if so, what should that minimum amount be (i.e., X tonnes/day)? Should this requirement vary for clean hydrogen produced from fossil fuels with carbon capture and storage (CCS), renewable energy, and nuclear energy? If a minimum is not specified, how may DOE incentivize larger capacity hubs?

In numerous I-WEST outreach events, stakeholders have noted the diversity of H_2 production options in the Intermountain West, including multiple pathways to electrolysis as well as low-carbon pathways utilizing natural gas resources. As an alternative to envisioning a hub as demonstrating a specific H_2 production pathway, it could be advantageous to consider hubs that can demonstrate multiple pathways. This could open opportunities for regions with nascent H_2 economies.

If DOE decides to require a minimum level of H_2 production, it should consider how to set a level that can accommodate regions with both mature and nascent H_2 economies. A level that is too high could leave regions with nascent economies out of consideration. Matching local/regional supply and demand should be the priority, as long as there is a credible path to scaling both production and demand in that region over the life of the Hub, to create a sustainable regional market, with less need for extensive new pipeline infrastructure connecting different regions.

3b. Related to 3a, how should DOE take into account specifying minimum required hydrogen production when considering capacity factors and the potential intermittency of generation, which would increase the cost and requirement for hydrogen storage?

Some regions have mature networks for an H_2 economy (production and utilization), whereas other regions are at an earlier stage of developing an economy. Hence, setting a minimum level of H_2 production should consider regional variability, where forward-looking H_2 economies may be more aligned with lower targets in the near term, which could grow as the H_2 economy matures. Regions with these nascent H_2 economies (such as the Intermountain West) are often overlooked in planning activities that are weighted to regions with a higher density of industrial activity and more mature H_2 economies.

3d. Should DOE prioritize the repurposing of historic fossil infrastructure in the regional hub(s) focused on production from fossil fuels and if so, over what time frame? If yes, should DOE incentivize an eventual transition from fossil fuels to another fuel source? What conditions should DOE place on the carbon intensity of the fossil fuels (with CCS) used in this hub other than what is already specified in the BIL?

Regions like the Intermountain West that have historically depended on fossil-based economies for revenue and employment are poised to experience energy transition rapidly, which will significantly impact local economies. Many I-WEST stakeholders have expressed concerns that the fiscal decline of fossil-fuel industries will exacerbate existing economic challenges in vulnerable communities, many of which are in rural areas populated by historically marginalized cultural groups. For example, there are 61 Tribal Nations located in the Intermountain West region, and those who have engaged in I-WEST are concerned about loss of revenue for Tribal governments and loss of jobs for Tribal members, due to energy transition. Coupled with workforce retraining efforts, repurposing historic fossil fuel infrastructure could mitigate some of these risks. Within the Intermountain West region, some of the most mature H_2 production projects are transforming and/or leveraging existing fossil infrastructure, including natural gas and propane transport pipelines, grid access, road/rail networks, and coal-fired power plants.

3e. How might hydrogen production be constrained by the availability of clean electricity or natural gas supply and distribution? Will hydrogen producers provide a sustainable market/revenue stream for clean electricity and natural gas that encourages new investments to expand electricity generation and natural gas production capacity? Are separate federal, state, or local incentives to expand clean electricity generation or natural gas production capacity available, necessary, or adequate?

The cost of electricity is critical factor affecting the cost of green H_2 production, which is forecasted at $1.50/kg "achievable" with $20/MW of renewable electricity. Optimum facility engineering design and supply chain management plays a significant role in achieving low green H_2 production costs. Within the Intermountain West region, nuclear power use is also being explored for H_2 production for power production. For example, I-WEST has learned that the Palo Verde nuclear power plant, located in western Arizona, will use six million tons of stored H_2 for 200 MWH electricity production during peak hours.

Given the presence of large natural gas reserves in the Intermountain West, the region can emerge as a leader in H_2 production for local use as well as for export to other regions. Still, there are a number of I-WEST stakeholders thinking beyond natural gas—several projects in the region are focused on biomass as a feedstock for H_2 production. The bioeconomy represents a growing opportunity space for the Intermountain West due to its large agricultural base and access to feedstocks.

I-WEST is developing a catalog of various ongoing, planned, and emerging initiatives across the Intermountain West region that are in the process of deploying projects related to decarbonization. Several H_2 production projects are currently under development, covering grey, blue and green H_2 production pathways. Combined, all the planned projects to date in the I-WEST region are expected to produce ~half a million tons of H_2 per year within the next 5-10 years.

H_2 deployment at large scale requires significant capital. Currently 45Q tax credit is not available for CCS from H_2 production operations. Extending 45Q to H_2 production as well as making other funds available for economic and workforce (e.g. Perkins Grant) development will be needed to facilitate large scale deployment. OEM incentives for fuel cell vehicles including incentives for fuel cost difference between H_2 and diesel will help to ramp up H_2 production.

3f. Should H2Hub funding be made available to upgrade or develop new dedicated clean electric or heat generating energy resources (e.g., renewables or other clean generation sources) needed to produce clean hydrogen?

Yes. Lack of current H_2 production by these sources indicates that funding would be beneficial to initiate transformation to produce clean H_2. The Intermountain West region is well poised and industry has interest in pursuing financially beneficial endeavors. Specific to nuclear energy H_2 production, current production is accounted for well in advance, indicating new dedicated sources would be needed to significantly expand capacity. Practically, this implies targeting modular nuclear or micro-nuclear technologies that are currently in the pipeline for approval, to be part of the production mix within a few years.

4a. What are the ideal timing and desirable features, terms, and conditions of off-taker agreements that would encourage construction and development of hydrogen hub infrastructure and long-term sustainability leading to local economic prosperity including union jobs and benefits to disadvantaged communities? Would hubs that supply multiple end users provide advantages, and in what ways?

I-WEST stakeholders have noted the diversity of H_2 utilization options in the Intermountain West, including pathways to electricity, ammonia, and transportation. As an alternative to envisioning a hub as demonstrating a specific H_2 utilization pathway, it could be advantageous to consider hubs that can demonstrate multiple pathways. This could open opportunities for regions with nascent H_2 economies.

4b. What approaches can applicants use to guarantee off-taker commitments and matching of supply and demand?

I-WEST stakeholders identified the ability to transport and utilize H_2 within and outside the Intermountain West region as a limiting factor for increasing green H_2 production, thus creating a supply vs. demand conundrum. A near-term opportunity to break the supply vs. demand paradox is to blend H_2 with natural gas using the current natural gas transportation infrastructure. This approach would establish a foundation for H_2 production in the region and could help accelerate the market adoption of fuel cell vehicles and production of renewable fuels and chemicals.

With the transportation sector being a significant opportunity space for H_2 utilization, I-WEST stakeholders recognized the importance of creating supply and demand for H_2 in parallel. They discussed how integrating on-site electrolyzers and H_2 filling stations that supply on-demand H_2 would enable early market adoption of fuel-cell vehicles. Stakeholders recognized that this strategy is unlikely to be adopted by the general population and suggested that converting existing government and commercial vehicle fleets from internal combustion engines to fuel cell vehicles could be the necessary catalyst for early market adoption. Organizations and commercial entities with large vehicle fleets such as airports, USPS, FedEx, Amazon, and local and state governments were identified as pivotal players to the broader adoption of H_2-based fuel cell vehicles. Military bases and national labs in the intermountain west can also be significant early adopters to create sustainable regional demand.

Green H_2 for power production is unlikely given that the green H_2 production cost is currently not competitive with natural gas. There may be some niche applications with economic viability to use green H_2 as a power generating fuel; for example, when the produced H_2 cannot be stored or transported. Although turbines operating on 100% H_2 have been demonstrated, they are not in widespread commercial use. Hydrogen blending with natural gas offers a potential pathway to establish the regional production and market supply of green H_2 supporting the ensuing growth in market demand.

The global financial outlook for H_2 one-offs is very challenging. In the US, the emerging markets for H_2 are industrial heating, cement production, fuel cells and steel production. Aside from fuel cells, currently there is limited availability of investment funds for H_2 related technologies. The interesting investment opportunities for H_2 utilization in the I-WEST region were identified as production of renewable fuels and chemicals.

A potential avenue to maximize efficiency, storage, and utilization of H_2 is to develop industry clusters that co-locate several different types of industries similar to the ones being developed in the UK. Strategically locating such industry clusters in the I-WEST region could be the best-case scenario from a techno-economic standpoint.

A key factor in commercially realizing a carbon-neutral strategy is the ability to get cheap financing and grants. Early-stage financing is extremely difficult to get, with approximately 1% of startups being funded. Mid-stage financing is equally challenging because to get mid-stage public financing the companies are required to hit around 50% of the expected revenue.

5a. A region could be defined as anything from a city, a state, multiple states, tribal communities, or a geographic area. Should DOE define the regions or allow applicants to define them within their proposal? If a definition is preferred, explain how regions should be defined for the purposes of this FOA and provide the rationale.

The I-WEST initiative can serve as a model for an approach that allows applicants to define a region based on shared energy challenges, concerns, and priorities. This approach could spur partnerships between states, cities, and communities that might otherwise be in competition if the regions are pre-defined, which could represent missed opportunities.

5b. In addition to sufficient energy and feedstock/water resources, what other regional factors should be considered when identifying and selecting regional hubs (e.g., economic considerations, policy considerations, environmental and energy justice considerations, geology, workforce availability and skills, current industrial and other relevant infrastructure and storage available/repurposed/reused, industry partners, minority-serving institutions [MSIs], minority-owned businesses, regional specific resources, security of supply, climate risk, etc.)?

The I-WEST project can serve as a blue print for a regional approach to identifying, selecting, and operating regional hubs. As part of its stakeholder engagement, I-WEST holds workshops, seminars, and leads community outreach centered on the following themes: technology, infrastructure, economics, policy, and societal readiness. This helps ensure that technology readiness is balanced with other key regional factors that, if not prioritized, could ultimately become roadblocks to any technology pathway for decarbonization. As previously discussed, the Intermountain West region has historically relied on fossil-fuel economies, which presents both advantages and risks in energy transition. Leveraging the advantages (natural resources, geology, workforce capabilities, existing infrastructure, etc.) must be balanced by addressing the risks (job and revenue loss, environmental impacts, cultural preservation) to ensure an equitable and just energy transition. This can only be achieved with an intentional strategy for a place-based approach that is designed with a specific region in mind, and with input from key stakeholders, from the grassroots level to the Sovereign Nations to state leadership.

6a. What level of natural gas resources should be required to qualify as a region with the "greatest natural gas resources"? How should DOE consider the difference between the available natural gas resources and the current natural gas production of an area when considering hub candidates? How should DOE consider the volatility of natural gas prices and its effect on production levels when defining these regions?

Hubs might consider the historical natural-gas markets in the region when building a business case for natural-gas based H_2 production. In particular, for regions that depend on natural gas sales on the open market, historical natural gas sales can be used as a guide to what to expect relative to fluctuations that might impact the business case for the H_2 hub. Additionally, regional energy plans could be factored into the analysis of the hub's business case inasmuch as plans for alternative regional uses of natural gas to support build-out of gas turbines for electricity might be a factor that could impact the long-term business case.

6b. How should DOE consider the volatility of natural gas prices and its effect on production levels when defining these regions? Should annual (or average over a five-year period) production and/or available proven reserves be the criteria for the above provision?

See answer under 6a for some context. In general, DOE might consider this volatility—along with potential alternative regional competition for natural gas—in assessment of the potential near- to mid-term business case for building a sustained H_2 economy based on natural gas. Regions might mitigate volatility and competition by having alternative parallel strategies for producing H_2. For example, the Intermountain West has multiple options for feedstocks into H_2 production, including natural gas and water (electrolysis) in the near term and biomass in the mid-term; in the case of electrolysis, the region has abundant solar and wind, and some states are also considering the potential for nuclear-power to drive electrolysis.

7b. What tools should H2Hubs utilize to meet the goals of providing opportunities for workers displaced from fossil industries and other industrial or resource-based industries in decline?

I-WEST stakeholders identified importance of regional colleges, community colleges, vocational schools, and universities in the context of workforce development as needed for energy transition. Partnering with such institutions could enable hubs to accelerate the development of regional workforces as needed for viable and sustainable H_2 economy.

Category 2: Solicitation Process, FOA Structure, and H2Hubs Implementation Strategy

8. DOE is evaluating funding mechanisms for the H2Hubs projects in accordance with the BIL. What applicable funding mechanisms are best suited to achieve the purposes of the H2Hubs (e.g., Cooperative Agreements,24 Grants, Other Transactions Authority25)?

DOE should consider funding mechanisms that incentivize partnering, both within the industrial stakeholder community and between industry stakeholders and potential research partners like national labs. Some mechanisms can inhibit such partnerships due to factors tied to intellectual property, cost sharing, and challenges in the agreement processes for DOE national labs. Recommendations: Fund national laboratories directly via a Work Authorization to mitigate the risk of delayed project starts and lengthy legal reviews associated with SPPs and subcontracts. Set a six-month (or less) deadline to execute agreements to set an expectation that all partners must commit to timely agreement execution. Require the use of national laboratory templates for agreements such as CRADAs and NDAs when partnering with DOE labs.

10. Does offering multiple launches roughly a year apart, as shown above in Figure 2, help facilitate expanding the hydrogen hub concept to more regions?

Yes. In particular, this strategy could help to level the field for regions with nascent H_2 economies. For example, regions like the Gulf Coast have extant H_2 economies that have built the stakeholder network needed to compete successfully for an H_2 hub, whereas regions like the Intermountain West may have excellent potential for an H_2 economy, but the stakeholder network may be less developed at present. Staggered launches (or even phased launches) might provide these nascent regions an opportunity to build the networks to a level commensurate with mature regions.

19. What external non-project partners/stakeholders (e.g., CBOs, DACs, tribal groups, state and local governments, economic development organizations, labor representatives) will be critical to the success of the H2Hubs? What types of outreach and engagement strategies are needed to make sure these stakeholders are involved during each phase of the H2Hubs? Are there best practices for equitably and meaningfully engaging stakeholders?

A number of local, non-project stakeholders will be crucial to ensuring the longevity of the H_2 hubs. While some of these stakeholders can and should be engaged directly by a successful hub team, DOE should consider additional outreach to ensure the H_2 economy grows beyond the hub. For example, I-WEST stakeholders encompass a myriad of non-project stakeholders, including tribal leadership, state and local leadership, local economic development organizations, regional colleges focused on workforce development, and community environmental groups. Outreach to these stakeholders have included seminars with energy experts; community workshops to discuss concerns, priorities, and ideas related to energy transition; and technology focused workshops with large and small H_2 project leaders.

When engaging with Sovereign Nations, I-WEST has learned that virtual events are not effective, compressed timelines are challenging and potentially not culturally appropriate, and relationship building with Tribal officials and career staff is key to establishing trust and buy-in. To ensure that Sovereign Nations are part of the energy transition process, DOE must develop a strategy that works with the communities from the outset to set achievable decarbonization goals for Tribes and their regions, and gives them cultural relevance (e.g., protecting Mother Earth and keeping communities together).

20. The H2MatchMaker tool will be available to help identify potential regional project partners. What specific fields/information would be valuable to include in the tool? What other mechanisms can DOE use to help facilitate teaming?

It would be valuable to incorporate a "national laboratory" component to the tool where labs can summarize their capabilities and relevant technologies and link prospective partners to Technology Transfer websites and resources. For example, LANL is revising and expanding its online "technology snapshot" inventory to reflect the priorities of both the H_2 hubs and the I-WEST initiative. The intent is to convey as comprehensively as possible the portfolio of capabilities, technologies, and intellectual properties that could be accessed and advanced via joint research partnership, and commercialized via license negotiation.

21. Based on EPAct 2005, Section 988, the cost share requirement for demonstration and commercial application projects is 50% cash and/or in-kind and must come from non-Federal resources (50% of the total project cost which includes both DOE share and recipient cost share). For example, a $1B award for the Phase 2 Hub Deployment will require $1B in matching cost share. Is it feasible for projects to meet this 50% cost share requirement on an invoice-by-invoice basis?

A 50% cost share requirement would be a significant (if not impossible) challenge for teams heavily composed of regional businesses and local academic partners—both of which represent key partnerships for regional efforts, especially those with nascent H_2 economies. DOE should offer a reduced cost share requirement for teams composed of small business, academic institutions, community-based organizations, and Tribes—this would incentivize teams to partner with these critical stakeholders.

24. What types of cross-cutting support (e.g., technical assistance) would be valuable from the DOE/national laboratories, and/or from other federal agencies, to provide in proposal development or project execution? Are there other entities that DOE could fund to provide technical assistance across multiple H2Hubs?

I-WEST stakeholders identified numerous technology gaps that could be addressed with technical assistance from the DOE national labs. The following are a few examples that LANL is well positioned to address: analysis and modeling—LANL can provide technoeconomic analyses, HazOps analyses, and process modeling and system integration; H2 safety—LANL has expertise in H_2 safety, H_2 sensors and in-line H_2 quality sensors; forensic analyses—LANL can help solve, mitigate and identify challenges related to construction and deployment of large-scale demonstrations; R&D needs—LANL can help with proposal development for projects focused on new catalysts to improve the durability of electrolyzers, new desalination technologies, new catalysts for the hydrogenation of CO_2, metal analyses of H2 embrittlement of pipelines, fugitive methane emissions monitoring, and new H_2 production catalysts.

Beyond addressing the technology gaps identified by I-WEST stakeholders, there are numerous other capabilities unique to the national laboratories that can be leveraged by the H_2 hubs. For example, LANL has extensive HPC facilities and capabilities; extensive capabilities in data science, data analysis, statistics, machine learning, AI, and simulations, including licensed software for CO_2 transportation; and critical infrastructure modeling. LANL also has decades of experience in cybersecurity and vulnerability detection related to energy-critical infrastructure and power transmission. Climate modeling capabilities at LANL can be applied to forecast effects of climate change on natural resources that may impact H_2 production or utilization. Modeling and simulation capabilities are also being applied to process optimization, techno-economics, and sustainability/life cycle analysis of H_2 production systems.

DOE should consider preferences for place-based engagement in the regions where national labs are located, as well as national non-exclusive licensing models championed by DOE to accelerate deployment of emerging technologies in any region. In addition to contributing their state-of-the-art S&T capabilities and expertise to the hubs, national labs have potential to serve as testbeds to test, validate, and demonstrate the integration of new technologies into the emerging infrastructure for production, distribution, and end-use.

26. How could funding under other BIL provisions (e.g., Section 40303, Carbon Capture Technology Program) be leveraged by the H2Hubs to maximize the impact of BIL funding?
I-WEST stakeholders have noted the diversity of H_2 utilization options in the Intermountain West, including pathways to electricity, ammonia, and transportation. As an alternative to envisioning a hub as demonstrating a specific H_2 utilization pathway, it could be advantageous to consider hubs that can demonstrate multiple pathways. This could open opportunities for regions with nascent H_2 economies.

DOE Hydrogen Program
Request for Information # DE-FOA-0002664.0002
Regional Clean Hydrogen Hubs Implementation Strategy

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

Description

This is a Request for Information (RFI) issued by the U.S. Department of Energy's (DOE) Hydrogen Program, on behalf of the Energy Efficiency and Renewable Energy (EERE) Hydrogen and Fuel Cell Technologies Office (HFTO), the Office of Fossil Energy and Carbon Management (FECM), the Office of Nuclear Energy (NE), and in collaboration with DOE's newly formed Office of Clean Energy Demonstrations (OCED). The intent of this RFI is to obtain public input regarding the solicitation process and structure of a DOE Funding Opportunity Announcement (FOA) to fund regional clean hydrogen hubs, in accordance with the Infrastructure Investment and Jobs Act.[1] Specifically, this RFI seeks input on:

- Regional Clean Hydrogen Hub Provisions and Requirements
- Solicitation Process, FOA structure, and Implementation Strategy
- Equity, Environmental and Energy Justice (EEEJ) Priorities
- Market Adoption and Sustainability of the Hubs

Information collected from this RFI will be used by DOE for planning purposes to develop the Regional Clean Hydrogen Hubs FOA. The information collected will not be published.

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 (BIL). 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, and ensuring stronger access to these economic benefits for underserved communities. The BIL appropriates more than $62 billion to DOE[2] to deliver a more equitable clean energy future for the American people by:

[1] Infrastructure Investment and Jobs Act, Public Law 117-58 (November 15, 2021), Subtitle B – Hydrogen Research and Development, Section 40314 – Additional clean hydrogen programs. https://www.congress.gov/bill/117th-congress/house-bill/3684

[2] 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

- 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 $8 billion for the five (5) year period encompassing fiscal years (FYs) 2022 through 2026 for the development of regional clean hydrogen hubs that demonstrate the production, processing, delivery, storage, and end-use of clean hydrogen.[3]

Clean hydrogen and related technologies, such as electrolyzers, fuel cells, and turbines, can play a key role in decarbonizing many sectors, including medium- and heavy-duty transportation, residential and commercial heating, power generation, and hard-to-decarbonize industries such as ammonia and steel. This will support the Biden Administration's goal to achieve a carbon-free electric grid by 2035 and a net zero emissions economy by 2050.[4]

Strengthening prosperity – by expanding good, safe union jobs and supporting job growth through investments in domestic manufacturing – are key goals set by President Biden, discussed in depth in his Executive Orders on Ensuring the Future Is Made in All of America by All of America's Workers (EO 14005), Tackling the Climate Crisis at Home and Abroad (EO 14008), Worker Organizing and Empowerment (EO 14025), and Promoting Competition in the American Economy (EO 14036). The regional clean hydrogen hubs will support the creation of good-paying jobs with the free and fair choice to join a union, the incorporation of strong labor standards, and training and placement programs, especially registered apprenticeship.[5]

[3] 42 USC 16161a(d)

[4] 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, 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/

[5] 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

One key pathway to achieving large-scale, commercially viable deployment of clean hydrogen is through matching the scaleup of clean hydrogen supplies with a concomitant and growing regional demand. Co-locating large scale clean hydrogen production with multiple end-uses can foster the development of low-cost hydrogen and the necessary supporting infrastructure to jumpstart the hydrogen economy in various market segments, create both near-term and long-term jobs and tax revenues for regional economies, and realize emissions reduction benefits. The regional clean hydrogen hubs (referred to as "H2Hubs" throughout the rest of this document) will contribute to achieving DOE's goals for H2@Scale,[6] which provides an overarching vision for how clean hydrogen can enable energy pathways across applications and sectors in an increasingly interconnected energy system (see Figure 1). The H2Hubs will also contribute to achieving, or exceeding, the clean hydrogen cost reduction targets for electrolyzers called for in the BIL ($2 per kilogram of H_2 by 2026)[7] and help to put the Hydrogen Program on track to reach the Hydrogen Shot[8] goal of $1 per 1 kilogram in 1 decade ("1 1 1").

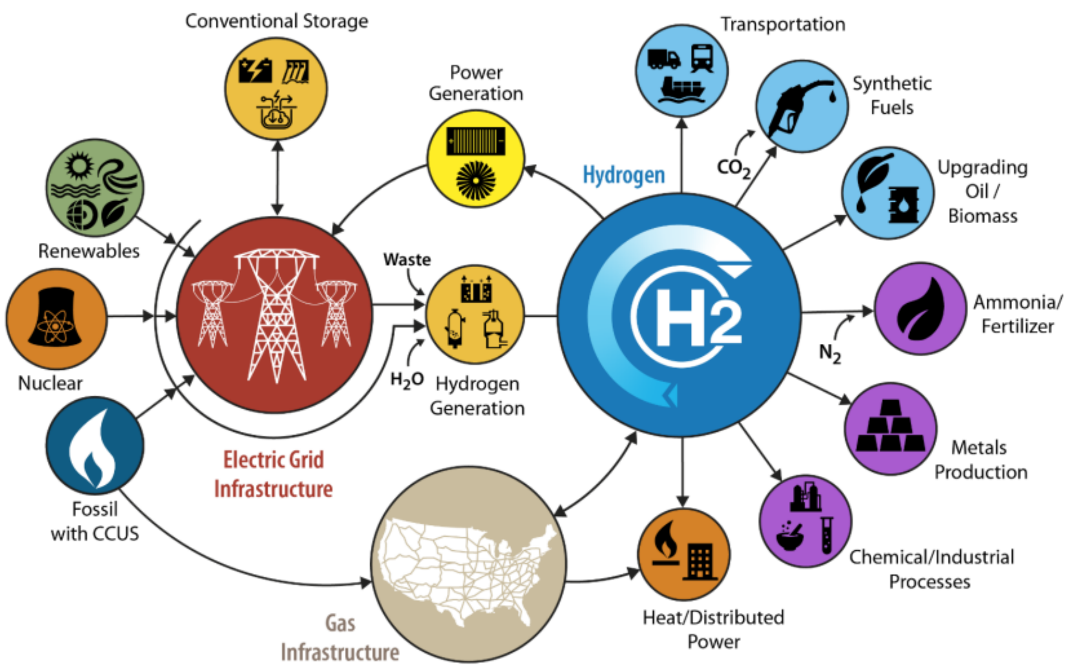

Figure 1 *The H2@Scale concept is based on hydrogen's potential to meet existing and emerging market demands across multiple sectors. It envisions how innovations to produce, store, transport, and utilize hydrogen can help realize that potential and achieve scale.*

[6] U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, Hydrogen and Fuel Cell Technologies Office. https://www.energy.gov/eere/fuelcells/h2scale
[7] 42 USC 16161d(c)(1)
[8] https://www.energy.gov/eere/fuelcells/articles/hydrogen-shot-introduction

Regional Clean Hydrogen Hubs – BIL Provisions

The specific provisions for H2Hubs are set forth in Section 40314 of the BIL, which amends Title VIII of the Energy Policy Act of 2005 (EPAct 2005)[9] by adding a new "Section 813 – Regional Clean Hydrogen Hubs." Section 813(a) defines the term "regional clean hydrogen hub" as "a network of clean hydrogen producers, potential clean hydrogen consumers, and connective infrastructure located in close proximity." Under Section 813(b), DOE "shall establish a program to support the development of at least four (4) regional clean hydrogen hubs that:

(1) demonstrably aid the achievement of the clean hydrogen production standard developed under section 822(a)[10]
(2) demonstrate the production, processing, delivery, storage, and end-use of clean hydrogen, and
(3) can be developed into a national clean hydrogen network to facilitate a clean hydrogen economy."

Section 813(c)(3) directs DOE to solicit proposals for the H2Hubs within 180 days of the BIL's enactment, and to make at least four hub selections within a year of receiving proposals. The BIL defines the following specific criteria that DOE shall use to the maximum extent practicable in making its selections for H2Hubs:

- **Feedstock diversity** – at least one hub shall demonstrate the production of clean hydrogen from fossil fuels, one hub from renewable energy, and one hub from nuclear energy.
- **End-use diversity** – at least one hub shall demonstrate the end-use of clean hydrogen in the electric power generation sector, one in the industrial sector, one in the residential and commercial heating sector, and one in the transportation sector.
- **Geographic diversity** – each regional clean hydrogen hub shall be located in a different region of the United States and shall use energy resources that are abundant in that region.
- **Hubs in natural gas-producing regions** – at least two regional clean hydrogen hubs shall be located in the regions of the United States with the greatest natural gas resources.

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[9] Energy Policy Act of 2005, Public Law 109–58, Title VIII – Hydrogen

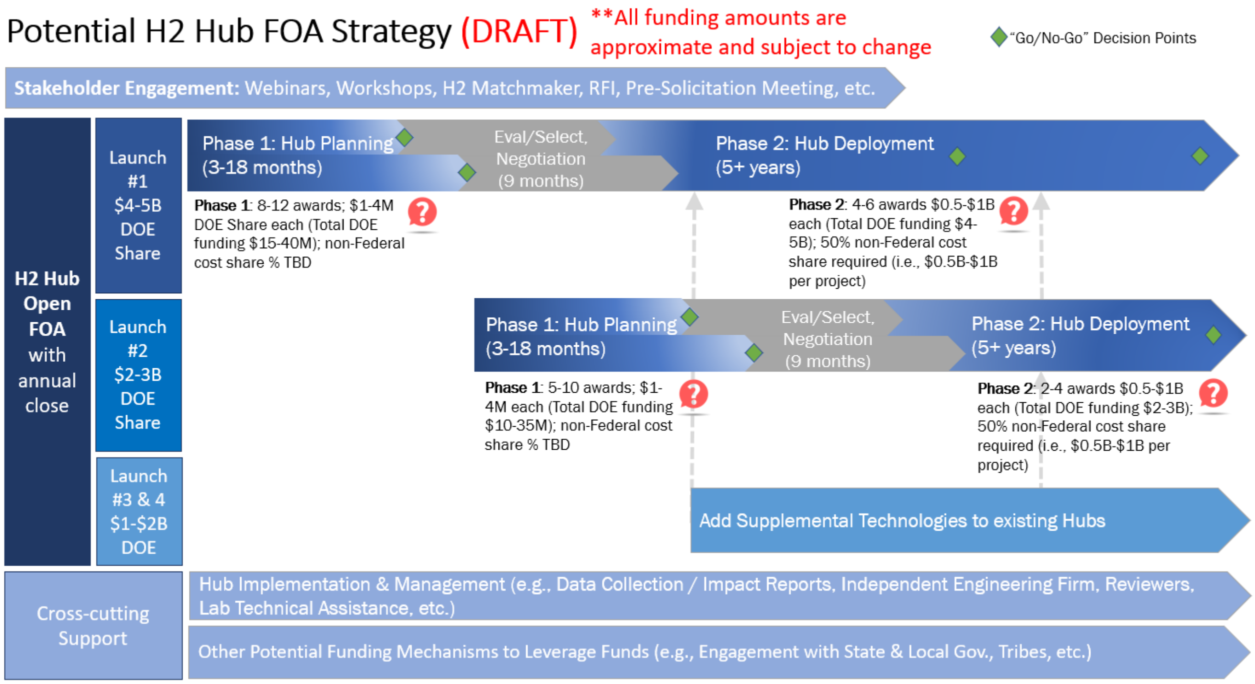
[10] Section 40315 of the BIL, which amends EPACT 2005 to add Section 822 – Clean Hydrogen Production Qualifications, requires DOE to consult with the Environmental Protection Agency and account for input from industry and other stakeholders to develop an initial standard for the carbon intensity of clean hydrogen production within 180 days (May 14, 2022), using a definition of "clean hydrogen" to mean hydrogen produced with a carbon intensity equal to or less than 2 kilograms of carbon dioxide-equivalent produced at the site of production per kilogram of hydrogen produced (kg CO_2e/kg H_2). Following development of the initial standard, and, as before, in consultation with the Environmental Protection Agency and accounting for input from industry and other stakeholders, DOE will determine whether the standard should be lowered below 2 kg CO_2e/kg H_2.

- **Employment** – DOE shall give priority to regional clean hydrogen hubs that are likely to create opportunities for skilled training and long-term employment to the greatest number of residents in the region.
- **Additional Criteria** – DOE may take into consideration other criteria that are necessary or appropriate to carry out the regional clean hydrogen hubs program.

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 in carrying out the Regional Clean Hydrogen Hub program.

Regional Clean Hydrogen Hub Implementation Strategy
This section provides a high-level draft plan for DOE's current vision to meet the BIL requirements by conducting a competitive solicitation to select and deploy H2Hubs. Please note this is a preliminary plan and it will likely evolve as DOE gathers feedback through the RFI and other stakeholder processes.

DOE envisions that the H2Hubs solicitation could be structured as a single, multi-year FOA with annual open and close dates for different "launches" over the FY 2022 – 2025 timeframe. Launches 1 and 2 would solicit, select, and deploy the H2Hubs, while Launches 3 and 4 would solicit and select new technologies, capabilities/end-uses, or partners that could be incorporated into and supplement the selected H2Hubs formed through Launches 1 and 2. Figure 2 below illustrates DOE's vision for what a future funding opportunity strategy could be. Potential funding amounts and the number of awards are all approximate and subject to change as noted in red in the figure.



*Notional timeline – allows flexibility for each project to be on own timeframe

In this draft strategy, Launches 1 and 2 would be essentially identical in structure and would consist of two main phases. DOE expects to evaluate applications based on detailed plans for Phase 1, as well as planned Phase 2 activities, partnerships/commitments, along with the long-term vision and strategy for the proposed H2Hub.

- **Phase 1 – Hub Planning:** This phase would focus on initial hub planning, which may include activities such as analysis of key metrics such as the decarbonization potential and energy resources/infrastructure/workforce in the proposed region, hub design, financing, and preliminary National Environmental Policy Act (NEPA) and related reviews. This Phase is expected to be approximately $1 to $4M DOE share for each potential H2Hub, plus required cost share (% cost share TBD)[11] and be administered over approximately 3-18 months depending on how much detailed advanced planning and analysis each team has already completed and how quickly the awardee can complete Phase 1 and submit to Phase 2. Phase 1 would likely include the key partners for each potential H2Hub (additional partners can be added in the Phase 2 proposal). This planning phase should include meaningful engagement by the H2Hub teams with

[11] 2 CFR § 910.130 Cost sharing (EPACT)

all communities in the region, with a focus on disadvantaged communities (DACs),[12] tribal communities and communities with environmental justice concerns, and communities facing the transition away from fossil fuel economies, as well as with labor unions and other key stakeholders. This would allow teams to gather input during the in-depth planning and design of potential hubs, including value proposition and benefits analyses, as well as the potential role of communities and community engagement throughout the project. The goal at the end of Phase 1 would be to have a full plan ready for the roll-out of the hub in Phase 2 as well as insight that potential critical reviews, approvals, or negotiations such as NEPA, financing, permitting, safety, partnering agreements, power purchase agreements, long-term hub sustainability, etc. have been evaluated and addressed as much as practical (given the funding and timing) to minimize potential risk.

- **Phase 2 – Hub Construction and Deployment**: This phase would be focused on the development and build-out of the Phase 1 design after completing NEPA reviews, permitting, etc. during the early stages of Phase 2. Phase 2 would include multiple Budget Periods with defined activities per Budget Period. DOE is in the process of defining activities for each Budget Period; however, for example, Phase 2 may include:
    - Phase 2a: Project Development (e.g., Front-End Engineering Design, completed NEPA reviews, siting, permitting, finalizing off-taker agreements and volumes, etc.)
    - Phase 2b: Hub Construction/Deployment
    - Phase 2c: Operation

  Go/No-Go reviews would be held between each Budget Period to evaluate the progress and readiness of the H2Hub to move to the next Budget Period. This Phase is expected to be $500 million to $1 billion DOE share for each H2Hub plus 50% cost share[13] (50% of the total project cost including both DOE share and recipient cost share, for a total project cost of $1 billion to $2 billion) and executed over approximately five or more years depending on the size and complexity of the H2Hub. Additional partners can be added as part of the Phase 2 continuation application.

  DOE expects to retain the services of an independent engineering firm to review all the Phase I and Phase 2 deliverables from planning through H2Hub operation. This could

[12] 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
[13] Recipient cost share is exclusive of other federal sources of funding and may not be applied to more than one federal cost share requirement.

include, but is not limited to, the review of: 1) quarterly reports and project milestones; 2) engineering construction and deployments designs; 3) financial plans and recipient's ability to meet cost sharing requirements; 4) risk management plans; and 5) an evaluation of the commercial readiness of proposed hub technologies.

To be considered for Phase 2 funding, H2Hub projects must successfully complete all Phase 1 planning activities and analysis, which may include, but are not limited to:

- Ability to meet or exceed the clean hydrogen production standard developed under Section 822(a)
- Ability to create and sustain jobs, particularly high paying union jobs, and support long-term jobs for local residents
- Ability to employ workers currently employed in the fossil industry or those that may no longer have jobs as a result of the clean energy transition, in regions where applicable
- Capacity to demonstrate the complete value chain at scale for production, processing, delivery, storage, and end-use of clean hydrogen
- Ability to drive sustained regional specific economic growth, including through demonstrated connections to the value chain at scale for production, processing, delivery, storage, and end-use of clean hydrogen
- Potential for the proposed H2Hub to be developed into a national clean hydrogen network to facilitate a clean hydrogen economy, including potential for replicability
- Quantification of decarbonization potential compared to alternate pathways
- Quantification of criteria pollutant emission reductions, compared to alternate pathways
- Project financial model and analysis including total project cost with revenue potential and pathway to private sector investment and commercial sustainability beyond the DOE funding
- EEEJ strategy, including significant and meaningful community engagement plans, connection to hubs and post-hub benefit, to ensure EEEJ goals are achieved
- Cost, quantity, and purity of hydrogen produced/demanded
- Potential for U.S. manufacturing of components/equipment across the hydrogen supply chain
- Reliability, availability, capacity of clean energy source(s)
- Availability of necessary hydrogen infrastructure including storage of hydrogen, energy feedstocks, and/or permanently sequestered CO_2, where applicable
- Commitment (or at least identification) of specific off-taker agreements (e.g., power purchase agreements)
- Creation of clear workforce education and training pathways, including registered apprenticeships, into high quality jobs (including union jobs)

- Effective use of regional resources/markets
- Market analysis that includes current and future supplier/off-take potential
- Plan to ensure environmental impacts such as water use, impact on DACs or adjacent regions, etc., are minimized
- Complete list of project partners with letters of commitment or MOUs
- Formal partnership with and support from relevant local labor unions, where applicable
- Potential for longevity and sustainability after DOE FOA funding ceases

During Phase 1, H2Hub recipients would also complete their preliminary engineering, construction and deployment designs, secure non-federal cost sharing and financial commitments for the full H2Hub deployment, obtain/identify land use rights and site access, begin preliminary NEPA and related reviews, identify permitting and regulatory requirements, as well as conduct preliminary hydrogen safety reviews to ensure a successful Phase 2. Specific Phase 1 activities will be tailored based on the status of each H2Hub.

In addition to the items noted above, the transition from Phase 1 to Phase 2 would require successful completion of established Go/No-Go decision points (similar to stage gate reviews), which will be specific to each H2Hub (developed during Phase 1 negotiations). The Phase 1 to Phase 2 Go/No-Go review will require the submission of a continuation application, which is expected to include a full Phase 2 technical proposal with a Phase 2 budget justification, as well as documentation showing successful completion of all Phase I requirements. Independent reviewers will review and score the continuation application. DOE will also utilize the services of an independent engineering firm to review the deliverables associated with the continuation application. This independent review will include an evaluation of each H2Hub technology to determine commercial deployment readiness. The Go/No-Go timing will be based on the proposed project's readiness to start the full hub construction/deployment and can be initiated as soon as the H2Hub project is ready during Phase 1. This approach allows flexibility for each project to progress on its own schedule for completion of the Phase 1 deliverables and Go/No-Go criteria. For example, proposed projects that have already completed their project development activities and related analysis prior to selection may be able to accelerate through Phase 1 faster than other projects that have not completed these activities.

As Figure 2 illustrates, DOE anticipates awarding approximately four to six Phase 2 projects in Launch 1 (pending the number of applicants with qualified hub proposals), and an additional two to four Phase 2 projects in Launch 2 (pending the outcome of Launch 1), with a goal of awarding a total of six to ten Phase 2 projects from Launches 1 and 2. DOE anticipates that the FOA will allow for a range of awards from $500 million to $1 billion, in order to allow for a range of regional hub sizes and complexities that meet the intent of the BIL. DOE anticipates funding a portfolio of H2Hubs that captures to the maximum extent practicable the full feedstock, end-use, and geographic diversity requirements in the BIL as noted above. Applicants not awarded funding in Launch 1 (FY22) may reapply alongside new applicants in the Launch 2 (FY23) FOA cycle.

To facilitate hydrogen hub team formation and to support the overall connection between hubs and the broader hydrogen economy, DOE announced the launch of H_2MatchMaker,[14] a voluntary online tool created to aid in fostering partnerships among key stakeholders by allowing potential partners to self-identify. H_2Matchmaker will include 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). The H_2Matchmaker tool is intended to help foster partnerships by increasing awareness and aligning potential needs in specific regions of the United States. DOE will not give preference to entities for use of the tool as it is completely voluntary (i.e., its use or non-use will have no impact on the eventual H2Hub selections).

In addition to this RFI, DOE has conducted other stakeholder outreach activities to help inform the development of the Regional Clean Hydrogen Hub FOA. For example, DOE hosted an H2IQ Webinar[15] on December 8, 2021, to provide an update on Hydrogen Shot, results of a previous RFI on potential regional clean hydrogen demonstrations, summary of hydrogen provisions in the BIL, and the H_2Matchmaker tool. DOE may conduct future outreach events to get input from various stakeholder groups (e.g., labor groups, state/local governments, tribes, communities with environmental justice concerns, communities with retiring or decommissioned fossil assets, etc.) throughout February and March. Finally, DOE plans to issue a draft FOA in the May 2022 timeframe and hold a Pre-Solicitation Meeting to solicit additional public input before publishing the FOA later in 2022.

Purpose

The purpose of this RFI is to solicit feedback from industry, government agencies, state and local coalitions, academia, research laboratories, labor unions, community-based organizations (CBOs),[16] and other stakeholders on issues related to the Regional Clean Hydrogen Hub FOA strategy.

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[14] https://www.energy.gov/eere/fuelcells/h2-matchmaker

[15] https://www.energy.gov/eere/fuelcells/hydrogen-and-fuel-cell-technologies-office-webinars

[16] Community-Based Organizations (CBOs) are public or private not-for-profit resource hubs that provide specific services to the community or targeted population within the community.

You may answer as few or as many of the questions below as you would like. Please use the bolded Category numbers and subnumbers as headings in your response to the greatest extent possible and refer to the questions (C1.1a, C2.12 etc.) in the body of your responses. This helps save time both for the responder and the reviewers.

Specifically, DOE is requesting input on the following categories and questions:

Category 1: **Regional Clean Hydrogen Hub Provisions and Requirements**

1. The BIL defines a "regional clean hydrogen hub" as "a network of clean hydrogen producers, potential clean hydrogen consumers, and connective infrastructure located in close proximity."[17]
    a. What should qualify as 'close proximity' in context of the hub requirements?
    b. What existing facilities and infrastructure, including pipelines and storage facilities, could be most easily leveraged by the H2Hubs?
    c. What types of new 'connective infrastructure' will be needed by the H2Hubs (e.g., pipelines, storage, etc.)?
    d. What supportive activities would make the hydrogen hubs successful and sustainable (e.g., workforce development, community-based organization engagement, domestic manufacturing, labor standards, etc.)?
2. The BIL states that H2Hubs must (1) demonstrably aid the achievement of the clean hydrogen production standard developed under Section 822(a) [defined as 2 kg CO_2e/kg H_2 at the point of production]; (2) demonstrate the production, processing, delivery, storage, and end-use of clean hydrogen; and (3) can be developed into a national clean hydrogen network to facilitate a clean hydrogen economy.[18]
    a. What CO_2 equivalent emissions should be met within the project and its supply chain? What strategies are available for, and how can DOE incentivize, the H2Hubs to reduce emissions not only at the point of production but also including upstream emissions? What challenges are there in measuring CO_2 equivalent emissions?
    b. Please specify CO2e/kg H_2 you anticipate at the point of production in addition to well to gate (i.e., including upstream emissions).
    c. Given the level of funding, and with the ultimate goal of developing a national clean hydrogen network, would four (4) large H2Hubs that each produce more than a certain amount of hydrogen (e.g., more than 1,000 tonnes/day, see question 3 to specify amount) or 6-10 H2Hubs of varying size be more effective?

[17] 42 USC 16161a(a)
[18] 42 USC 16161a(b)

    d. What policies, infrastructure, or other considerations could be put in place to enable the H2Hubs to develop into a national clean hydrogen network in the future?
    e. How should the H2Hubs be asked to measure progress toward the administration's goal of transforming the economy by 2050 to achieve net-zero emissions goals? Please be as specific as possible.
3. FEEDSTOCK DIVERSITY: "To the maximum extent practicable– (i) at least 1 regional clean hydrogen hub shall demonstrate the production of clean hydrogen from fossil fuels; (ii) at least 1 regional clean hydrogen hub shall demonstrate the production of clean hydrogen from renewable energy; and (iii) at least 1 regional clean hydrogen hub shall demonstrate the production of clean hydrogen from nuclear energy."[19]
    a. Should DOE require a minimum level of hydrogen production per regional clean hydrogen hub, and if so, what should that minimum amount be (i.e., X tonnes/day)? Should this requirement vary for clean hydrogen produced from fossil fuels with carbon capture and storage (CCS), renewable energy, and nuclear energy? If a minimum is not specified, how may DOE incentivize larger capacity hubs?
    b. Related to 3a, how should DOE take into account specifying minimum required hydrogen production when considering capacity factors and the potential intermittency of generation, which would increase the cost and requirement for hydrogen storage?
    c. What terms should be required for an H2Hub powered by renewable energy to demonstrate clean production (e.g., a power purchase agreement with a renewable generator, or direct connection to a co-located renewable generator)?
    d. Should DOE prioritize the repurposing of historic fossil infrastructure in the regional hub(s) focused on production from fossil fuels and if so, over what time frame? If yes, should DOE incentivize an eventual transition from fossil fuels to another fuel source? What conditions should DOE place on the carbon intensity of the fossil fuels (with CCS) used in this hub other than what is already specified in the BIL?
    e. How might hydrogen production be constrained by the availability of clean electricity or natural gas supply and distribution? Will hydrogen producers provide a sustainable market/revenue stream for clean electricity and natural gas that encourages new investments to expand electricity generation and natural gas production capacity? Are separate federal, state, or local incentives

[19] 42 USC 16161a(c)(3)(A)

   to expand clean electricity generation or natural gas production capacity available, necessary, or adequate?
   f. Should H2Hub funding be made available to upgrade or develop new dedicated clean electric or heat generating energy resources (e.g., renewables or other clean generation sources) needed to produce clean hydrogen?

4. END-USE DIVERSITY: "To the maximum extent practicable– (i) at least 1 regional clean hydrogen hub shall demonstrate the end-use of clean hydrogen in the electric power generation sector; (ii) at least 1 regional clean hydrogen hub shall demonstrate the end-use of clean hydrogen in the industrial sector; (iii) at least 1 regional clean hydrogen hub shall demonstrate the end-use of clean hydrogen in the residential and commercial heating sector; and (iv) at least 1 regional clean hydrogen hub shall demonstrate the end-use of clean hydrogen in the transportation sector."[20]
   a. What are the ideal timing and desirable features, terms, and conditions of off-taker agreements that would encourage construction and development of hydrogen hub infrastructure and long-term sustainability leading to local economic prosperity including union jobs and benefits to disadvantaged communities? Would hubs that supply multiple end users provide advantages, and in what ways?
   b. What approaches can applicants use to guarantee off-taker commitments and matching of supply and demand?
   c. The climate value of displacement may vary across end uses. How should the climate benefit of different hydrogen end uses be considered?
5. GEOGRAPHIC DIVERSITY: "To the maximum extent practicable, each regional clean hydrogen hub– (i) shall be located in a different region of the United States; and (ii) shall use energy resources that are abundant in that region."[21]
   a. A region could be defined as anything from a city, a state, multiple states, tribal communities, or a geographic area. Should DOE define the regions or allow applicants to define them within their proposal? If a definition is preferred, explain how regions should be defined for the purposes of this FOA and provide the rationale.
   b. In addition to sufficient energy and feedstock/water resources, what other regional factors should be considered when identifying and selecting regional hubs (e.g., economic considerations, policy considerations, environmental and energy justice considerations, geology, workforce availability and skills, current industrial and other relevant infrastructure and storage available/repurposed/reused, industry partners, minority-serving institutions

[20] 42 USC 16161a(c)(3)(B)
[21] 42 USC 16161a(c)(3)(C)

[MSIs], minority-owned businesses, regional specific resources, security of supply, climate risk, etc.)?

6. HUBS IN NATURAL GAS-PRODUCING REGIONS: "To the maximum extent practicable, at least 2 regional clean hydrogen hubs shall be located in the regions of the United States with the greatest natural gas resources."[22]
    a. What level of natural gas resources should be required to qualify as a region with the "greatest natural gas resources"? How should DOE consider the difference between the available natural gas resources and the current natural gas production of an area when considering hub candidates? How should DOE consider the volatility of natural gas prices and its effect on production levels when defining these regions?
    b. How should DOE consider the volatility of natural gas prices and its effect on production levels when defining these regions? Should annual (or average over a five-year period) production and/or available proven reserves be the criteria for the above provision?
7. EMPLOYMENT: DOE "shall give priority to regional clean hydrogen hubs that are likely to create opportunities for skilled training and long-term employment to the greatest number of residents of the region."[23]

    In keeping with the administration's goals, and as an agency whose mission is to help strengthen our country's energy prosperity, the Department of Energy strongly supports investments that expand union jobs, improve job quality through the adoption of strong labor standards, increase job access, strengthen local economies, and develop a diverse workforce for the work of building and maintaining the country's energy infrastructure and growing domestic manufacturing. The Department intends to use the H2Hubs to support the creation of good-paying jobs with the free and fair choice to join a union and the incorporation of strong labor standards and training and placement programs, especially registered apprenticeship. Respondents to this RFI are encouraged to include information about how this program can best support these goals.

    a. What tools should H2Hubs utilize to meet the goals of creating good union jobs and work opportunities for local residents in the construction phase of the project and in the long-term operations phase of the project?
    b. What tools should H2Hubs utilize to meet the goals of providing opportunities for workers displaced from fossil industries and other industrial or resource-based industries in decline?

[22] 42 USC 16161a(c)(3)(D)
[23] 42 USC 16161a(c)(3)(E)

c. How should short-term build-out (i.e., construction phase) employment and long-term operational employment opportunities be measured and evaluated?
d. What would "success" look like, especially related to Diversity, Equity and Inclusion (DEI) and support for union and energy transition jobs?
e. How should H2Hubs include workforce development and training activities (e.g., by including institutions of higher education, such as MSIs, community-based organizations, registered apprenticeship programs, joint labor-management apprenticeship programs and quality community-based pre-apprenticeship programs, as project partners)? In addition to each H2Hub having its own workforce development and jobs plan, should there be a nationally coordinated effort between hubs (and other hydrogen activities) to ensure an adequately trained workforce is available? If so, how should this be designed?
f. How will the H2Hub training model offer opportunities for a range of jobs across the hydrogen supply chain?
g. How should labor standards be incorporated in project planning stages to support the creation of high-quality, good-paying jobs?

Category 2: **Solicitation Process, FOA Structure, and H2Hubs Implementation Strategy**

8. DOE is evaluating funding mechanisms for the H2Hubs projects in accordance with the BIL. What applicable funding mechanisms are best suited to achieve the purposes of the H2Hubs (e.g., Cooperative Agreements,[24] Grants, Other Transactions Authority[25])?
9. What are the key review criteria (e.g., technical merit, workplan, market transformation plan, team and resources, financial, regional economic benefits, environmental justice, DEI) that DOE should use to evaluate and select the H2Hubs as well as evaluate readiness to move from Phase 1 to Phase 2?
10. Does offering multiple launches roughly a year apart, as shown above in Figure 2, help facilitate expanding the hydrogen hub concept to more regions?
11. What specific activities should be conducted in Phase 1 vs. Phase 2? Should Phase 2 be further broken into multiple sub-phases, and if so, what should be included in each sub-phase?
12. How much time will be needed to complete the Phase 1 activities? Have some regional teams already completed analysis and design activities?
13. Are the proposed funding levels for Phase 1 and Phase 2 appropriate/adequate?
14. How much funding should DOE allocate for adding new technologies, capabilities/end-uses, or partners to the existing hubs (i.e., Launches 3 and 4)?

[24] For more information about Cooperative Agreements, see the DOE Guide to Financial Assistance: https://www.energy.gov/management/articles/department-energy-guide-financial-assistance

[25] Agreements under the Other Transactions Authority (OTA), Section 1007 of EPAct 2005

15. What safety criteria (e.g., safety plan reviews, outreach to Authority Having Jurisdiction [AHJ] entities such as code/fire officials, training) should DOE use to evaluate readiness to move from Phase 1 to Phase 2?
16. What resources might H2Hubs need regarding safety, permitting, and siting, particularly in relation to the Hydrogen Safety Panel[26] and submission of safety plans.
17. What environmental reviews and permitting challenges might H2Hubs encounter? Where can approaches such as "dig once" relating to buried conduits, pipelines, and other infrastructure (e.g., CO_2 pipelines) be developed and incentivized to reduce impact? Please provide examples of how community consultation and consent-based siting can successfully be included in the environmental and permitting review process.
18. Are there existing draft or final federal NEPA documents (e.g., environmental assessments and/or environmental impact statements) for similar or related proposals that could inform DOE NEPA reviews for the H2Hubs?
19. What external non-project partners/stakeholders (e.g., CBOs, DACs, tribal groups, state and local governments, economic development organizations, labor representatives) will be critical to the success of the H2Hubs? What types of outreach and engagement strategies are needed to make sure these stakeholders are involved during each phase of the H2Hubs? Are there best practices for equitably and meaningfully engaging stakeholders?
20. The H_2MatchMaker tool[27] will be available to help identify potential regional project partners. What specific fields/information would be valuable to include in the tool? What other mechanisms can DOE use to help facilitate teaming?
21. Based on EPAct 2005, Section 988, the cost share requirement for demonstration and commercial application projects is 50% cash and/or in-kind and must come from non-Federal resources (50% of the total project cost which includes both DOE share and recipient cost share). For example, a $1B award for the Phase 2 Hub Deployment will require $1B in matching cost share. Is it feasible for projects to meet this 50% cost share requirement on an invoice-by-invoice basis?
22. Is there sufficient manufacturing capacity to produce the necessary hydrogen related components/equipment within the U.S. to supply all the eventual H2Hubs? What incentives/programs exist or can be put in place to encourage and foster U.S. manufacturing? What potential challenges or opportunities might exist to meet the new Buy American requirements in the BIL?[28]

[26] https://h2tools.org/hsp

[27] https://www.energy.gov/eere/fuelcells/h2-matchmaker

[28] New Buy American requirements are located in Division G – Other Authorizations; Title IX – Build America, Buy America of the Infrastructure Investment and Jobs Act (IIJA), Public Law 117-58, which was enacted into law on November 15, 2021. https://www.congress.gov/bill/117th-congress/house-bill/3684

23. Please identify any iron, steel, manufactured goods, or construction materials that will be crucial for building out the H2Hubs that would not typically be procured domestically. For each, please specify how H2Hubs could work to procure these items domestically, and any potential barriers to domestic procurement, such as lack of availability or cost.
24. What types of cross-cutting support (e.g., technical assistance) would be valuable from the DOE/national laboratories, and/or from other federal agencies, to provide in proposal development or project execution? Are there other entities that DOE could fund to provide technical assistance across multiple H2Hubs?
25. What data should DOE collect from the H2Hubs to evaluate the impact of the program? How should this data and the program outcomes be disseminated to the public? In addition, EPAct 2005 Section 817 requires that three national labs (the National Energy Technology Laboratory, the Idaho National Laboratory, and the National Renewable Energy Laboratory) will work together to serve as a 'clearinghouse' for the H2Hubs and for the Clean Hydrogen Manufacturing and Recycling Program (Section 815). What data or information should be part of this 'clearinghouse'?
26. How could funding under other BIL provisions (e.g., Section 40303, Carbon Capture Technology Program) be leveraged by the H2Hubs to maximize the impact of BIL funding?

Category 3: **Equity, Environmental and Energy Justice (EEEJ) Priorities**

EEEJ benefits will be a high priority as the H2Hubs are developed. For the purposes of this RFI, DOE has identified the following non-exhaustive list of policy priorities as examples to guide DOE's implementation of Justice40[29] in DACs: (1) decrease energy burden;[30,31,32] (2) decrease environmental exposure and burdens;[33] (3) increase access to low-cost capital; (4) increase the clean energy job pipeline and job training for individuals;[34] (5) increase clean energy enterprise

[29] The Justice40 Initiative states that 40% of the overall benefits of certain federal investments will flow to DACs, and that projects will have minimal negative impacts on communities with environmental justice concerns. The Justice40 Interim Guidance defines benefits as direct and indirect investments (and program outcomes) that positively impact disadvantaged communities and provides examples (Page 4): https://www.whitehouse.gov/wp-content/uploads/2021/07/M-21-28.pdf

[30] The Initiative for Energy Justice https://iejusa.org/glossary-and-appendix/#glossary_of_terms

[31] DOE's LEAD tool illustrates energy burden in U.S. https://www.energy.gov/eere/slsc/maps/lead-tool

[32] Drehobl, A., Ross, L., and Ayala, R. 2020. How High are Household Energy Burdens? Washington, DC: ACEEE.

[33] Tessum, C., et al., 2019. Inequity in consumption of goods and services adds to racial–ethnic disparities in air pollution exposure. Proceedings of the National Academy of Sciences.

[34] DOE's US Energy & Employment Jobs Report (USEER), https://www.energy.gov/us-energy-employment-jobs-report-useer; Department of Labor, Civilian Labor Force by Sex, https://www.dol.gov/agencies/wb/data/facts-over-time/women-in-the-labor-force

creation (e.g., minority-owned or diverse business enterprises); (6) increase energy democracy, including community ownership; (7) increase parity in clean energy technology access and adoption; and (8) increase energy resilience.

27. What strategies, policies, and practices can H2Hubs deploy to support EEEJ goals (e.g., Justice40)? How should these be measured and evaluated for the H2Hubs?
28. What EEEJ concerns or priorities are most relevant for the H2Hubs?
29. What measures should H2Hub project developers take to ensure that harm to communities with environmental justice concerns, including local pollution, are mitigated?
30. How can H2Hubs ensure community-based stakeholders/organizations are engaged and included in the planning, decision-making, and implementation processes (e.g., including community-based organizations on the project team)?
31. How can DOE support meaningful and sustained engagement with H2Hub relevant disadvantaged communities?

Category 4: **Market Adoption and Sustainability of Hubs**

32. What mechanisms (e.g., tax/other incentives, offtake structures, prizes, competitions, alternative ownership structures for hydrogen production bundling demand, contracts for difference, etc.) would be valuable to incentivize market-based supply and demand?
33. What role/actions can DOE take to support reliable supply and demand for potential hydrogen producers and customers?
34. If DOE asks for a market analysis as part of the application process, what should the analysis include so that DOE can be confident that a proposed project will be successful?
35. What can DOE provide/do that would be helpful to a project to facilitate its collaborations with potential financing partners?
36. How can DOE support the H2Hubs in working together to increase competitiveness and scale?
37. Which regional and site-specific metrics should DOE track to estimate the impact of hydrogen production on regional water availability?
38. Other than greenhouse gas emissions, what sustainability metrics should DOE include in evaluating the hubs (e.g., impact on regional water resources, availability of decarbonized electricity production resources, climate risk impacts on the resilience of the H2Hubs)?
39. The goal is for the H2Hubs to be sustainable beyond the BIL funding (i.e., without additional government funding). To what extent will the H2Hubs be capable of demonstrating a path to economic viability after the BIL funded phases and how should the FOA and project (once awarded) be structured to ensure this outcome?

Category 5: Other

40. Please provide any additional information or input not specifically requested in the questions above that you believe would be valuable to help DOE develop a Regional Clean Hydrogen Hub FOA, including any specific criteria that DOE may take into consideration in implementing the Hub program.

Disclaimer and Important Notes

This RFI is not a Funding Opportunity Announcement (FOA); therefore, DOE is not accepting applications at this time. DOE may issue a FOA in the future based on or related to the content and responses to this RFI; however, DOE 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 DOE chooses to issue a FOA regarding the subject matter. Final details, including the anticipated award size, quantity, and timing of DOE 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. DOE 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. DOE will not provide reimbursement for costs incurred in responding to this RFI. Respondents are advised that DOE 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 DOE 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. Submittal via email is the preferred method, 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 DOE 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 H2Hubs@hq.doe.gov no later than 5:00pm (ET) on March 21, 2022, with subject line **"H2Hubs RFI response**." Responses must be provided as attachments to an email. It is recommended that attachments with file sizes exceeding 25MB be compressed (i.e., zipped) to ensure message delivery. Responses must be provided as a Microsoft Word (.docx) or Adobe PDF (.pdf) attachment to the email, and no more than 15 pages in length (plus any additional pages necessary to include the original questions), 12-point font, 1-inch margins. Only electronic responses will be accepted. For ease of replying and to aid categorization of your responses, **please copy and paste the RFI questions, including the question numbering, and use them as a template for your response.** Respondents may answer as many or as few questions as they wish.

DOE will not respond to individual submissions or publish publicly 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. DOE 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. DOE may or may not issue a Funding Opportunity Announcement (FOA) based on consideration of the input received from this RFI.