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Request for Information # DE-FOA-0002664
Regional Clean Hydrogen Hubs Implementation Strategy

Key Principles for Creating Successful and Sustainable Regional Clean Hydrogen Hubs

The Center for Houston's Future, an independent twenty-year-old non-profit affiliated with the Greater Houston Partnership (the Houston region's major economic development organization) is pleased to submit these comments in response to the Department's Request for Information on its upcoming Clean Hydrogen Hub solicitation.

The Center focuses on understanding future global trends and their impact on the Houston region, and then, working with community, business, and government partners, spurring actions to improve Houston's presence as a major global city.

Against the backdrop of climate change and Houston's leading position as the world's energy capital, the Center has been heading a community effort focused on recognizing that Houston can and should become the "low-carbon" energy capital. The Center, over the past several years, has undertaken research, conferences, webcasts, projects, work with partners and other activities to catalyze this vision.

As a result of this work, we believe that the Texas Gulf Coast, home to the nation's largest concentration of hydrogen production assets, dedicated hydrogen pipeline infrastructure and large number of sophisticated industrial hydrogen customers, can leverage these unique assets to become a global clean hydrogen leader.

Our research has shown that the Texas Gulf Coast anchors one of the world's leading hydrogen systems, producing one third of U.S. total hydrogen gas per year from 48 production plants and over 900 miles of hydrogen pipelines (representing over half the US hydrogen pipelines capacity and a third of global capacity). Three of the world's six hydrogen salt storage caverns are located near Houston. Our assets will also allow us to lead not only in "blue" hydrogen but in "green" hydrogen. ERCOT is the largest wind power state and second largest utility scale solar state, and our research shows Texas will be able to produce green hydrogen at globally competitive prices.

Building on this assessment, the Center has led an intensive process of convening energy companies, academic institutions, local and state government agencies, and nonprofits to work collaboratively on developing a common vision and roadmap for creating a clean hydrogen ecosystem in the Houston region. Currently, over 120 stakeholders are participating in this roadmap development process, assisted by the global consulting firm McKinsey & Company. We expect to publicly release the roadmap in the next month.

As part of this process, the Center asked that stakeholders provide input to our RFI responses. We received input to these comments from 22 companies and reviewed the separate responses of 6 companies. The combination of our roadmap development project, work with a broad cross-section of stakeholders, and requests for input led us to develop our own perspective on several principles that we believe will be the key success factors in implementing the Department's hydrogen hub program. While we received a significant amount of feedback, these comments are our own.

Below we define, and then apply those Key Principles in our comments on specific questions.

1. **DOE should use the hydrogen hub program to accelerate the creation of broad-based hydrogen ecosystems**. An analysis of the creation of strategic energy ecosystems has shown that the recipe for success in ecosystem development in the natural gas, electricity, and chemicals industries involves leveraging the interdependencies between the 3 Fs (feedstock, facilities and financial).[1] Thus, creating a successful energy ecosystem requires developing a network of assets that connects processes, creates new products, and creates supply flexibility and unifies a disjointed asset base. DOE should provide/expand mechanisms to support and collaborate with governmental authorities. Hub proposals that can demonstrate that they have such strong partnerships should be prioritized.

   In addition to these basic ecosystem building blocks, creating successful hydrogen ecosystems will require an additional layer of transparent emissions measurement and verification (M&V).[2] Creating a digital layer that will allow for open, interoperable and transparent carbon measurement and verification will not only ensure confidence that the public investment in creating clean hydrogen meets the statutory carbon intensity standard contained Bipartisan Infrastructure Law, but will also create the opportunity to develop financial markets that provide for the development of liquid tradeable commodities.

   In its approach to the creation of hydrogen hubs, the Department should thus focus on creating a "layered model" of innovation (see Key Principle 6), physical assets, digital infrastructure and financial markets that will lead to the development of liquid and transparent markets and sustainable hydrogen ecosystems.

   This implies that the Department's approach must go beyond simply focusing on physical asset demonstration projects but should also seek creative ways to incorporate the IT infrastructure and financial/market transaction infrastructure as well.

   Focusing on ecosystem development, rather than demonstration project development, is consistent with the UK's[3] and EU's[4] Hydrogen Strategies. Each of these strategies includes

[1] England and Mittal, A Strategic Oil and Gas Ecosystem, Deloitte Oil and Gas Ecosystem paper
[2] GTI's Open Hydrogen Initiative https://www.gti.energy/ohi/#home-ohi is an example of an open source measurement and verification approach.
[3] https://www.gov.uk/government/publications/uk-hydrogen-strategy
[4] https://energy.ec.europa.eu/topics/energy-system-integration/hydrogen_en

not only initiatives for cleaner hydrogen production, but also transport networks and storage, end use – and especially markets. Indeed, the UK[5] and the EU[6] are developing a business model for hydrogen that uses the market structure as a way to pull forward demand, supply and infrastructure.

The Department appears to be considering this type of integrated ecosystem approach that focuses on creating liquidity and markets. As DOE's Jigar Shah recently observed:

"That's why today's clean hydrogen projects are built on bilateral arrangements between hydrogen producers and hydrogen purchasers. But for the industry to grow to scale, it will require multiple producers serving multiple buyers. That's what the industrial hubs are for," Shah said. "You find people who want to provide the backbone of clean hydrogen, and also the backbone of CO2 removal, which we also fund." That could allow would-be users of clean hydrogen to "just plug in" to infrastructure that can make it available, he said. "You've got risk reduction — no one company has to solve the problem." [7]

2. **DOE should allow flexibility in letting the hubs define their boundaries and size**. The Department should provide flexibility to allow each hub to define itself based on its own strengths and existing infrastructure and potential infrastructure. This will allow hubs to best shape their growth and sustainability for H2 production/use and emissions reductions – DOE's ultimate goals. Clearly in the early stages of market hub development, close proximity to resources has advantages. But as documented in a recent University of Texas study,[8] market hub maturation brings several types of transportation infrastructure to provide a means to achieve close proximity. For example, as the world's leading energy hub, Houston has accomplished this through physical proximity as well as pipelines to supply oil and gas or feedstocks (e.g., Permian basin) and demand (e.g., the whole Gulf Coast basin and even West Coast and East Coast markets), electric transmission lines for accessing renewable electricity and a world-class port for shipping energy internationally. Indeed, this is relevant for hydrogen as well: Houston has the US largest hydrogen pipeline as well as trucking to access the greatest concentration of hydrogen demand and supply in the US today.

3. **DOE should go for scale**. In Silicon Valley Venture Capitalist John Doerr's recent book, Speed and Scale, he makes the point that we need to "go for the gigatons" if we are to achieve net zero targets with the sense of urgency demanded by climate change. He notes that the cost of clean hydrogen will take 20 years or more in most parts of the world without significant economies of scale. As the UK hydrogen strategy also recognizes,[9] going for the gigatons and building scale in the 2020's means leveraging existing scale infrastructure such as Houston's.

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[5] https://www.gov.uk/government/consultations/design-of-a-business-model-for-low-carbon-hydrogen
[6] Op cit.
[7] Which states will win out on $9.5B in federal clean hydrogen funding?, CanaryMedia
[8] Hydrogen Infrastructure Expansion Requires Realistic Framework, https://sites.utexas.edu/h2/featured-publications/
[9] Op cit.

4. **DOE should prioritize Demand while Building supply drivers.** Rather than a technology push model that focuses mostly on learning curve effects of reducing the cost of supply, DOE should also focus on demand creation at scale. We note that the growth in other clean energy (e.g., solar, wind) in the last decade has been demand driven -- corporate/ government PPA's and state RPS mandates provided significant demand volume so that suppliers could achieve economies of scale. Prioritizing the development of the large drivers of demand will create a self-reinforcing cycle of entrepreneurial interest and innovation that lead the next round of market-based innovation and leverages the federal hub investment. By putting as much or more effort into creating new demand and applications for hydrogen (including local, state and especially federal government procurement of H2 for appropriate end uses), DOE can then use market forces to create the technology innovations that will then further reduce costs. This is also consistent with the UK's "total systems" approach.

5. **DOE should focus on carbon-intensity and extend this idea across the full value chain.** If DOE's ultimate goal is "going for the gigatons" then this means decarbonizing existing sources of hydrogen as well as supporting newer green technologies, Existing technologies can provide scale as newer technologies come down the cost curve and build the infrastructure required for scale. At the same time, there needs to be a common scorecard of carbon intensity and an accounting for the entire life cycle (value chain) emissions of hydrogen from production to end use in order to create a level playing field. For example, a reduction in fugitive methane emissions during production and transport may be a more cost-effective means to produce hydrogen and reduce carbon. A corollary to this is that fuels related to hydrogen (e.g., ammonia, methanol, renewable natural gas) should be included as options to accelerate the achievement of lowering both total carbon footprint and total cost to achieve the gigaton reduction.

6. **DOE should focus on end-to-end innovation at scale.** DOE can accelerate innovation by focusing on building an end-to-end clean innovation ecosystem that incorporates everything from basic R&D to commercialization and avoids the "valleys of death."[10] This point is accentuated in a recent NAS collaborative study that suggests that DOE "should innovate the process of innovation." The NAS study reiterates the focus on the full end-to-end ecosystem and further suggests it be demand-lead like much DOD innovation.[11] The demand-driven full ecosystem could better focus the vast amounts of talent for innovation in universities and research organizations, some of which is currently siloed by institution. For example, Houston's innovation in the energy sector to date has benefitted from access to thousands of energy-focused researchers (including 300 in hydrogen) in the Texas universities as well as corporate R&D. DOE should build on the momentum of its new Office of Clean Energy Demonstrations[12] and seek to build collaborative teams focused on solving big challenges across institutional lines.

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[10] https://energyfuturesinitiative.org/news/2019/2/6/clean-energy-innovation-report
[11] https://www.nationalacademies.org/our-work/enhancing-federal-clean-energy-innovation-a-workshop
[12] https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/new-doe-office-could-help-bridge-valley-of-death-for-clean-energy-technologies-67566604

7. **DOE should seek to find creative ways to meet Equity, Environmental and Energy Justice (EEEJ) goals that support its primary objectives of cost and emissions reductions.** For example, Hydrogen Hubs that target industrial end uses often can also improve air quality in Disadvantaged Communities where industry is located. Similarly, targeted education and workforce training can reduce unemployment while providing the workforce needed for growing the H2 Hub. Finally, EEEJ benefits can often be accelerated by synergistically leveraging existing EEEJ processes in the target hub areas. These activities will also help businesses meet emerging ESG criteria, which provides synergies in attracting funding in today's ESG-sensitive capital markets.

We now answer selected DOE RFI questions using the Key Principles stated as a guide.

Category 1: Regional Clean Hydrogen Hub Provisions and Requirements Section

(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.

(a) What should qualify as 'close proximity' in context of the hub requirements?

DOE should let economic viability not geographical 'close proximity' define hubs. Key Principle #2 directly addresses this question.

2. **DOE should allow flexibility in letting the hubs define their boundaries and size**. The Department should provide flexibility to allow each hub to define itself based on its own strengths and existing infrastructure and potential infrastructure. This will allow hubs to best shape their growth and sustainability for H2 production/use and emissions reductions – DOE's ultimate goals. Clearly in the early stages of market hub development, close proximity to resources has advantages. But as documented in a University of Texas study,[13] market hub maturation brings several types of transportation infrastructure[14] to provide a means to achieve close proximity. For example, as the world's leading energy hub, Houston has accomplished this both through physical proximity as well as pipelines to supply (e.g., Permian basin) and demand (e.g., the whole Gulf Coast basin and even West Coast and East Coast markets), electric transmission lines for accessing renewable electricity and a world-class port for shipping energy internationally. Indeed, this is relevant for hydrogen as well – Houston has the US largest hydrogen pipeline as well as trucking to access the greatest concentration of hydrogen demand and supply in the US today.

1(b) What existing facilities could be most easily leveraged?

As discussed in the introduction, Houston is the nation's largest hydrogen hub: 48 H2 production plants producing 1/3 of the US H2 production and over 900 miles of H2 pipelines (over half the US H2 pipelines and a third of the global H2 pipelines.) It also has transmission lines that access the US's leading wind generation area – and which soon may be expanded off-shore[15]. All of these existing facilities, pipelines, and storage (including caverns) for hydrogen, CO2, ammonia and

[13] See n. 8

[14] Some envision electricity and hydrogen being transported over the same pipeline using superconductor-type technology. https://ieeexplore.ieee.org/iel5/9451/30010/01373284.pdf

[15] https://www.texasmonthly.com/news-politics/offshore-wind-power-brownsville-shipyard-renewable-energy/

natural gas, electric transmission lines and generation Hydrogen SMR's conversion for carbon capture, make Houston a region where existing facilities could be most easily leveraged.

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

We believe "connective infrastructure" should be the full hydrogen ecosystem as our Key Principle #1 states.

DOE should use the hydrogen hub program to accelerate the creation of broad-based hydrogen ecosystems. An analysis of the creation of strategic energy ecosystems has shown that the recipe for success in ecosystem development in the natural gas, electricity, and chemicals industries involves leveraging the interdependencies between the 3 Fs (feedstock, facilities and financial).[16] Thus, creating a successful energy ecosystem requires developing a network of assets that connects processes, creates new products, and creates supply flexibility and unifies a disjointed asset base. DOE should provide/expand mechanisms to support and collaborate with governmental authorities. Hub proposals that can demonstrate that they have such strong partnerships should be prioritized.

In addition to these basic ecosystem building blocks, creating successful hydrogen ecosystems will require an additional layer of transparent emissions measurement and verification (M&V).[17] Creating a digital layer that will allow for open, interoperable and transparent carbon measurement and verification will not only ensure confidence that the public investment in creating clean hydrogen meets the statutory carbon intensity standard contained in the Bipartisan Infrastructure Law, but will also create the opportunity for the development of financial markets that provide for the development of liquid tradeable commodities.

In its approach to the creation of hydrogen hubs, the Department should thus focus on creating a "layered model" of innovation (see Key Principle 6), physical assets, digital infrastructure and financial markets that will lead to the development of liquid and transparent markets and sustainable hydrogen ecosystems.

This implies that the Department's approach must go beyond simply focusing on physical asset demonstration projects but should also seek creative ways to incorporate the IT infrastructure and financial/market transaction infrastructure as well. Focusing on ecosystem development, rather than demonstration project development, is consistent with the UK's[18] and EU's[19] Hydrogen Strategies.[20] Each of these strategies includes not only initiatives for cleaner hydrogen production, but also transport networks and storage, end use – and especially markets. Indeed, the UK[21] and

[16] England and Mittal, A Strategic Oil and Gas Ecosystem, Deloitte Oil and Gas Ecosystem paper

[17] GTI's Open Hydrogen Initiative https://www.gti.energy/ohi/#home-ohi is an example of an open source measurement and verification approach.

[18] https://www.gov.uk/government/publications/uk-hydrogen-strategy

[19] https://energy.ec.europa.eu/topics/energy-system-integration/hydrogen_en

[20] Although we generally support the direction of the UK and EU hydrogen strategies, we are not automatically embracing every detail. For example, at this time we are not embracing widespread dedicated hydrogen residential heating networks.

[21] https://www.gov.uk/government/consultations/design-of-a-business-model-for-low-carbon-hydrogen

the EU[22] are developing a business model for hydrogen that uses the market structure as a way to pull forward demand, supply and infrastructure.

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(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.)?

This should include strong labor standards, as well as robust workforce development commitments in the form of Department of Labor-registered apprenticeship programs, as well as DOL-certified craft training programs. Hydrogen hubs should begin with deep engagement and consultation with local labor organizations to provide feedback on job quality.

The role of supportive activities is also captured by our Key Principle #7.

7. DOE should seek to find creative ways to meet Equity, Environmental and Energy Justice (EEEJ) goals that support its primary objectives of cost and emissions reductions. For example, hydrogen hubs that target industrial end uses often can also improve air quality in Disadvantaged Communities where industry is located. Similarly, targeted education and workforce training can reduce unemployment while providing the workforce needed for growing the H2 Hub. Finally, EEEJ benefits can often be accelerated by synergistically leveraging existing EEEJ processes in the target hub areas. These activities will also help businesses meet emerging ESG criteria, which provides synergies in attracting funding in today's ESG-sensitive capital markets.

Having said that, all six of our other Key Principles are important "supporting activities" in making H2 Hubs "successful and sustainable."

(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 CO2e/kg H2 at the point of production]; (2) demonstrate the production, processing, delivery, storage, and

[22] Op cit.

[23] https://www.canarymedia.com/articles/hydrogen/which-states-will-win-out-on-9-5b-in-federal-clean-hydrogen-funding?utm_campaign=canary&utm_medium=email&_hsmi=204939925&_hsenc=p2ANqtz-9ztuYnRyuSU_z6u1C_cF_WmgOjzCgV5JRTebiPJdspQ4a6s9fd1IRQF6mMTJruCf-DdS1ZXp-NeNIKqhTLs3vxmNuukQ&utm_source=newsletter

end-use of clean hydrogen; and (3) can be developed into a national clean hydrogen network to facilitate a clean hydrogen economy.

(a) 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?

This question goes directly to the heart of our Key Principle #5:

DOE should focus on carbon-intensity and extend this idea across the full value chain. If DOE's ultimate goal is "going for the gigatons" then this means decarbonizing existing sources of hydrogen as well as supporting newer green technologies, Existing technologies can provide scale as newer technologies come down the cost curve and build the infrastructure required for scale. At the same time, there needs to be a common scorecard of carbon intensity and an accounting for the entire life cycle (value chain) emissions of hydrogen from production to end use in order to create a level playing field. For example, a reduction in fugitive methane emissions during production and transport may be a more cost-effective means to produce hydrogen and reduce carbon. A corollary to this is that fuels related to hydrogen (e.g., ammonia, methanol, renewable natural gas) should be included as options to accelerate the achievement of lowering both total carbon footprint and total cost to achieve the gigaton reduction.

Part of Key Principle #1 is also relevant here:

… Therefore, ecosystems [hubs] ought to encompass not only physical assets, but a digital layer that will allow for open, interoperable and transparent carbon measurement and verification (such as GTI's Open Hydrogen Initiative https://www.gti.energy/ohi/#home-ohi) and a financial transaction/ market layer that allows for development of liquid tradeable commodities.

The Department should consider reducing the CO2 from existing SMR hydrogen plants as a way to make early strides in achieving scale in clean hydrogen production volumes. As the Intergovernmental Panel on Climate Change has observed, the faster carbon reductions are achieved, the greater the beneficial impact on climate change. In essence, a Gigaton of carbon reduced in 2025 has a bigger climate benefit than a Gigaton of carbon reduced in 2030.

Targeting brownfield changes in existing infrastructure would be the best way to achieve significant early gigaton reductions and the methods discussed in this section help to provide the incentives and insure the credibility of any brownfield actions.[24]

First, experts participating in the Center's working group suggest that in order to accelerate uptake of new clean hydrogen investment and make a near term impact, existing producers could be incentivized to reduce the carbon intensity of their existing SMR's even if only modestly at first (e.g., 60%) with a roadmap to increase this value over time (i.e., in excess of 95%). While some have suggested a target of 90% reduction in carbon emissions intensity of those SMR plants, our

[24] https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf

working group participants are concerned that industry will be hesitant to make the capital investments necessary for a 90% carbon reduction in old SMR plants.

Models for "ratcheting down" carbon intensity can be drawn from experience with California's Low Carbon Fuel Standard (LCFS) that seeks to achieve improving carbon intensity over time. Our observers note that the LCFS model could be modified to suit clean hydrogen production. Furthermore, this LCFS model also allows for entities to meet their full pathway carbon reduction targets through upstream measures where possible.

Consistent with these principles, we believe the Department should urge the EPA to adopt a mechanism that allows participants flexibility to achieve a carbon-intensity target. The EPA RIN program provides some flexibility as one example that allows component flexibility.

Under this approach, reducing methane leakage upstream may be a more cost-effective way to meet the emission reduction target for the full pathway. Some working group participants believe reducing methane leakage is a good and necessary opportunity to reduce carbon intensity of the natural gas-based hydrogen production value chain, but leakage verification through monitoring is critical.

In an environment where these measurements are not available, a reasonable market-based assumption on methane leakage could be adopted. (Argonne National Labs uses available field data to populate its DOE-supported GREET model.) Methods to account for traceability of carbon intensity of methane for each source could be adopted, but accurate accounting will not be trivial to measure and enforce in the near term. Our observers suggest a phasing in of such accounting to allow time for appropriate methods and tools to be established. The GREET model may be a good starting point. Over time we expect registries such as the GTI Open Hydrogen Initiative to capture more precise and site-specific emissions data. These efforts also will make it easier for businesses to substantiate the "E" of their ESG scores in obtaining financing and ESG-sensitive buyers.

While accommodating the existing SMR value chain, this carbon accounting approach is not biased in favor of SMR. The approach also allows cleaner methods of producing hydrogen to be part of the value chain as they reach price points that industry and consumers are willing pay.

(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?

We suggest DOE adopt an approach taken by the UK during the initial phase of the hub development process and not have a firm number in Phase 1 on the number of number of hubs initially funded. Similarly, Germany is casting a "wide net" in its regional competitions and awarding grants to 45 regions (15 original plus 30 new regions)."[25] Rather than creating a "contest"

[25] https://fuelcellsworks.com/news/new-boost-for-local-german-hydrogen-economy-hyland-launches-second-round-with-30-new-regions/

between various regions of the country for a limited number of hubs, this "wide net" approach has the advantage of allowing strengths and opportunities throughout the country to be identified and developed. It is also likely that during the opportunity identification process, various hubs might combine to create larger hubs in Phase 2 and going forward. We believe that this method would be the best way accomplish DOE's objective of building a robust national hydrogen network.

This approach could be achieved relatively cost effectively. Funding more proposals at the $1-4 million level in Phase 1, under almost any circumstance, would be less than 1% of DOE's $8 billion total budget, and should lead to a better outcome.

(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?

Below we define two major initiatives that DOE could take to enable H2Hubs. First, adopt Key Principle #6.

> **DOE can accelerate innovation by focusing on building an end-to-end clean innovation ecosystem that incorporates everything from basic R&D to commercialization and avoids the "valleys of death."**[26] This point is accentuated in a recent NAS collaborative study that suggests that DOE "should innovate the process of innovation." The NAS study reiterates the focus on the full end-to-end ecosystem and further suggests it be demand-lead like much DOD innovation.[27] The demand-driven full ecosystem could better focus the vast amounts of talent for innovation in universities and research organizations, some of which is currently siloed by institution. For example, Houston's innovation in the energy sector to date has benefitted from access to thousands of energy-focused researchers (including 300 in hydrogen) in the Texas universities as well as corporate R&D. DOE should build on the momentum of its new Office of Clean Energy Demonstrations[28] and seek to build collaborative teams focused on solving big challenges across institutional lines.

Second, DOE should support other Federal government activities that enhance the growth in H2 demand – such as Clean H2 procurement targets for federal agencies and assisting sister agencies in refining policies to encourage H2 growth, such as helping the EPA refine regulations to increase the role of H2 in meeting Renewable Fuel Standards. We suggest that DOE could work with the EPA in two ways:

- Defining one or more pathways for hydrogen as a compliance option for the Renewable Fuel Standard (RFS).
- Encouraging flexibility in how alternate pathways for hydrogen could be considered and valued based on their relative Carbon Intensity, similar to the CA LCFS.

Achieving this can potentially provide three benefits:

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[26] https://energyfuturesinitiative.org/news/2019/2/6/clean-energy-innovation-report Also see https://energycommerce.house.gov/sites/democrats.energycommerce.house.gov/files/documents/Witness%20Testimony_Moniz_06.16.20%20%5BUPDATED%20v2%5D.pdf

[27] https://www.nationalacademies.org/our-work/enhancing-federal-clean-energy-innovation-a-workshop

[28] https://www.spglobal.com/marketintelligence/en/news-insights/latest-news-headlines/new-doe-office-could-help-bridge-valley-of-death-for-clean-energy-technologies-67566604

- increase the demand for hydrogen (if refineries and other industry can use low carbon H2 to meet RFS requirements, that provides additional incentive to use low carbon H2).
- provide the basis for a national clean hydrogen market network (since RFS is a national program).
- potentially lower the cost of RFS compliance – see study referenced below.

In our answer to 2(a) we noted the benefit of a focus on carbon intensity to allow market participants the opportunity to find lower cost opportunities throughout the hydrogen value chain (production to end use) to reduce carbon intensity of hydrogen. Some of our industry observers highlighted the CA LCFS market as including hydrogen as a compliance option and also as providing flexibility.

As of this writing EPA has several pending proposed alternate renewable fuel pathways for hydrogen.[29] DOE should seek to resolve issues with these proposals. Beyond that, there may be additional ways to build in flexibility for alternate renewable fuel pathways. We note the EPA has RFS pathways and fuels of varying GHG reducing potential –ranging from 20-60%. One study found that the co-existence of the CA LCFS and RFS programs allowed lower compliance costs than just the RFS program alone.[30] Some are advocating a National LCFS that could accelerate the demand for low-carbon hydrogen.[31]

(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.

Given the administration's volume-based goal of net-zero emission, the H2Hubs progress should primarily be measured by these major success metrics:

- Volume of H2 produced
- Volume of H2 consumed
- Volume of CO2 equivalent emissions reduced
- How close to $2/kg of H2 is the Value Chain costs

Secondary metrics should be measured:

- # of jobs provided
- Progress in training the workforce for the H2 economy
- EEEJ
    - Air quality impact
    - Jobs impact
    - Energy and Environmental Cost Impacts

These metrics are also consistent with those of the UK Hydrogen Strategy.[32] As noted in the response to Question 2(a), our industry observers suggest that in order to accelerate uptake of new clean hydrogen investment and make a near term impact, existing producers could be

[29] https://www.epa.gov/renewable-fuel-standard-program/pending-petitions-renewable-fuel-pathways.
[30] "Interactions between California's Low Carbon Fuel Standard and the National Renewable Fuel Standard," J. Whistance, Energy Policy, February 2010, pp. 447-455. https://www.sciencedirect.com/science/article/abs/pii/S0301421516305936
[31] https://us.eversheds-sutherland.com/portalresource/lookup/poid/Z1tOl9NPluKPtDNIqLMRV56Pab6TfzcRXncKbDtRr9tObDdEr8ZCma3!/fileUpload.name=/What%20Hydrogen%20Cos.%20Should%20Know%20About%20Fuel%20Incentives.pdf.
[32] https://www.gov.uk/government/publications/uk-hydrogen-strategy .

incentivized to reduce the carbon intensity of their existing SMR's even if only modestly at first (e.g., 60%) with a roadmap to increase this value over time (i.e., in excess of 95%). A reasonable reference point for means to "ratchet down" carbon intensity could come from California's Low Carbon Fuel Standard that means to achieve improving carbon intensity over time. The LCFS model could be modified to suit clean hydrogen production.

(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

(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?

We believe a minimum for a clean H2Hub is not necessary if DOE focuses on the current and projected impacts per the success metrics as defined in our response to Questions 2(e) and 9. Of course, the credibility of the projected impacts will be considered.

And as noted in our response to 2(e) and (9), particularly relevant are our Key Principles #3 (DOE should go for scale) and Key Principle #7 (DOE should seek to find creative ways to meet Equity, Environmental and Energy Justice (EEEJ) goals that support its primary objectives of cost and emissions reductions.). Some of our industry observers also asked us to reinforce here the relevance of Key Principle #5 (DOE should focus on carbon-intensity and extend this idea across the full value chain.) As elaborated in our response to Q2(a), our observers see Key Principle #5 (DOE should focus on carbon-intensity and extend this idea across the full value chain) as key in supporting Key Principle #3 to "incentivize larger capacity hubs."

(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?

DOE should prioritize repurposing the infrastructure of historic fossil fuels, to accomplish cost-effective hydrogen production and carbon reduction at reasonable cost and scale. For example, many identify blending hydrogen into natural gas pipelines as an early win. In addition, DOE should incentivize a transition, but the transition should focus on the success metrics and change in carbon intensity of the whole value chain. See our answers to Q2(a) and Q2(e). We believe this approach will best harness innovation and commercialization to achieving the success metrics -- and that no additional "carbon intensity conditions" are necessary for the transition.

(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.

(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?

Focusing on a diversity of end uses will be important since the economics of using lower carbon hydrogen will be better for some end uses than others. Lowering the carbon intensity of the value chain of today's biggest end uses such as oil refining, petrochemicals and heavy industry could jump start the demand for hydrogen. Providing incentives to jump-start demand could also be an effective tool, as discussed in our Key Principle #4:

4. **DOE should prioritize Demand while building Supply drivers:** Rather than a technology push model that focuses mostly on learning curve effects of reducing the cost of supply, DOE should also focus on demand creation at scale. We note that the growth in other clean energy (e.g., solar, wind) in the last decade has been demand driven -- corporate/ government PPA's and state RPS mandates provided significant demand volume so that suppliers could achieve economies of scale. Prioritizing the development of the large drivers of demand will create a self-reinforcing cycle of entrepreneurial interest and innovation and that lead the next round of market-based innovation that leverages the federal hub investment. By putting as much or more effort into creating new demand and applications for hydrogen (including local, state and especially federal government procurement of H2 for appropriate end uses), DOE can then use market forces to create the technology innovations that will further reduce costs. This is consistent with the UK's "total systems" approach.

(c) The climate value of displacement may vary across end uses. How should the climate benefit of different hydrogen end uses be considered?

First, consistent with our responses to Q2(d), Q2e) and Q4(a), in the near term, some end uses (refining and industrial) or natural gas fugitive emissions will likely yield greater carbon impacts to benefit all. Second, some end uses will have local air quality benefits, especially with those located in Disadvantaged Communities. These include refining, industrial and transfer warehouses for heavy duty trucks that would otherwise use diesel. These observations are consistent with our Key Principle #7 (DOE should encourage H2 Hubs whose growth leads to synergies in EEEJ job creation.)

(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.

(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

DOE should allow the maximum amount of flexibility as described in Principle #2.

(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."

(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?

See our answer to Q1(a).

(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.

(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?

Oil and gas is often boom and bust, and as an industry, workers have become used to following the work. Hydrogen offers some of the best opportunities for oil and gas workers to transfer skills, but they will need some training on the specifics of hydrogen production and transportation. Most major oil companies have employee training programs. These programs will be refined to include hydrogen-specific skills such as production and transportation. Certificates recognized by industry that can be added to resumes to show completed training would be one method. We often learn by doing, so we need more projects to get the ball rolling.

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)?

Our observers note some DOE demonstration-scale initiatives[33] haven't succeeded because of the mismatch in government and industry budget cycles. The potential is even greater here, with bigger funding levels and more partners. Some "handholding" may be needed for companies not used to terms and conditions associated with accepting government funds.

(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)

[33] Carbon Capture and Storage: Actions Needed to Improve DOE Management of Demonstration Projects | U.S. GAO; Advanced Reactor Research: DOE Supports Multiple Technologies, but Actions Needed to Ensure a Prototype Is Built | U.S. GAO.

that DOE should use to evaluate and select the H2Hubs as well as evaluate readiness to move from Phase 1 to Phase 2?

We believe the key review criteria should be tied to the key success metrics, as discussed on our answer to Q2(e) and as supported by our answer to Q2(a). The key review criteria included in the question are generally consistent with this. One item we would add is “What is the Hub’s track record to date with H2Hub related activities – or very similar Hub activities?”

(13) Are the proposed funding levels for Phase 1 and Phase 2 appropriate/adequate?

More dollars should be allocated for Phase 1 – potentially 2-4x more. This is especially true for larger Hubs with more existing resources and businesses active in the Hub. We suggest DOE show some flexibility on this relative to the scale of benefits demonstrated to be achieved by the Hub. Also see our answer to 2(c).

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

(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?

We believe this is addressed by our Key Principle #7, as provided in the answer to 1(d).

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?

As discussed in Principle #4, we believe that DOE should focus on creating demand-side incentives and should look to the UK’s work on hydrogen business models.

(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.

In addition to the 7 Key principles discussed at the beginning of this document, several of our industry observers made some comments that we think provide helpful context.

- Clear early alignment on objectives for each hub is critical including hydrogen production capacity.
- It is a risk to focus too closely on hydrogen production itself. Equal effort must be applied to developing hydrogen distribution, transport and end-use to ensure off-takes are sufficiently clear to ensure progress.
- Beyond the initial phase, it is important to consider the roadmap to take projects to completion and additional prospects to seed a wider hydrogen industry for export. By addressing this up front, DOE can ensure a robust execution model is in place, projects are executable and the funding is leveraged to the maximum extent possible.