December 9, 2022

Sent via email to: CThydrogentaskforce@strategen.com

Connecticut Green Bank
75 Charter Oak Ave., Suite 1-103
Hartford, CT 06106

Re: Environmental Advocates' Joint Response to Request for Public Comments to the Connecticut Hydrogen Task Force

Dear Connecticut Green Bank:

Thank you for the opportunity to submit written comments to inform the final legislative report of the Connecticut Hydrogen Task Force.[1] Conservation Law Foundation, Sierra Club, the Nature Conservancy in Connecticut, Acadia Center, Save the Sound, Eastern CT Green Action, and People's Action for Clean Energy are public interest organizations that are working to align Connecticut's energy policies with the state's statutory climate commitments and decarbonize the electric sector, transportation sector, and buildings sector, which are the three major sources of Connecticut's greenhouse gas emissions. We appreciate the opportunity to provide these joint comments and look forward to participating further in Connecticut's efforts to establish policies that facilitate the responsible and strategic deployment of clean hydrogen.

While we appreciate the opportunity to provide comments in response to the efforts of this task force, we would also like to draw attention to the overarching issue of cost, which is not directly addressed in any of the question prompts.

Production costs: Creating hydrogen from natural gas or water requires large amounts of energy. Connecticut has higher electric rates than any other state in the continental U.S. These higher electricity costs would increase the costs of hydrogen production in Connecticut. Using the most energy efficient technology available to convert natural gas to make 1 kg of hydrogen requires approximately 5 kWh of electricity.[2] Hydrogen produced through this method will cost approximately three times the cost of natural gas per unit of energy produced. Using electrolysis of water to make hydrogen requires even more energy (1 kg of hydrogen requires 50-55 kWh[3]) and is thus more expensive. However, hydrogen produced from electrolysis offers significant climate and health benefits and total cost will depend on the buildout of renewable energy to power electrolysis.[4]

[1] Connecticut Green Bank, *Special Act No. 22-8, Public Request for Written Comments* (Nov. 8, 2022), https://www.ctgreenbank.com/wp-content/uploads/2022/11/Public-Request-for-Written-Comments-CGB-V2.pdf.
[2] 2020 US DoE, Office of Fossil Energy, HYDROGEN STRATEGY: Enabling A Low-Carbon Economy, https://www.energy.gov/sites/prod/files/2020/07/f76/USDOE_FE_Hydrogen_Strategy_July2020.pdf.
[3] 2020 DoE Cost of Electrolytic Hydrogen Production with Existing Technology, https://www.hydrogen.energy.gov/pdfs/20004-cost-electrolytic-hydrogen-production.pdf.
[4] Bloomberg NEF, 2021, 'Green' Hydrogen to Outcompete 'Blue' Everywhere by 2030, https://about.bnef.com/blog/green-hydrogen-to-outcompete-blue-everywhere-by-2030/.

Transport costs: Transportation, storage, and delivery of hydrogen can represent significant costs and energy inefficiencies due to hydrogen's relatively low volumetric energy density. Storing and transporting hydrogen under atmospheric conditions is highly inefficient, so hydrogen is almost always liquefied or put under very high pressure. Liquefaction is costly and liquified hydrogen is best transported by tankers. Utilization of current natural gas infrastructure for hydrogen transport would not be sufficient; large capital investments in new infrastructure for hydrogen transport through pipelines would be necessary.

Retrofitting the current 590 miles of natural gas transmission pipelines in Connecticut for hydrogen would cost ~$367 million ($0.621 million/mile).[5] Building new transmission pipelines for hydrogen would cost ~$1.28 billion ($2.17 million/mile), which is a low estimate given current right-of-way costs. If Connecticut were to inject hydrogen into existing natural gas pipelines as a blend, the maximum percentage of hydrogen is between 15-20%. A 15-20% blend would still require extensive pipeline upgrades and various new safety procedures for venting and flaring.[6] Such blending would only continue to prop up the natural gas industry in the state, leaving ratepayers on the hook for indefinite upgrades to aging and expensive infrastructure.

Storage costs: Hydrogen storage systems will also need large capital investments. Finding locations that are safe, cost effective, and efficiently help meet energy load will require extensive planning and stakeholder input. Storage system capital costs range from $15-20/kg of liquid hydrogen depending on the scale and size of tanks.[7] Storing or using hydrogen at atmospheric pressure and temperature requires a substantial amount of space and energy, which will contribute to ongoing costs.

Additionally, the cost of storing carbon from "blue" hydrogen and carbon capture and storage (CCS) projects is expensive despite current federal tax policy (45Q tax credit[8]). CCS is not economically competitive today in most applications. There are only twelve CCS facilities currently operating in the United States, and only one is part of a hydrogen production plant.[9] Storage of captured carbon in Connecticut is unlikely because the state lacks geologic carbon storage capabilities (e.g., coal seams, natural gas wells, salt/saline deposits). Any CCS projects in Connecticut would most likely involve shipping the captured carbon out of state.

Defining Clean Hydrogen

1. **Based on Federal guidance in the Infrastructure Investment and Jobs Act and the Inflation Reduction Act, clean hydrogen is defined as hydrogen that is produced through a process that results in a lifecycle greenhouse gas emissions rate of not greater than 4 kilograms of CO2e per kilogram of hydrogen and with less than 2**

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[5] Pipeline retrofit and new build 2021 estimates for hydrogen, https://www.statista.com/statistics/1220856/capex-new-retrofitted-h2-pipelines-by-type/#:~:text=For%20one%20kilometer%20of%20distribution,million%20U.S.%20dollars%20per%20kilometer.

[6] Melaina, M W, Antonia, O, and Penev, M. Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues. United States: N. p., 2013. Web. doi:10.2172/1068610.

[7] 2020 DOE Hydrogen and Fuel Cells Program Review Hydrogen Storage Cost Analysis (ST100), https://www.hydrogen.energy.gov/pdfs/review20/st100_houchins_2020_o.pdf.

[8] Section 45Q Credit for Carbon Oxide Sequestration.

[9] Clean Air Task Force 2021 estimate, https://www.catf.us/carbon-capture/program/.

kilograms of CO2e per kilogram of hydrogen at the point of production. Do you believe that Connecticut should pursue a more stringent definition for clean hydrogen than the one that has been established by the Federal government? If so, why? If not, why not?

Connecticut should pursue a more stringent definition for clean hydrogen than the one established by the federal government. An appropriate state definition of clean hydrogen should include only green hydrogen produced with zero-carbon renewable energy. Those zero-carbon resources must be additional to prevent any double counting of their clean energy attributes.

Hydrogen that is produced from co-located renewable sources should qualify as clean under the Connecticut definition only if it meets the following criteria: (1) the renewable energy source(s) must either (a) be newly constructed *or* (b) only used to supply energy for hydrogen production when they would otherwise be curtailed; (2) there are no active[10] renewable energy credits (RECs) or environmental attribute credits associated with these renewable resources; and (3) the producer documents that the renewables were used at the time of hydrogen production (on an hourly basis). This is necessary to ensure that the producer does not receive credit for on-site renewable generation when grid electricity is actually being used.

Hydrogen that is produced with electricity from the grid should qualify as clean under the Connecticut definition only if it meets the following criteria: (1) the producer purchased RECs from a newly constructed renewable energy facility; (2) the producer timely retired the RECs so no other entity can claim the renewable attributes; (3) the electric generator associated with the RECs is connected to the same balancing authority as the producer *or* has agreed to dynamically transfer electricity to the producer's balancing authority; and (4) the producer uses the energy to produce hydrogen in the same hour that the renewable source provides electricity to the grid.

The definition of clean hydrogen must exclude fossil fuels (even if paired with carbon capture), biogas, or biomass as a feedstock. Blue hydrogen—hydrogen produced from fossil fuels with carbon capture—must be excluded from the definition of clean hydrogen, as it does not achieve the requisite greenhouse gas emission reductions to support Connecticut's climate commitments. The proposed federal definition, allowing 4 kilograms of CO2e per kilogram of hydrogen and less than 2 kilograms of CO2e per kilogram of hydrogen at the point of production, would likely include blue hydrogen. Relying on blue hydrogen rather than green hydrogen would eviscerate the intended climate benefits of hydrogen and would increase total greenhouse gas emissions relative to burning fossil fuels for heating.

Professors Bob Howarth and Mark Jacobson recently studied the emissions implications of blue hydrogen and found that the greenhouse gas footprint of blue hydrogen is 20 percent *greater* than burning natural gas or coal for heat and 60 percent *greater* than burning diesel oil for heat.[11] The authors assumed captured carbon dioxide could be stored indefinitely without any leakage, an extremely charitable assumption given the completely unproven validity of long-term carbon dioxide storage. The results showed an increase in emissions over burning fossil fuels because while blue hydrogen reduces direct carbon dioxide emissions (albeit incompletely), it

[10] Timely retired credits would not pose a problem because they would not result in double counting.
[11] Howarth & Jacobson, How green is blue hydrogen? Energy Sci. & Eng'r (July 2021).

increases fugitive emissions of methane, a far more potent greenhouse gas. In fact, due to this methane leakage, total carbon dioxide equivalent emissions from blue hydrogen were only 9-12 percent lower than gray hydrogen.[12] The authors further tested the robustness of their conclusions against different assumed leakage rates and found that the conclusion held even assuming a low methane leakage rate of 1.54 percent.[13] The authors also tested the rigor of their conclusions assuming blue hydrogen is produced using a combination of natural gas and 100 percent zero emissions renewable energy—while retaining assumptions that captured carbon dioxide can be stored indefinitely without leakage—and found that total greenhouse gas emissions were still nearly half those from combusting natural gas as a fuel.[14]

The emissions associated with blue hydrogen are in addition to other challenges, including achieving high rates of carbon capture in practice[15] and the cost per ton of capturing the carbon.[16] A clean hydrogen definition should not include hydrogen produced with fossil fuels utilizing carbon capture and storage because large amounts of energy are required to operate the CCS project and to transport and store the captured carbon,[17] which creates additional potential sources of emissions. Captured carbon is often used in fertilizer production and oil/gas recovery, both of which increase downstream greenhouse gas emissions, further undermining the intent of capturing carbon in the first place.

With a clean hydrogen definition that includes only non-fossil fuel, 100% zero-carbon feedstock, Connecticut can use new, dedicated local renewable resources to produce green hydrogen for the sectors of the economy that are most challenging to electrify. This will help meet our climate goals, support local jobs, and insulate consumers from fossil fuel price shock volatility.

There has been substantial discussion about alignment with the federal guidance at Hydrogen Task Force working group meetings. Some participants expressed concerns that a more stringent state definition would make it more difficult for hydrogen projects in Connecticut to obtain federal funding. However, Strategen indicated that the federal guidance just establishes minimum requirements: it is a floor, not a ceiling. Having more stringent state requirements thus would not preclude Connecticut projects from obtaining federal funding, unless that funding is specifically for production methods that do not qualify as clean hydrogen in Connecticut.

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[12] *Id.*
[13] *Id.*
[14] *Id.*
[15] Carbon capture projects associated with hydrogen production to date have achieved onsite carbon dioxide capture rates below 70 percent, far below the blue hydrogen industry goal of 95 percent. David Schlissel et al., *Blue Hydrogen: Technology Challenges, Weak Commercial Prospects, and Not Green*, IEEFA (Feb. 2022), at Slides 18-20, available at Blue-Hydrogen-Presentation_February-2022.pdf (ieefa.org).
[16] These costs have been in excess of $63/ton for capture rates below 85 percent, and substantially higher for higher capture efficiency. *Id.* at Slide 26. These are more than double the costs that would be required to make carbon capture financially viable.
[17] Schmelz William J., Hochman Gal and Miller Kenneth G. 2020, Total cost of carbon capture and storage implemented at a regional scale: northeastern and midwestern United States Interface, Focus.102019006520190065http://doi.org/10.1098/rsfs.2019.0065; 2019 DOE Integrated Carbon Capture and Storage in the Louisiana Chemical Corridor, https://www.lsu.edu/ces/publications/2019/doe_carbonsafe_02-18-19.pdf.

Stakeholder Engagement and Equity

2. **When and how should the state of Connecticut engage with environmental justice and disadvantaged communities throughout the clean hydrogen planning and development process? What steps can the state take to support EJ and disadvantaged communities' engagement in these processes?**

Connecticut should develop an outreach plan to educate the public about the state's clean hydrogen planning and development process. As a starting point, state officials should reach out to regional councils of government, municipal officials, Energy Task Force members and the CT Energy Network, environmental and environmental justice (EJ) groups, business and/or industry associations and groups, and community groups. Existing social networks and email distribution lists should be utilized to reach stakeholders that likely have an interest in hydrogen or energy issues more generally, but the state should also identify other potential stakeholder groups that may not currently be engaged and determine how to reach these people as well. This will be particularly important for reaching historically marginalized populations.

Targeted outreach to EJ and disadvantaged communities is warranted because these populations have historically borne the brunt of negative impacts from energy and industrial infrastructure. In addition, these communities often have fewer social, educational, legal, and financial resources to engage in planning processes. As a first step, the Connecticut Equity and Environmental Justice Advisory Council (CEEJAC) should be consulted and should participate in creating equity and EJ-focused components of the state's hydrogen outreach plan.

Best practices in public outreach should be utilized, such as meeting communities where they are (e.g. by attending local meetings at places of worship, schools, community centers, etc.), holding meetings on the weekend or evening when more working people can attend, providing outreach materials in accessible language (both in English and in other languages spoken in the community), providing options for in-person and remote meetings, recording and transcribing meetings for later viewing online, and providing free food, childcare, and compensation for people who participate in community meetings.

For any hydrogen siting decisions that may impact EJ or disadvantaged communities, early and meaningful stakeholder engagement will be critical, as will consideration of cumulative impacts. State and local siting authorities and project proponents should make it a priority to identify and engage with potentially affected communities early in the siting process, while there is still an opportunity for local residents to influence the siting location and suggest measures, such as community benefits agreements, to mitigate any negative impacts associated with the hydrogen project. Because many of these communities disproportionately experience negative impacts from existing energy and industrial infrastructure, siting authorities must consider the cumulative impacts of adding hydrogen infrastructure to these existing burdens.

3. **What steps should the state of Connecticut take to ensure that the clean hydrogen economy provides equitable benefits for environmental justice and disadvantaged communities?**

Workforce development opportunities should be established that will help facilitate an equitable transition to a clean energy economy and create high-quality, well-paying jobs for state residents. For example, training and apprenticeship programs could be established at community colleges and technical high schools or training institutes. It may be most efficient for hydrogen workforce development initiatives to be integrated into broader clean energy training programs, rather than setting them up as standalone programs. This approach would limit the risk of new trainees having trouble finding employment in a particular field or sector, for example if the deployment of a particular technology or approach does not occur as quickly as expected.

Clean energy workforce development programs, including programs specifically focused on clean hydrogen, should include goals, quantifiable metrics, and regular progress reports so the state can monitor progress and make adjustments as needed. In addition, the state should seek public input on these programs and invite stakeholders to participate in their development.

Connecticut should focus on creating targeted clean hydrogen workforce development opportunities for populations that face systemic discrimination and/or are underrepresented in the workforce, including women, minorities, people with English as a second language or limited English proficiency, and formerly incarcerated individuals. Hydrogen-related career pathways should also be made available to people who currently work in the fossil fuel industry. These people have strong incentives to oppose a transition away from fossil fuels, so programs that realign their incentives with Connecticut's climate and energy policies would be helpful.

In the siting context, any hydrogen infrastructure in Connecticut should not increase the cumulative burdens of EJ communities. While there may be circumstances in which siting such infrastructure in an EJ community would be acceptable to that community, any negative impacts from the infrastructure should be properly accounted for and mitigated (e.g., via measures in a community benefits agreement) so they do not add to the community's cumulative burdens. If siting is considered in an EJ community, early and meaningful outreach to local residents and community groups will be critical to facilitate their participation in the process.

There are over 800 brownfield sites in Connecticut (approximately 4,000 acres total).[18] Many of these brownfields are located in EJ communities and distressed municipalities, where residents are burdened by environmental harms from former and existing uses and infrastructure. Connecticut should avoid siting hydrogen infrastructure on these brownfields. In addition to EJ concerns, there are size constraints on using brownfields for hydrogen projects. Most of the state's brownfields are less than five acres, too small for siting most hydrogen infrastructure.[19] Moreover, siting hydrogen production, transport, or storage infrastructure on brownfields is not recommended due to safety, cost, and remediation criteria.[20] All of these concerns indicate that

[18] CT DEEP, *Connecticut Brownfields Inventory*, https://portal.ct.gov/DEEP/Remediation--Site-Clean-Up/Brownfields/Brownfields-Site-Inventory.
[19] D. D. Papadias and R. K. Ahluwalia, Bulk Storage of Hydrogen, 2021, https://www.osti.gov/pages/servlets/purl/1840539.
[20] R.Tarkowski, 2019, Underground hydrogen storage: Characteristics and prospects. Renewable and Sustainable Energy Reviews, 105: 86-94, https://doi.org/10.1016/j.rser.2019.01.051.

Connecticut should not site hydrogen projects on brownfields. The state should instead prioritize solar development on brownfield sites.[21]

Hydrogen End-Uses

4. **The Hydrogen Task Force has been exploring hydrogen end uses including: critical facilities, aviation, cargo ships, material handling equipment, long-haul heavy duty trucks, fuel cells for peak power generation, high heat industrial processes, buses, ferries, rail, hydrogen blending in pipelines, and light-duty vehicles. How should the state address differing stakeholder perspectives about hydrogen end use prioritization? Which specific end uses are of greatest concern, and why? What actions can or should the state take to continue to solicit stakeholder feedback?**

There is a great deal of interest in the potential for green hydrogen[22] as a long-term decarbonization strategy in selected circumstances, most notably hard-to-decarbonize sectors like high-heat industrial processes. However, hydrogen is not a viable pathway to decarbonization for end uses that can be electrified directly, including buildings and most forms of transportation. It is far more efficient and cost-effective to use electricity directly (e.g., to power electric vehicles and electric heat pumps) rather than using it to produce green hydrogen.[23]

Deployment of clean hydrogen should be limited to hard-to-decarbonize applications that cannot easily or cost-effectively be electrified. Notably, hydrogen does not make economic sense as a decarbonization strategy for light-duty vehicles or buildings, which are the largest sources of greenhouse gas emissions in Connecticut.[24] As RMI recently explained at a technical session on alternative fuels for Connecticut's Comprehensive Energy Strategy, "Direct electrification should be prioritized [over alternative fuels such as hydrogen] whenever possible—it is more efficient, cheaper, and can bring human health and broader environmental benefits."[25]

The buildings sector in particular is an end use for which hydrogen makes little sense. First, there are limits on how much hydrogen can be used in home appliances like furnaces and boilers. Appliances that were designed for methane gas cannot safely accommodate a high level of hydrogen.[26] End-use appliances are not made to combust hydrogen and costly appliance replacement would be required to accommodate substantial hydrogen blends. Hydrogen cannot

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[21] Matthew Popkin, Rocky Mountain Institute, *The Time is Ripe for Communities to Embrace Clean Energy on Brownfields* (Sept. 26, 2022), https://rmi.org/time-for-communities-to-embrace-clean-energy-on-brownfields/.
[22] "Green" hydrogen is produced using only renewable energy sources to power the electrolysis of water. Currently, electrolysis of water accounts for less than 0.1% of hydrogen production. International Energy Agency, *The Future of Hydrogen: Seizing Today's Opportunities*, 42 (2019), https://iea.blob.core.windows.net/assets/9e3a3493-b9a6-4b7d-b499-7ca48e357561/The_Future_of_Hydrogen.pdf.
[23] Cara Bottorff, Sierra Club, *Challenges with Alternative Fuels and Strategies for Optimal Use*, Slide 63 (labeled Page 65) (Nov. 4, 2022), https://portal.ct.gov/-/media/DEEP/energy/ConserLoadMgmt/Master-Slide-Deck_TM-6_Alt-Fuels_PM.pdf (estimating that "Green hydrogen is 20-40% less efficient than using renewables directly").
[24] Connecticut Department of Energy & Environmental Protection, *2018 Connecticut Greenhouse Gas Inventory*, 5 (2021), https://portal.ct.gov/-/media/DEEP/climatechange/GHG_Emissions_Inventory_2018.pdf.
[25] Tessa Weiss, RMI, *Why Prioritize Low Carbon Fuels for Industry and Heavy Transport?*, Slide 127 (Nov. 4, 2022), https://portal.ct.gov/-/media/DEEP/energy/ConserLoadMgmt/Master-Slide-Deck_TM-6_Alt-Fuels_PM.pdf.
[26] *Id.* at 27; Jairo Duran, *Safety Issues to Consider When Blending Hydrogen with Natural Gas* (Feb. 17, 2021), https://processecology.com/articles/safety-issues-to-consider-when-blending-hydrogen-with-natural-gas

be readily substituted for methane in equipment above a blend of 25% hydrogen.[27] Such a low level of hydrogen blending has limited emissions benefits (even assuming green hydrogen is used), because the remaining 75% of fuel would still be methane. Further, because hydrogen has a substantially lower energy density than methane, far greater quantities must be combusted to generate the same energy or heat. Hydrogen has a heat content of only approximately 30 percent that of methane.[28] Consequently, despite the expense and complexity, blending hydrogen into methane gas streams at low concentrations does very little to reduce total greenhouse gas emissions. Replacing equipment so it can accommodate higher levels of hydrogen would be more costly than simply switching to an electric heat pump because so many infrastructure upgrades are needed to safely transport and use high levels of hydrogen to heat buildings.

Second, hydrogen provides diminished emissions benefits in a leak-prone distribution system. Hydrogen is highly leakable due to its small molecular size. The leakage rates for hydrogen are expected to be 1.3-2.8 times greater than those for methane.[29] Hydrogen is also an indirect greenhouse gas with a 100-year global warming potential 5.8 times greater than carbon dioxide.[30] Recent research suggests that on shorter (and more relevant) time scales, the global warming potential for hydrogen is far higher: 19 to 38 for 20-year global warming potential and 34 to 66 for 10-year global warming potential.[31] Any strategy built around hydrogen would need to consider and quantify the potential for adverse climate impacts due to hydrogen leakage during production, transport, and use.

Lastly, there are safety and health concerns associated with the use of hydrogen in homes. Hydrogen is highly combustible, even in low concentrations, raising concerns about the safety of its increased use in homes. A study by the UK government estimated that explosions in homes would increase more than fourfold if hydrogen were to replace gas in homes.[32] Further, hydrogen combustion results in significant air pollution: while reaction of hydrogen in a fuel cell produces only water, combustion of hydrogen results in significant formation of harmful nitrogen oxides. Nitrogen oxides are a pollutant in their own right, and are also the primary contributor to ground level ozone (smog) and a precursor of dangerous fine particulate matter. Indeed, combustion of pure hydrogen may result in far greater emissions of nitrogen oxides than burning methane.[33]

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[27] Jeff St. John, Green Tech Media, *Green Hydrogen in Natural Gas Pipelines: Decarbonization Solution or Pipe Dream?* (Nov. 30, 2020), https://www.greentechmedia.com/articles/read/green-hydrogen-in-natural-gas-pipelines-decarbonization-solution-or-pipe-dream.

[28] Ulf Bossel & Baldur Eliasson, Energy and the Hydrogen Economy, at 5, https://afdc.energy.gov/files/pdfs/hyd_economy_bossel_eliasson.pdf ("at any pressure, the volumetric energy density of methane gas exceeds that of hydrogen gas by a factor of 3.2 (neglecting non-ideal gas effects)").

[29] Fotis Rigas & Paul Amyotte, Myths and Facts about Hydrogen Hazards, 31 Chem. Eng'r Transactions 913, 914 (2013), available at https://www.aidic.it/cet/13/31/153.pdf.

[30] Derwent, R., Simmonds, P., O'Doherty, S., Manning, A., Collins, W. and Stevenson, D. 2006. "Global Environmental Impacts of the Hydrogen Economy." Int. J. of Nuclear Hydrogen Production and Applications. 1(1): 57-67. Available at: http://agage.mit.edu/publications/global-environmental-impacts-hydrogen-economy.

[31] Ilissa B. Ocko & Steven P. Hamburg, Climate consequences of hydrogen leakage, Atmospheric Chemistry & Physics (preprint, discussion started Feb. 18, 2022), available at https://acp.copernicus.org/preprints/acp-2022-91/acp-2022-91.pdf.

[32] Collins, Leigh, 'Hydrogen in the home would be four times more dangerous than natural gas': government report, (RechargeNews.com, last updated August 2, 2021), available at https://www.rechargenews.com/energy-transition/hydrogen-in-the-home-would-be-four-times-more-dangerous-than-natural-gas-government-report/2-1-1047218.

[33] Sasan Saadat & Sara Gersen, Reclaiming Hydrogen for a Renewable Future: Distinguishing Oil & Gas

Hydrogen potentially makes sense as a road transport fuel in the limited context of heavy duty long-haul trucking. As discussed at a recent technical session DEEP held on alternative fuels, hydrogen offers the greatest value for long-haul heavy duty trucks (Class 8). These trucks are the heaviest class of vehicle and cannot easily be electrified because they would require such large batteries (which are also heavy) and because their long travel routes and strict schedules are less amenable to regular charging patterns than most other types of vehicles,[34] including school buses, transit buses, most other medium-and heavy-duty vehicles, and light-duty vehicles.

The Hydrogen Task Force's January report should clearly identify different stakeholders' perspectives on hydrogen end uses (and other topics addressed in the report) and specify areas of consensus and disagreement. The state should establish a robust stakeholder engagement process, as we suggest in our response to Question 2, *supra*, to ensure that there are ongoing opportunities for the public to meaningfully engage in the state's approach to clean hydrogen deployment.

Earthjustice has identified a set of criteria for deploying green hydrogen that can helpfully guide Connecticut's actions. Specifically, for green hydrogen to make sense as a climate solution all of the following criteria must be met:

1. There are no low-cost decarbonization strategies available;
2. There are no electric technologies being developed that could take advantage of zero-emission electricity directly;
3. The logistics and costs of infrastructure for hydrogen transportation and storage can be contained;
4. Technologies for using hydrogen fuel in the sector are or will be available; and
5. Transitioning to green hydrogen could reduce air pollution.[35]

Ultimately, as Energy Innovation recommends, "state utility regulators and policymakers should be highly scrupulous and discerning of hydrogen blending proposals and avoid costly dead ends on the road to a decarbonized future."[36] These dead ends include using hydrogen for direct power generation and replacing fossil gas in buildings. As Michael Liebreich of

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Industry Spin from Zero-Emission Solutions, Earthjustice (Aug. 2021), https://earthjustice.org/features/green-hydrogen-renewable-zero-emission, at 18 (citing Cellek Mehmet Salih & Ali Pınarbaşı, Investigations on Performance and Emission Characteristics of an Industrial Low Swirl Burner While Burning Natural Gas, Methane, Hydrogen-Enriched Natural Gas and Hydrogen as Fuels, 43 Int'l J. of Hydrogen Energy 1994, 1205 (Jan. 11, 2018), https://www.sciencedirect.com/science/article/abs/pii/S0360319917319791) (finding that burning pure hydrogen would emit more than six times more nitrogen oxides than burning methane).

[34] *See, e.g.*, Bernd Heid, Christopher Martens, & Markus Wilthaner, McKinsey & Company, *Unlocking hydrogen's power for long-haul freight transport* (Aug. 2, 2022), https://www.mckinsey.com/capabilities/operations/our-insights/global-infrastructure-initiative/voices/unlocking-hydrogens-power-for-long-haul-freight-transport.

[35] Sasan Saadat & Sara Gersen, Reclaiming Hydrogen for a Renewable Future: Distinguishing Oil & Gas Industry Spin from Zero-Emission Solutions, Earthjustice (Aug. 2021), available at https://earthjustice.org/features/green-hydrogen-renewable-zero-emission.

[36] Energy Innovation, Assessing the Viability of Hydrogen Proposals (Mar. 2022), available at https://energyinnovation.org/wpcontent/uploads/2022/03/Assessing-the-Viability-of-Hydrogen-Proposals.pdf.

Bloomberg New Energy Finance observes, gas distribution companies are lobbying for hydrogen use in domestic heating not to address climate change, but because "they want to get us locked into using their gas pipes for decarbonisation, because that's their asset."[37] Connecticut has a chance to chart its own course for hydrogen not dictated by the preferences of the gas utilities and gas power plant owners. The Hydrogen Task Force should approach this task objectively, fully and fairly evaluating the feasibility, economics, and emissions impacts of hydrogen.

Hydrogen Supply

5. **If local (in-state) hydrogen supply is expected to limit in-state hydrogen end use applications, should the state consider the role of hydrogen imports in meeting supply needs?**

As we explain below, it is unlikely that Connecticut can meet 100% of its clean hydrogen supply needs with in-state production. Even if the state had a surplus of renewable generation to produce green hydrogen—which is not the case—there are enormous infrastructure costs and siting challenges associated with the large-scale buildout of hydrogen infrastructure.

Connecticut's small geographic size, relatively dense population, and lack of existing infrastructure suggest that in-state hydrogen production is likely to face high costs and siting difficulties. Importing clean hydrogen may therefore be more cost-effective than producing it locally, although analysis is needed to determine how these costs may work out in practice.

In addition to analyzing the expected in-state supply of clean hydrogen and the relative costs of in-state vs. imported clean hydrogen, Connecticut must ensure that any imported clean hydrogen meets the state's qualifications for clean hydrogen[38] and is consistent with the state's greenhouse gas reduction requirements under the Global Warming Solutions Act.[39]

While production of green hydrogen is likely to increase significantly in coming years, the availability of new and surplus renewable resources needed to produce green hydrogen will remain a limiting factor in Connecticut and elsewhere. Currently, fossil gas generates 53% of electricity in the New England regional grid.[40] Renewable generation and storage dominate the interconnection queue,[41] but there are questions about how quickly these resources can be integrated into the grid due to factors that are hindering the urgently needed expansion of transmission infrastructure and market reforms that would accelerate the deployment of renewables in the region.

Decarbonizing the grid while maintaining reliability and keeping up with increased electricity demand is already a major challenge. Using electricity to produce green hydrogen would further increase demand and make it harder for New England states to decarbonize the

[37] Leigh Collins, Liebreich: 'Oil sector is lobbying for inefficient hydrogen cars because it wants to delay electrification,' Recharge (June 30, 2021), https://www.rechargenews.com/energy-transition/liebreich-oil-sector-islobbying-for-inefficient-hydrogen-cars-because-it-wants-to-delay-electrification-/2-1-1033226.
[38] For recommendations on how Connecticut should define clean hydrogen, see response to Question 1, *supra*.
[39] Conn. Gen. Stat. § 22a-200a.
[40] ISO-New England, *Resource Mix*, https://www.iso-ne.com/about/key-stats/resource-mix.
[41] ISO-New England, *Generator Interconnection Queue*, https://irtt.iso-ne.com/reports/external.

grid and meet their state climate goals. The Massachusetts 2050 Energy Pathways Report found that green hydrogen is unlikely to scale until there are sufficient surplus quantities of renewable electricity for cost-effective production, which the report projected would occur in the 2040s at the earliest.[42] And even in such a scenario, the report found that green hydrogen was likely to be cost-effective only in difficult-to-electrify sectors, with electrification still being more cost-effective in the buildings sector.[43]

Hydrogen Infrastructure

6. What additional processes should the state consider to ensure that use of pipeline infrastructure for hydrogen transport is implemented safely, and supports community and climate goals?

Best practices for the production, transport, delivery, storage, and use of clean hydrogen are still in development.[44] Pipeline safety is overseen at the federal level by the Pipeline and Hazardous Materials Safety Administration (PHMSA). PHMSA has recognized that there are major research gaps for safely using existing pipelines for potential hydrogen transport.[45] Given the safety concerns associated with hydrogen transport and use, following best practices and establishing stringent regulatory requirements will be critical to minimize the chances of explosions and other risks. Safety requirements should be established and regularly updated in accordance with the best available science. In addition, regulators should provide a robust public engagement process to ensure that community concerns are taken into account.

There are significant safety and infrastructure concerns associated with hydrogen due to its higher flammability and leakage rates.[46] Upgrading existing gas infrastructure and appliances to safely transport and use hydrogen in the building sector would require enormous investments, which do not make economic sense given the need to prioritize hydrogen for hard-to-decarbonize applications. Moreover, such a massive overhaul of existing infrastructure would take many years, at a time when emissions reductions must be achieved as quickly as possible. Use of green hydrogen in the building sector does not make sense from a cost perspective and would not reduce emissions at the speed and scope needed to meet state climate goals.

Hydrogen can cause pipe embrittlement and cannot safely be transported through many existing gas pipelines.[47] While estimates may vary by distribution system, hydrogen cannot be blended into the gas distribution system at high volumes. An empirical study of hydrogen blending conducted this year by the California Public Utilities Commission found that a "systemwide blending injection scenario becomes concerning as hydrogen blending approaches

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[42] Buildings Sector Report: A Technical Report of the Massachusetts 2050 Decarbonization Roadmap Study, 5 (2020), https://www.mass.gov/doc/building-sector-technical-report/download.
[43] *Id.* at 103.
[44] U.S. Dept. of Energy, Hydrogen and Fuel Cell Technologies Office, *Regulations, Guidelines, and Codes and Standards*, https://www.energy.gov/eere/fuelcells/regulations-guidelines-and-codes-and-standards.
[45] PHMSA report, https://primis.phmsa.dot.gov/rd/mtgs/020707/GlynHazelden_Hydrogen.pdf.
[46] Sara Gersen & Sasan Saadat, Earthjustice, *Reclaiming Hydrogen for a Renewable Future*, 19 (Aug. 2021), https://earthjustice.org/sites/default/files/files/hydrogen_earthjustice_2021.pdf
[47] *Id.*

5% by volume."[48] In Connecticut, over 50% of gas mains are made of steel or iron, which cannot be used to transport a high level of hydrogen.[49] Upgrading or replacing these pipelines so they could be safely used for hydrogen would be enormously expensive, as "[b]uilding a hydrogen pipeline can cost up to 68% more per mile than a conventional fossil gas pipeline."[50] Using truck or rail transport would also be expensive because hydrogen must be highly compressed, making these options realistic only for smaller volumes of hydrogen.[51]

7. **What enabling infrastructure do you believe is highest priority for the state to pursue to support the development of Connecticut's hydrogen economy, and why?**

Deployment of clean hydrogen should be limited to hard-to-decarbonize applications that cannot easily or cost-effectively be electrified, and any build out of infrastructure should focus on those applications. Such hard-to-decarbonize end uses include high-heat industrial processes, aviation, maritime, chemical feedstocks, and long-haul trucking. Connecticut should not invest in infrastructure to distribute hydrogen to buildings through the gas distribution system. This end use is not appropriate for hydrogen, as explained in response to Question 4, *supra*.

Liquefaction plants, tankers, storage facilities, pipelines, compressors, and dispensers necessary for hydrogen utilization will be very costly, despite tax incentives and federal funding opportunities. Initial investment and ongoing cost through maintenance and monitoring will be substantial, with the financial burden primarily falling on Connecticut residents. Prioritization of end uses will help define lifetime costs, and we recommend limiting investment into the highest priority end uses only, such as the hard-to-decarbonize end uses mentioned above.

In the transport sector, Connecticut should consider prioritizing hydrogen fueling infrastructure for long-haul heavy duty trucks. Coordinated deployment of hydrogen fueling stations for heavy duty trucks along Connecticut's existing alternative fuel corridors (and potentially other routes as needed) could help accelerate a shift away from diesel trucks. Notably, diesel trucks are a major source of air pollution in Connecticut. Emissions from these vehicles disproportionately affect low-income and minority residents, who often live in urban areas and closer to highways and other busy roadways than wealthier, white residents.

Policies that will accelerate a transition to clean trucks, most notably California's Advanced Clean Trucks (ACT) rule, will be critical to speed up the adoption of both electric and hydrogen fuel cell trucks in Connecticut. Notably, New Jersey, New York, Massachusetts, and Vermont have already adopted the ACT rule, and Connecticut is expected to adopt the rule in 2023. Connecticut should coordinate with these neighboring states and others in the region on developing the infrastructure needed to accommodate increasing numbers of electric trucks and hydrogen fuel cell trucks. Establishing an adequate supply of green hydrogen will be critical to

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[48] California Public Utilities Commission, Rulemaking No. R.13-02-008, Hydrogen Blending Impacts Study: Final Report (July 18, 2022)
[49] Mike Henchen, RMI, *Low Carbon Fuels' Limited Role in Building Decarbonization*, Slide 53 (Nov. 4, 2022), https://portal.ct.gov/-/media/DEEP/energy/ConserLoadMgmt/Master-Slide-Deck_TM-6_Alt-Fuels_PM.pdf.
[50] Sara Gersen & Sasan Saadat, Earthjustice, *Reclaiming Hydrogen for a Renewable Future*, 19 (Aug. 2021), https://earthjustice.org/sites/default/files/files/hydrogen_earthjustice_2021.pdf (citing Julien Dumoulin-Smith et al., US Alternative Energy, Bank of America, at 4 (June 28, 2021).
[51] *Id.*

ensure that increased deployment of hydrogen fuel cell trucks (and other uses of hydrogen) results in emissions reductions. This consideration should be a central component of the northeastern states' regional hydrogen hub proposal and their hydrogen policies.

Hydrogen Funding and Policy Activities

8. **What portions of the hydrogen value chain (uses, sources, transport, storage) would be most benefited by further development of additional policy or regulatory guidance? Why, and what gaps should these policies be seeking to address?**

Portions of hydrogen supply infrastructure are regulated by international, federal, state, and local entities.[52] However, there is considerable ambiguity as to which existing regulations are applicable to hydrogen. At present, most pipelines that transport hydrogen in the United States are owned and operated by merchant hydrogen producers, located where large hydrogen users, such as petroleum refineries and chemical plants, are concentrated (mainly around the Gulf Coast). Regulations for other end uses have yet to be created and/or implemented.

As discussed in response to Question 6, *supra*, there are significant safety concerns associated with hydrogen. These concerns are particularly salient in the context of residential heating, in which there is little risk tolerance because the consequences of a home explosion could be devastating. Safety should be a paramount consideration in the context of hydrogen transport, storage, and end uses, and state regulators should establish and enforce robust regulatory requirements that prioritize public safety.

9. **Federal funding is hoped to represent a significant portion of hydrogen funding but is not expected to meet all funding needs. Which hydrogen investments (infrastructure, manufacturing, end use equipment, workforce training, etc.) would be the most important for the state to consider funding? Why?**

Hydrogen has potential as an alternative fuel and energy storage source. The need to move rapidly towards economy-wide decarbonization, electrification, and energy efficiency does not allow any potential energy option to be ignored. However, hydrogen must be prioritized for hard-to-decarbonize applications because it does not make sense for all sectors. The federal government is releasing $8 billion through the 2021 Infrastructure Investment in Jobs Act to research and develop hydrogen power regional hubs. Additional funding ($1.5 billion) will be available for "clean" hydrogen research. Connecticut should pursue this federal funding for investment in infrastructure that targets hard-to-electrify sectors and end uses only, thereby making the most of federal funds.

10. **What are the best mechanisms for state agencies to gain visibility into federal funding opportunities pursued by individual commercial actors or other organizations? What actions can the state take to support these applications?**

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[52] Baird, Austin Ronald, Ehrhart, Brian David, Glover, Austin Michael, and LaFleur, Chris Bensdotter. *Federal Oversight of Hydrogen Systems*. United States: N. p., 2021. Web. doi:10.2172/1773235.

As the market for clean hydrogen develops, it will be important for state agencies and interested members of the public to assess the status of federal funding opportunities and projects in our state. At this early stage, this may simply involve establishing a publicly available, online resource that identifies and links to requests for information (RFIs) and requests for proposals (RFPs), including applicable deadlines. However, these federal funding opportunities will soon lead to actual funded projects. The state should start planning now to gather information about potential, pending, and completed hydrogen projects in Connecticut, and it should make that information publicly available as soon as possible.[53]

The task force should solicit information from stakeholders, including hydrogen project proponents, on the best means of gathering information about projects. At the very least, the state should solicit information on what entities in Connecticut have submitted responses to federal hydrogen RFIs and RFPs. This information should be submitted to the state on a rolling basis while there are outstanding federal funding opportunities. A mandatory reporting requirement could also be considered (e.g., for utility companies).

To increase transparency and public awareness of federal funding opportunities, the Green Bank and/or DEEP's Bureau of Energy and Technology Policy should create a publicly accessible, searchable database with information on federal funding opportunities and the status of projects that have applied for or received funding. The database should include, for example, the funding source(s), amount of funding available, amount of funding awarded, type of project, project developer(s), geographic location(s), etc. A complementary mapping tool should also be developed so people can see where projects are or will be located. It would be valuable for state agencies, other interested stakeholders, and the general public to easily access this information.

The CT Department of Transportation (CT DOT) recently launched a publicly available Active Projects by Funding Type Map.[54] The map "displays the locations of planned and active construction capital projects throughout Connecticut and identifies the source of project funding, including Infrastructure Investment and Jobs Act (IIJA) funds. . . . [The map] also indicates basic information about each project and is linked to other resources which provide greater detail."[55] A similar mapping tool should be developed for federally funded hydrogen projects in Connecticut.

Providing information about hydrogen funding opportunities and transparency around projects in Connecticut is an appropriate role for the state.[56] This will create a more level playing field by enabling all stakeholders to easily obtain information about funding opportunities, and it will facilitate public engagement in the development of clean hydrogen projects in Connecticut. This transparency, coupled with robust public engagement for projects that will be sited in the state, will be critical to ensure that Connecticut moves forward with an equitable approach to

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[53] Information should be publicly available to the maximum extent allowed under existing law. Protected proprietary or confidential information would not be publicly available.

[54] CT DOT, *Active Projects by Funding Type Map*, https://ctdot.maps.arcgis.com/apps/dashboards/52e9ba95ad914e34b149966420e9db08.

[55] CT DOT, *CTDOT Launches Interactive Map with Active IIJA Project Information* (Oct. 26, 2022), https://portal.ct.gov/DOT/CTDOT-Press-Releases/2022/CTDOT-Launches-Interactive-Map-with-Active-IIJA-Project-Information.

[56] We do not otherwise support using state dollars to subsidize private entities in their efforts to obtain federal funding for hydrogen projects.

hydrogen that benefits state residents, aligns with state climate goals, and does not burden environmental justice communities or other marginalized populations.

11. What federal funding opportunities have stakeholders applied to? Are these formula grants or competitive? Are these opportunities hydrogen-related? Do stakeholders have lessons learned to share based on the application or implementation process?

As discussed in response to Question 10, *supra*, stakeholders and the general public would benefit from publicly available information about federal hydrogen funding opportunities and the status of projects in Connecticut. Such a resource is unlikely to be developed without state involvement and should be a priority for the state.

The undersigned organizations have not applied for any federal hydrogen funding opportunities, and we do not have information about what entities in Connecticut have applied. Discussions at Hydrogen Task Force and working group meetings have shed some light on what entities in Connecticut are pursuing federal funding; however, few details have emerged, and the status of potential projects is unclear. This situation is unlikely to change in the absence of state action. We encourage the state to gather this information, make it publicly available, and update it on a regular basis so state agencies, interested stakeholders, and the public have a clear sense of the evolving hydrogen landscape in Connecticut. This baseline information will be critical to facilitate an equitable approach to clean hydrogen deployment that aligns with Connecticut's statutory climate goals and with principles of equity and environmental justice.

Respectfully submitted,

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