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U.S. Department of Energy
1000 Independence Ave SW
Washington, D.C. 20585

Re: Comments by Clean Energy Group regarding Notice of Intent to Prepare an Environmental Impact Statement (EIS) for the California Hydrogen Hub; Department of Energy (DOE) Docket DOE-HQ-2024-0087.

Dear Kristin Welch,

Clean Energy Group (CEG), a national nonprofit organization that works to provide innovative technical, economic and policy solutions to enable communities to participate equitably in the clean energy transition, is pleased to provide these comments in response to the Department of Energy's (DOE) notice of intent to prepare an Environmental Impact Statement (EIS) for the California Hydrogen Hub, also known as the Alliance for Clean Hydrogen Renewable Energy Systems (ARCHES). These comments reflect the position of CEG and do not necessarily reflect the positions of CEG's partner organizations or funders.

For the past four years, CEG has worked extensively with environmental justice and community-based partners on hydrogen issues. Through its national Hydrogen Information and Public Education initiative, CEG is working to counter misinformation regarding hydrogen by developing a repository of research and information on the viability of issues related to the production and use of hydrogen. In addition, through this initiative, CEG supports the work of frontline organizations to understand and critically evaluate how hydrogen production may benefit or harm their communities.

The development of the California Hydrogen Hub and the scope of this environmental impact statement will have wide ranging implications for the evaluation of federally funded hydrogen projects moving forward. Ensuring that the environmental impact of California's hydrogen hub is accurately evaluated is crucial in developing a hydrogen economy that supports, rather than hinders, vital decarbonization efforts, and minimizes harm to environmental justice communities. An analysis of the chemical properties of hydrogen and how it interacts with surrounding materials and the atmosphere, as well as an examination of production methods and end uses proposed by ARCHES, will be necessary in determining the best path forward for this regional hub.

EIS Comment Deadline

First and foremost, we urge DOE to extend the deadline for comments on the proposed scope of the EIS by another 60 days. ARCHES has provided limited information on the scope and locations of the proposed projects, leading to a lack of community knowledge and awareness of the potential environmental impact of the development of this hub. Extending the comment period would allow more time for crucial information to be released that would inform community engagement and education around the environmental impact statement.

All three in person scoping meetings for this EIS process have been cancelled, scheduled for the 19th, 25th, and 27th of February. These meetings would have provided an opportunity for community members to provide input, an important step in the process. Extending the deadline for comments would be a step in the right direction to ensure that all voices be heard and incorporated into the scope.

Hydrogen's Global Warming Potential

While hydrogen does not produce carbon dioxide (CO2) when combusted, the rapid expansion of a hydrogen economy could still exacerbate global warming. Hydrogen interacts with the atmosphere in four main ways: 1) it extends the lifetime of methane in the atmosphere; 2) it increases the production of ozone; 3) it increases the production of stratospheric water; and 4) it alters the production of certain aerosols. These atmospheric effects culminate in an extreme global warming potential, nearly 12 times that of CO2 over 100 years after release. When looking at a time scale of 20 years, hydrogen contributes to climate warming 35 times more than CO2.[1] Venting hydrogen is part of standard industry safety practices during the production, transportation, and storage of this gas, and understanding the effects of introducing hydrogen into the atmosphere through these practices is imperative to analyzing the climate impacts of increased hydrogen production and use through the California Hydrogen Hub.

In addition to purposeful venting of hydrogen into the atmosphere, hydrogen will be introduced into the atmosphere through unintentional leakage. Due to its small molecular size and low density, hydrogen gas is highly prone to leakage. While exact data on leakage is limited, many models have pointed to the necessity for leakage rates to be kept at a minimum as hydrogen production and use increases to mitigate the climate warming effects.[2] Leak detection for

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[1] Sand, Maria, Ragnhild Bieltvedt Skeie, Marit Sandstad, Srinath Krishnan, Gunnar Myhre, Hannah Bryant, Richard Derwent, et al. "A Multi-Model Assessment of the Global Warming Potential of Hydrogen." Communications Earth & Environment 4, no. 1 (June 7, 2023): 203. https://doi.org/10.1038/s43247-023-00857-8.

[2] Bertagni, Matteo B., Stephen W. Pacala, Fabien Paulot, and Amilcare Porporato. "Risk of the Hydrogen Economy for Atmospheric Methane." Nature Communications 13, no. 1 (December 13, 2022): 7706. https://doi.org/10.1038/s41467-022-35419-7, Ocko, I. B., and S. P. Hamburg. "Climate Consequences of Hydrogen Emissions." Atmospheric Chemistry and Physics 22, no. 14 (2022): 9349–68. https://doi.org/10.5194/acp-22-9349-2022.

hydrogen is a nascent technology, still being developed and refined, and relying on this limited data could underestimate the true climate warming effects of hydrogen production and use.[3]

ARCHES has stated that it intends to produce 515 metric tons per day (mtpd) of hydrogen by 2030.[4] The impact of intentional and unintentional release of hydrogen into the atmosphere through industry standard venting and inevitable leakage while producing and offtaking this 515 mtpd of hydrogen could have far reaching consequences for the climate and must be included in the scope of the EIS.

Hydrogen Safety

Hydrogen's chemical properties increase the safety risks from leaks and ignition. Hydrogen has a wide ignition range and burns hotter than the most utilized and studied flammable gas, methane. When it ignites, hydrogen flames are invisible during the daytime.[5] Additionally, there are no commercially available odorants for hydrogen, an odorless gas, that could aid crucial leak detection, especially around workers and customers.[6] The properties of hydrogen flames paired with inadequate leak detection technology make the production and transportation of this gas of particular concern.

ARCHES has proposed the use of hydrogen combustion for power generation in existing gas turbines, beginning with the blending of natural gas and hydrogen and moving towards 100% hydrogen combustion.[7] When combusted, hydrogen produces on average six times as much NOx as methane.[8] NOx pollution is a public health hazard that does significant damage to the respiratory system over time. Many frontline communities located near existing heavily polluting power plants or existing oil and gas production sites have developed serious health disparities due to overexposure to NOx. These impacts are not limited to areas where production or combustion takes place, and adverse health impacts are seen even when NOx emissions are within permitted limits.

Existing NOx emissions control technologies, such as using a catalytic reaction, diluting the fuel mix with water or steam, or using newer low-NOx technology such as a dry low NOx (DLN) combustion system, are not equipped to handle higher blends of hydrogen and natural gas.

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[3] Qanbar, Mohammed W., and Zekai Hong. "A Review of Hydrogen Leak Detection Regulations and Technologies." *Energies* 17, no. 16 (August 15, 2024): 4059. https://doi.org/10.3390/en17164059.
[4] Alliance for Renewable Clean Hydrogen Energy Systems, "Technical Volume" (April 2023) https://archesh2.org/wp-content/uploads/2024/08/ARCHES-Technical-Volume-Redacted.pdf
[5] Martin, Paul, Ilissa B. Ocko, Sofia Esquivel-Elizondo, Roland Kupers, David Cebon, Tom Baxter, and Steven P. Hamburg. "A Review of Challenges with Using the Natural Gas System for Hydrogen." *Energy Science & Engineering* 12, no. 10 (October 2024): 3995–4009. https://doi.org/10.1002/ese3.1861.
[6] Ibid.
[7] Alliance for Renewable Clean Hydrogen Energy Systems, "Technical Volume" (April 2023) https://archesh2.org/wp-content/uploads/2024/08/ARCHES-Technical-Volume-Redacted.pdf
[8] Cellek, Mehmet Salih, and 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." International Journal of Hydrogen Energy 43, no. 2 (January 11, 2018): 1194–1207. https://doi.org/10.1016/j.ijhydene.2017.05.107.

During a pilot hydrogen blending demonstration at NYPA's Brentwood facility, NOx emissions increased as much as 24 percent as the fraction of hydrogen increased. To keep NOx emissions within permitted limits, the plant had to significantly increase water consumption.[9] At best, in newer turbines developed to successfully combust 100 percent hydrogen while deploying NOx emissions control technologies, NOx emissions remain like that of a newer natural gas plant.[10] Environmental justice communities are already seeing adverse health impacts from NOx emissions at these levels, and introducing a new source of NOx emissions could have devastating effects.

When combusting hydrogen in gas turbines, special consideration must be made to the interaction of hydrogen with typical turbine materials. Hydrogen corrodes metals through a process called hydrogen embrittlement (HE), where hydrogen diffuses into the alloy and combines with carbon to form methane, which then creates crack in the metal. Exposure to hydrogen can result in a decreased resistance to fracture and an exacerbation of the existing flaws in steel and other types of metal.[11] The nickel-based alloy that typically comprise gas turbine blades are particularly susceptible.[12] Corrosion of these components due to the introduction of hydrogen could result in safety failures and a decrease in turbine durability.

HE is an issue across the production, transportation, storage, and end use of hydrogen. Increased scrutiny must be paid to the types of metals and materials used throughout the hydrogen supply chain to prevent corrosion, decreased fracture resistance, and accelerated degradation. While plastic is not impacted by HE, hydrogen can permeate through polyethylene at a rate six to seven times higher than methane.[13] PNWH2 has proposed hydrogen pipelines to transport the fuel to various end uses, and the development of hydrogen storage facilities, making it imperative that the materials used for this infrastructure are not susceptible to hydrogen embrittlement, lattice dilation, or permeation. Negative interactions with these materials could lead to increased leakage, hazardous explosions, and decreased infrastructure longevity.

The California central valley is a key location in ARCHES proposed project network, encompassing many of the individual projects including a power generation project at the Lodi

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[9] "Hydrogen Cofiring Demonstration at New York Power Authority's Brentwood Site: GE LM6000 Gas Turbine." https://restservice.epri.com/publicdownload/000000003002025166/0/Product

[10] Kawasaki Heavy Industries, Ltd. "World's First Successful Technology Verification of 100 percent Hydrogen Fueled Gas Turbine Operation with Dry Low NOx Combustion Technology Improving Power Generation Performances to Realize a Hydrogen Society," July 21, 2020. https://global.kawasaki.com/news_200721 1e.pdf.

[11] Raju, Arun SK, and Alfredo Martinez-Morales. "Hydrogen Blending Impacts Study." Prepared by: University of California, Riverside. Prepared for: The California Public Utilities Commission. https://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M493/K760/493760600.PDF

[12] Zhang, Zhichao, Jurriaan Peeters, Vera Popovich, and Can Ayas. "Combined Effects of Stress and Temperature on Hydrogen Diffusion in Non-Hydride Forming Alloys Applied in Gas Turbines." International Journal of Hydrogen Energy 47, no. 71 (August 19, 2022): 30687–706. https://doi.org/10.1016/j.ijhydene.2022.07.006.

[13] Islam, Aminul, Tahrim Alam, Nathan Sheibley, Kara Edmonson, David Burns, and Manuel Hernandez. "Hydrogen Blending in Natural Gas Pipelines: A Comprehensive Review of Material Compatibility and Safety Considerations." International Journal of Hydrogen Energy 93 (December 3, 2024): 1429–61. https://doi.org/10.1016/j.ijhydene.2024.10.384.

Energy Center in San Joaquin Valley. This region is plagued with some of the worst air quality in California and the country, and introducing new sources of air pollution through hydrogen combustion would have grave implications for some of California's poorest areas.[14]

Hydrogen Production

ARCHES intends to produce the majority of its proposed 515 mtpd of hydrogen through electrolysis with renewable energy, also known as green hydrogen. Electrolysis is a water-intensive process; for every kilogram of hydrogen produced through electrolysis, a minimum of 2.6 gallons of purified water is needed. This water is transformed into hydrogen and cannot be recycled back to the source.[15] The water demand does not end there. Depending on end use, additional water is needed for cooling, making green hydrogen's water consumption a major area of concern especially in extreme drought prone areas like California.[16]

The production of green hydrogen is also very energy intensive, and 60 percent of the energy put into electrolysis is lost.[17] The impact of energy use on California's grid and the potential diversion of renewable energy resources away from electrification needs to be further evaluated considering ARCHES' intention to connect most electrolyzers to the California grid according to the Technical Volume.[18]

Producing hydrogen using electrolyzers powered by electricity from the grid could result in more emissions than hydrogen produced through fossil fuels, unless the electrolysis is matched with new hourly renewable generation.[19] The final guidance released by the Treasury regarding the 45V Clean Hydrogen Production Tax credit reflects this by requiring eligible facilities to match their production with new renewable generation. However, California is exempt from this requirement.[20] This makes it unlikely that ARCHES projects will match their hydrogen production with new renewable generation, even if the electrolyzers are grid connected. DOE must consider the implications for California's grid as these new sources of heavy demand come online, increasing reliance on dirtier forms of electricity generation.

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[14] Carly Phillips, "Climate Change Threatens Already Poor Air Quality in California's Central Valley," *Union of Concerned Scientists*, July 26, 2022. https://blog.ucsusa.org/carly-phillips/climate-change-threatens-already-poor-air-quality-in-californias-central-valley/.

[15] Makhijani, Arjun, Thomas Hersbach, "Hydrogen: What Good Is It?," Institute for Energy and Environmental Research, January 2024. https://ieer.org/wp/wp-content/uploads/2024/01/What-Good-is-Hydrogen-IEER-report-for-Just-Solutions-January-2024.pd

[16] Luhn, Alec "A Fifth of U.S. Green Hydrogen Projects Eyed for Water-Stressed Areas," Floodlight August 7, 2024. https://floodlightnews.org/green-hydrogen-projects-eyed-for-water-stressed-areas/

[17] Energy.gov. "Technical Targets for Proton Exchange Membrane Electrolysis." Accessed February 27, 2025. https://www.energy.gov/eere/fuelcells/technical-targets-proton-exchange-membrane-electrolysis.

[18] Alliance for Renewable Clean Hydrogen Energy Systems, "Technical Volume" (April 2023) https://archesh2.org/wp-content/uploads/2024/08/ARCHES-Technical-Volume-Redacted.pdf

[19] Ricks, Wilson, Qingyu Xu, and Jesse D Jenkins. "Minimizing Emissions from Grid-Based Hydrogen Production in the United States." *Environmental Research Letters* 18, no. 1 (January 2023): 014025. https://doi.org/10.1088/1748-9326/acacb5.

[20] Federal Register. "Credit for Production of Clean Hydrogen and Energy Credit," January 10, 2025. https://www.federalregister.gov/documents/2025/01/10/2024-31513/credit-for-production-of-clean-hydrogen-and-energy-credit.

In addition to electrolysis, ARCHES proposes to produce hydrogen through biomass gasification using woody biomass, a feedstock derived from trees. Despite producing abundant levels of greenhouse gases and other air pollutants during the process of gasification, energy generated from biomass is frequently heralded as carbon neutral and the greenhouse gas emissions are excluded from lifecycle analyses. These emissions, regularly called "biogenic emissions", are claimed to be part of the natural carbon lifecycle, ignoring the effects of human activity on this cycle. ARCHES has stated that it does not intend to count CO2 emissions from "biogenic sources" which will undercount the true effect of the CO2 emissions produced through the use of biomass. Considering these CO2 emissions to be carbon neutral undercuts the true global warming impact of this production method, and disregarding the emissions produced through biomass would lead to a false evaluation of the impacts of this production method.[21]

Funding the production of hydrogen through woody biomass gasification would increase demand for woody biomass potentially leading to deforestation and the weakening of local forest ecosystems.[22]

Biomass gasification does not result in pure hydrogen, but produces a syngas of hydrogen, carbon monoxide, carbon dioxide, and methane along with other hydrocarbon compounds that must be removed and reformed.[23] The production and transportation of syngas can provide novel hazards due to its explosive and toxic nature which could result in syngas pipeline rupture, so special consideration must be placed on this production pathway.[24] Biomass gasification also produces harmful impurities like particulate matter, nitrogen compounds, sulfur-containing compounds, and heavy metals which can produce damaging emissions and corrosion.[25] Tar is an additional byproduct of concern which can corrode and block equipment and decrease efficiency.

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[21] Udawattage, Wasana,"Why Is It Essential to Calculate Biogenic Carbon Emissions?" Accessed February 27, 2025. https://www.sustamize.com/blog/why-is-it-essential-to-calculate-biogenic-carbon-emissions; Birdsey, Richard, Philip Duffy, Carolyn Smyth, Werner A Kurz, Alexa J Dugan, and Richard Houghton. "Climate, Economic, and Environmental Impacts of Producing Wood for Bioenergy." *Environmental Research Letters* 13, no. 5 (May 1, 2018): 050201. https://doi.org/10.1088/1748-9326/aab9d5; "Biomass Energy is Polluting: A False Climate Solution that Worsens the Climate Crisis" Accessed February 27, 2025. CBD Forest Bioenergy Briefing Book, Polluting the Climate;

[22] Searchinger, Timothy D., Tim Beringer, Bjart Holtsmark, Daniel M. Kammen, Eric F. Lambin, Wolfgang Lucht, Peter Raven, and Jean-Pascal Van Ypersele. "Europe's Renewable Energy Directive Poised to Harm Global Forests." *Nature Communications* 9, no. 1 (September 12, 2018): 3741. https://doi.org/10.1038/s41467-018-06175-4; "Satellite images show link between wood pellet demand and increased hardwood forest harvesting." Accessed February 27, 2025. Biomass-White-Page.pdf

[23] Tezer, Özgün, Nazlıcan Karabağ, Atakan Öngen, Can Özgür Çolpan, and Azize Ayol. "Biomass Gasification for Sustainable Energy Production: A Review." *International Journal of Hydrogen Energy* 47, no. 34 (April 2022): 15419–33. https://doi.org/10.1016/j.ijhydene.2022.02.158.

[24] Stolecka, Katarzyna, and Andrzej Rusin. "Analysis of Hazards Related to Syngas Production and Transport." *Renewable Energy* 146 (February 1, 2020): 2535–55. https://doi.org/10.1016/j.renene.2019.08.102.

[25] Rakesh N, and S. Dasappa. "A Critical Assessment of Tar Generated during Biomass Gasification - Formation, Evaluation, Issues and Mitigation Strategies." *Renewable and Sustainable Energy Reviews* 91 (August 1, 2018): 1045–64. https://doi.org/10.1016/j.rser.2018.04.017.

Tar is a carcinogen and is highly toxic, so exposure to this compound through water sources could greatly impact human and environmental health.[26]

The production of hydrogen through biomass gasification will be paired with carbon capture and storage (CCS), a technology that has not been proven at scale, and does not capture the air pollutants present during the gasification process.[27]Additionally, CCS projects employ carbon dioxide pipelines that lead to long term storage. These pipelines can leak and even rupture, emitting climate warming gases and potentially poisoning surrounding residents as seen in the Sartartia, MI pipeline rupture.[28]

Hydrogen End Use

Development plans proposed for ARCHES include the production, storage, and transport of liquid hydrogen. Hydrogen liquefaction is a very energy intensive process. Hydrogen transforms into a liquid from a gas at –253 degrees Celsius, a much lower temperature than other liquid fuels, so more energy is needed for the conversion and to maintain the liquid state of hydrogen. To convert ~12,000L of gaseous hydrogen into ~14L liquid hydrogen (both equaling 1kg), around 13.8 kWh of energy is used.[29]

Storing and transporting liquid hydrogen provides novel issues. Through the duration of time that the liquid hydrogen is stored and transported, one to five percent of the liquid will evaporate into gas per day. Allowing this expanded hydrogen gas to remain in storage containers with liquid hydrogen would lead to explosions, so it is industry practice to vent this hydrogen gas into the atmosphere.[30] This extensive venting practice will have major implications for the climate due to hydrogen's global warming effects and must be taken into consideration during an environmental evaluation.

The Environmental Impact Statement is an important step in evaluating the consequences of a fully developed ARCHES hub. As the hydrogen economy proliferates, it is crucial that all environmental and social harms related hydrogen production and use at ARCHES be investigated.

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[26] Cortazar, M., L. Santamaria, G. Lopez, J. Alvarez, L. Zhang, R. Wang, X. Bi, and M. Olazar. "A Comprehensive Review of Primary Strategies for Tar Removal in Biomass Gasification." *Energy Conversion and Management* 276 (January 15, 2023): 116496. https://doi.org/10.1016/j.enconman.2022.116496, Mishra, Amit Kumar, R N Singh, and Pratyush Pingita Mishra. "Effect of Biomass Gasification on Environment," 2015. 14c3f7580ca39c7a

[27] Jacobson, Mark Z. "The Health and Climate Impacts of Carbon Capture and Direct Air Capture." *Energy & Environmental Science* 12, no. 12 (December 4, 2019): 3567–74. https://doi.org/10.1039/C9EE02709B, Institute of Energy Economics and Financial Analysis, "Carbon Capture and Storage: An Unproven Technology." Accessed February 27, 2025. https://ieefa.org/ccs.

[28] Radtke, Pam, "CO2 Pipeline Company Draws $2.4M Fine for Menacing Federal Inspectors," *Floodlight*. February 12, 2025. https://floodlightnews.org/co2-pipeline-company-draws-fine-for-menacing-federal-inspectors/.

[29] Zhang, Tongtong, Joao Uratani, Yixuan Huang, Lejin Xu, Steve Griffiths, and Yulong Ding. "Hydrogen Liquefaction and Storage: Recent Progress and Perspectives." *Renewable and Sustainable Energy Reviews* 176 (April 1, 2023): 113204. https://doi.org/10.1016/j.rser.2023.113204.

[30] Ibid.

In conclusion, CEG urges the DOE to analyze and evaluate impacts including but not limited to the global warming effects of venting and leaking hydrogen into the atmosphere, increased NOx emissions from hydrogen combustion, flammability of hydrogen, extreme water and energy intensity of green hydrogen production and hydrogen liquefaction, diversion of renewable energy away from electrification and towards hydrogen production, and the pollution and unintended deforestation of woody biomass use for hydrogen production. These issues could have grave consequences for the health and safety of Californians and broader decarbonization goals within the state, and the EIS is an opportunity to ensure the most just and effective path forward.

We would welcome a conversation to discuss these issues further if that is of interest.

Respectfully submitted,

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