Comment Received From: Natural Resources Defense Council (NRDC)
Submitted On: 8/7/2021
Docket Number: 21-IEPR-05

NRDC comments on the role of hydrogen to support Californiaâ€™s clean energy transition

Additional submitted attachment is included below.

Comments of the Natural Resources Defense Council (NRDC) on the IEPR Commissioner Workshop on Hydrogen to Support California's Clean Energy Transition

Docket Number 21-IEPR-05

August 6, 2021

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The Natural Resources Defense Council (NRDC) appreciates the opportunity to comment on the potential for hydrogen to support California's clean energy transition. NRDC is a non-profit membership organization with more than 95,000 California members who have an interest in receiving affordable energy services while reducing the environmental impact of California's energy consumption and transitioning to a thriving climate-safe society.

The following comments:

- Highlight the potential for hydrogen to support deep decarbonization goals by substituting for fossil fuels in the most challenging sectors of the economy, including aviation, maritime shipping, steelmaking and long-distance freight trucking.
- Provide some brief background on the current state of the hydrogen industry in California and the U.S.
- Discuss the two hydrogen production pathways currently receiving much of the policy and investor interest – green electrolytic hydrogen and blue hydrogen – and argues that green electrolytic hydrogen offers a more compelling case and a safer bet for California based on current evidence.
- Discuss the various end-use applications for hydrogen and argues that while it has great potential to decarbonize challenging sectors where electrification faces technical hurdles,

it is inefficient relative to electrification in a wide range of applications –notably as a source of building heat.

- Call into question claims that hydrogen would be a "no-disruption" solution relative to electrification owing to the potential to repurpose the existing gas network.
- Highlight the necessity of exercising caution in relation to hydrogen blending initiatives, the near-term repurposing of methane gas pipelines and the buildout of new dedicated hydrogen networks to avoid the stranding of methane gas and hydrogen assets and locking Californians into expensive decarbonization routes.

HIGH-LEVEL SUMMARY

Hydrogen has unique potential to support decarbonization goals, but it also has important drawbacks to which policymakers must be acutely sensitive.

Hydrogen can support the deep decarbonization of the economy by acting as a valuable complement to proven and established climate solutions like energy efficiency, clean electricity, and electrification. It offers unique potential to substitute for fossil fuels in challenging sectors where electrification faces technical hurdles, including aviation, maritime shipping, steelmaking and long-distance freight trucking. It could also support a very high renewable grid by serving as a seasonal form of electric storage. In California, hydrogen can bolster the reliability of a highly clean electric grid and support the state's efforts to enact a strong clean energy standard and can unlock a competitive future for the state's steelmaking industry in a clean economy.

However, because the market for hydrogen is nascent, hydrogen's deployment as a decarbonization tool is fraught with uncertainties and requires that decisionmakers first understand hydrogen's strengths and limitations. Hydrogen's potential is accompanied by potential pitfalls associated with its production, transport, and use (discussed below) and to which policymakers and stakeholders must be acutely sensitive. One of the main risks associated with an overeager switch to hydrogen includes steering limited public and private investments away from deploying reliable, cost-effective, and readily available decarbonization solutions like direct electrification. This could lock Californians into unnecessarily expensive decarbonization pathways or lead to the stranding of hydrogen assets should challenges to hydrogen-heavy pathways prove too great, undermining necessary climate progress in this decade and beyond.

California policymakers should endeavor to design a strategic, targeted, and evidence-based policy framework that leverages hydrogen's unique potential while avoiding unintended economic, public health, and climate consequences. Specifically, decisionmakers should adopt a policy framework for hydrogen within a broader ambitious clean energy agenda by:

1. Identifying hydrogen's strengths and limitations by way of an independent, system-wide assessment.
2. Endeavoring to ensure that a hydrogen agenda does not derail necessary action on proven, readily available solutions that must be taken today.
3. Orienting subsidies and support for hydrogen deployment towards applications where it adds the most value, commensurate with the system-wide assessment.
4. Orienting investments, policy incentives, and subsidies towards electrolytic green electrolytic hydrogen.
5. Exercising caution in relation to proposals for hydrogen blending, the repurposing of existing gas pipelines, and the buildout of new hydrogen pipelines.

I. HYDROGEN: BACKGROUND

The current hydrogen hype is largely driven by proliferating deep decarbonization goals.

One of the main reasons that hydrogen is receiving an elevated level of hype, both globally and in the U.S., is the proliferating national commitments to deep decarbonization, commensurate with the demands of the climate crisis. To date, 59 countries have established economy-wide net-zero greenhouse gas (GHG) emissions targets by sometime around 2050. Those commitments have driven countries to grapple with the necessity of finding clean energy solutions to substitute for fossil fuels in the most challenging sectors of the economy, including aviation, maritime shipping, steelmaking and long-distance freight trucking[1]. Those applications require either a

[1] Michael Liebreich, *Separating Hype from Hydrogen – Part Two: The Demand Side*, Bloomberg New Energy Finance, October 2020, https://about.bnef.com/blog/liebreich-separating-hype-from-hydrogen-part-two-the-demand-

chemical feedstock to drive a chemical reaction – as in steelmaking – or dense forms of energy to propel heavy equipment like vessels, aircrafts, and large trucks across long distances. Electrification – the solution to decarbonize much of the economy – faces technical hurdles in those applications because it may either require an entirely new process to forgo chemical reactions which it cannot serve – as in steelmaking- or may require very large batteries to propel heavy equipment across long distances, creating weight and payload issues for freight trucks, aircrafts and shipping vessels. In contrast, hydrogen offers many of the attributes that those challenging applications demand: it has high energy density – nearly three times that of diesel or gasoline – and can act as a chemical feedstock in heavy industry applications. Hydrogen has thus emerged as a compelling potential tool for decarbonization, as a complement to established climate solutions like electrification, efficiency, and renewable energy.

II. HYDROGEN PRODUCTION

Current hydrogen production process is highly polluting.

Hydrogen gas is not found in stand-alone form on earth and must be produced from another element that contains it. More than 95% of all hydrogen used in the U.S. is produced from methane gas in a process called steam methane reformation (SMR)[2]. In this process, methane gas is both used as the source of hydrogen, i.e., "feedstock," and combusted at high temperatures to provide the energy that drives the process. SMR is a major source of climate pollution in the U.S., emitting more than 90 million metric tons of carbon dioxide per year as well as large amounts of health-damaging air pollutants such as nitrogen oxides, volatile organic compounds,

side/ ; Simon Evans, John Gabbatiss, *In-Depth Q&A: Does the World Need Hydrogen to Solve Climate Change*, CarbonBrief, November 2020, https://www.carbonbrief.org/in-depth-qa-does-the-world-need-hydrogen-to-solve-climate-change

[2] U.S. Department of Energy, *Hydrogen Production: Natural Gas Reforming*, https://www.energy.gov/eere/fuelcells/hydrogen-production-natural-gas-reforming

and particulate matter.[3] Hydrogen produced through SMR is generally referred to as "grey" hydrogen.

Hydrogen production can be cleaned up to produce low-carbon hydrogen and green electrolytic hydrogen.

The use of hydrogen as a tool for deep decarbonization is premised on the decarbonization of its production process. To date, various alternatives to conventional SMR have been proposed, but the two currently receiving the most interest and attention are electrolysis, particularly when powered by renewable electricity, and SMR coupled with carbon capture. In the electrolysis process, water is used as the hydrogen feedstock, rather than methane gas. Electricity is used to split water into its constituents, hydrogen and oxygen, and to the extent that the electricity is generated by a renewable resource such as wind, solar, geothermal or hydro, the hydrogen is zero-carbon and air pollution-free. Hydrogen produced in this manner is often referred to as "green hydrogen" or "green electrolytic hydrogen".

Alternatively, the traditional SMR process can be equipped with carbon capture to produce "blue hydrogen." In this case, the hydrogen produced is low-carbon, but for two reasons it is not zero-emission. First, the efficiency of carbon capture has not been demonstrated beyond 90 to 95%, so the SMR process will likely result in some residual emissions. Second, there will be methane emissions from leakage during the production of methane gas and its transport to the SMR facility.[4]

In California, biomass-based pathways are also garnering interest from some parties. The SMR process can be fed with biomethane or biogas in lieu of fossil gas to produce hydrogen, or alternatively, dry biomass could be gasified to produce hydrogen. The latter process remains pre-commercial.

Today, green electrolytic and blue hydrogen are more costly than grey hydrogen. Green electrolytic hydrogen currently costs up to 5 times more and blue hydrogen costs about 2 times

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[3] Pingping Sun, Ben Young, Amgad Elgowainy, Zifeng Lu, Michael Wang, Ben Morelli, and Troy Hawkins, *Criteria Air Pollutants and Greenhouse Gas Emissions from Hydrogen Production in U.S. Steam Methane Reforming Facilities*, ACS Publications, April 2018, https://pubs.acs.org/doi/10.1021/acs.est.8b06197

[4] Dennis Y.C. Leunga, Giorgio Caramannab M. Mercedes, Maroto-Valerb, An overview of current status of carbon dioxide capture and storage technologies, November 2014, Science Direct, https://www.sciencedirect.com/science/article/pii/S1364032114005450

more than grey hydrogen. However, significant cost reductions are projected by 2030 and beyond, notably in green electrolytic hydrogen production (Figure 1). This is owing to anticipated large equipment cost reductions linked to projected increased deployment and ensuing economies of scale together with continued reductions in the costs of renewable electricity[5]. Bloomberg New Energy Finance (BNEF) estimates that, preconditioned on strong policy support, green electrolytic hydrogen could nearly compete with grey hydrogen and outcompete blue hydrogen in the U.S. by 2030. Recently announced federal and regional initiatives targeting ambitious green electrolytic hydrogen cost reductions by 2030 – including the Department of Energy's Hydrogen Shot initiative and the HyDeal L.A. initiative in California – increase the plausibility of the BNEF projections materializing[6]. By 2050, BNEF projects, green electrolytic hydrogen will have a decisive cost advantage over both grey and blue hydrogen, shown in Figure 1.

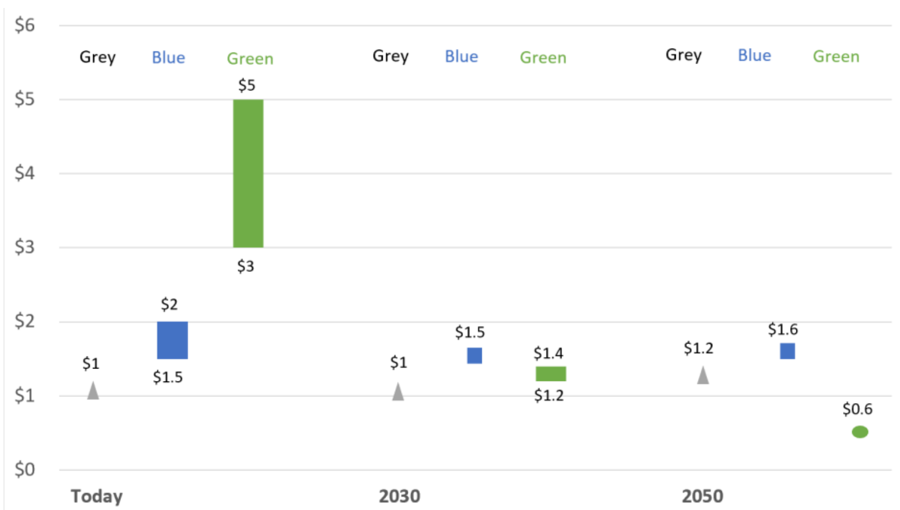

Figure 1: U.S. Hydrogen Production Costs ($/kg). Data sourced from BNEF, U.S. DOE and Resources for the Future[7].

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[5] HIS Markit, *IHS Markit: Production of Carbon-Free "Green" Hydrogen Could Be Cost Competitive by 2030*, July 2020, https://news.ihsmarkit.com/prviewer/release_only/slug/bizwire-2020-7-15-ihs-markit-production-of-carbon-free-green-hydrogen-could-be-cost-competitive-by-2030

[6] US Department of Energy, *Secretary Granholm Launches Hydrogen Energy Earthshot to Accelerate Breakthroughs Toward a Net-Zero Economy*, June 2021, https://www.energy.gov/articles/secretary-granholm-launches-hydrogen-energy-earthshot-accelerate-breakthroughs-toward-net ; BusinessWire, *LADWP Joins HyDeal LA, Targets Green electrolytic hydrogen at $1.50/kilogram by 2030*, May 2021, https://www.businesswire.com/news/home/20210517005210/en/LADWP-Joins-HyDeal-LA-Targets-Green-Hydrogen-at-1.50kilogram-by-2030

[7] BloombergNEF, *'Green' Hydrogen to Outcompete 'Blue' Everywhere by 2030*, May 2021, https://about.bnef.com/blog/green-hydrogen-to-outcompete-blue-everywhere-by-2030/ ; US Department of Energy,

Green electrolytic hydrogen offers a more compelling case and a safer bet relative to "blue" and biomass-based hydrogen in the U.S. and California

First, and as discussed above, blue hydrogen is projected to face challenging medium and long-term economics relative to green electrolytic hydrogen. A number of best available projections converge with BNEF and estimate that owing to its anticipated rapid scale up in this decade, green electrolytic hydrogen could compete with, and even outcompete, blue hydrogen in the U.S. on a cost basis by 2030, with a widening cost differential in favor of green electrolytic hydrogen thereafter[8]. This is owing to both projected dramatic cost reductions in the capital costs of electrolyzers – the equipment where the water splitting process occurs – and expected continued reductions in the cost of wind and solar energy. In contrast, the SMR process is mature with markedly slimmer opportunities for cost reductions. The following quote by BNEF's lead hydrogen analyst, Martin Tengler, summarizes the cost dynamics well:

> By 2030, it will make little economic sense to build blue hydrogen production facilities in most countries, unless space constraints are an issue for renewables. Companies currently banking on producing hydrogen from fossil fuels with CCS will have at most ten years before they feel the pinch. Eventually those assets will be undercut, like what is happening with coal in the power sector today.[9]

Therefore, it is a better bet for California to focus on a green electrolytic hydrogen trajectory that is poised to offer continuous cost reductions.

Second, the emissions from methane leakage and residual carbon emissions at the SMR site reduce the compatibility of blue hydrogen with a pathway to net-zero GHG emissions and thereby raise its risk profile due to the potential for asset stranding. This shortcoming is manifested in reputable and independent studies showing little blue hydrogen deployment in net-

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Secretary Granholm Launches Hydrogen Energy Earthshot to Accelerate Breakthroughs Toward a Net-Zero Economy; Jay Bartlett and Alan Krupnick, *Decarbonized Hydrogen in the US Power and Industrial Sectors: Identifying and Incentivizing Opportunities to Lower Emissions* , December 2020, Resources for the Future , https://www.rff.org/publications/reports/decarbonizing-hydrogen-us-power-and-industrial-sectors/

[8] IRENA, *Green electrolytic hydrogen Cost Reduction*, December 2020, https://irena.org/-/media/Files/IRENA/Agency/Publication/2020/Dec/IRENA_Green_hydrogen_cost_2020.pdf

[9] Institute for Energy Economics and Financial Analysis, Green electrolytic hydrogen to be cost-competitive by 2030—BloombergNEF, April 2021, https://ieefa.org/green-hydrogen-to-be-cost-competitive-by-2030-bloombergnef/

zero pathways relative to other clean hydrogen sources.[10] Furthermore, the local air pollution impacts of blue hydrogen, such as NOx emissions from the production process, are a significant drawback that raise health and equity concerns for communities living in the vicinity of projects.

Similarly, biomass-based hydrogen carries a set of critical risks.[11] First, the sustainability of the hydrogen resource is tightly linked to the sustainability of the biomass feedstock, the determination of which is layered with complexities. In addition, pursuing biomass-based hydrogen contends with supply limitations, considering the limited supply of sustainable biomass and the projected competition for it across sectors in a decarbonized economy. Finally, using biomethane or biogas in lieu of fossil gas in the SMR process still creates harmful air pollution impacts associated with the production process. There is also the risk that biogas "credits" from out-of-state projects may be used to justify the continued use of SMR with fossil gas in California, allowing local air pollution to continue while providing dubious climate benefits.

Third, pursuing a heavy blue or biomass-based hydrogen pathway forgoes a set of compelling benefits associated with green electrolytic hydrogen. As discussed in section IV below, green electrolytic hydrogen production can bolster the economics and reliability of a highly renewable grid. Accordingly, pursuing green electrolytic hydrogen is consistent with SB 100's directive of achieving 100 percent clean electricity by 2045.

It would therefore be prudent for California policymakers to hedge against the series of risks and uncertainties associated with blue and biomass-based hydrogen by orienting investment agendas toward green electrolytic hydrogen, harnessing the full potential of the state's abundant renewables potential resource.

[10] James H. Williams, Ryan A. Jones, Ben Haley, Gabe Kwok, Jeremy Hargreaves, Jamil Farbes, Margaret S. Torn , Carbon-Neutral Pathways for the United States, January 2021, https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020AV000284 ; Princeton University, *Net-Zero America Project*, December 2020, https://acee.princeton.edu/rapidswitch/projects/net-zero-america-project/; Sustainable Development Solutions Network, *America's Zero Carbon Action Plan*, November 2020, https://www.unsdsn.org/Zero-Carbon-Action-Plan

[11] For a detailed assessment of the sustainability and availability of possible biogas feedstocks see: *A Pipe Dream or Climate Solution? The Opportunities and Limits of Biogas and Synthetic Gas to Replace Fossil Gas* (NRDC, June 2020): https://www.nrdc.org/sites/default/files/pipe-dream-climate-solution-bio-synthetic-gas-ib.pdf

III. HYDROGEN END-USE APPLICATIONS

Hydrogen is uniquely suited to decarbonize the challenging sectors of the economy where electrification faces hurdles.

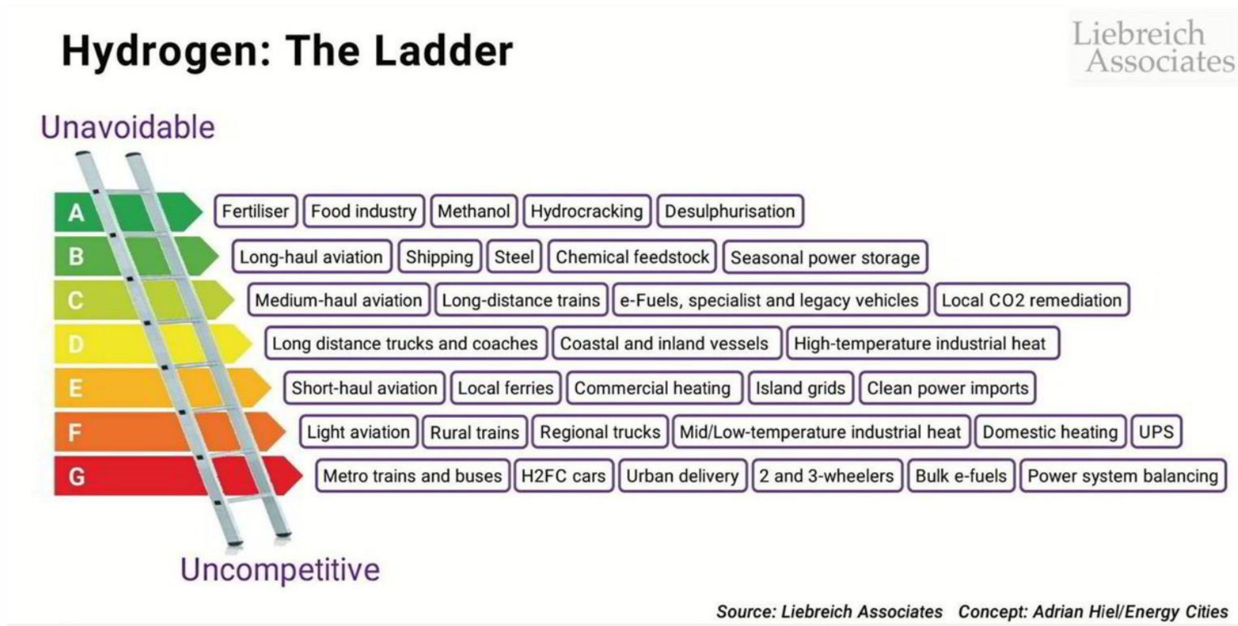
The production and use of hydrogen typically involve a series of energy conversions that incur high efficiency losses. For instance, more than 20 percent of electricity is lost in the production of green electrolytic hydrogen, and hydrogen equipment and appliances such as fuel cell cars and boilers are generally much less efficient than electric alternatives. These losses make hydrogen a relatively costly option for many applications that can be feasibly served by more efficient solutions like direct electrification. Using renewable electricity directly to power building appliances and cars is a more efficient solution relative to using it to first produce hydrogen which would then serve the various applications. The most compelling technical and economic case for hydrogen is therefore in applications where it is uniquely suited to the task – i.e. where direct electrification is either not technologically feasible or is very costly.[12] Those include aviation, maritime shipping, steelmaking, chemicals productions and long-distance freight trucking.

Green electrolytic hydrogen could also bolster the reliability and cost-effectiveness of a highly clean grid. On the one hand, it is a promising form of seasonal electricity storage.[13] It can be produced when there is excess renewable energy, especially in the fall and spring, stored for several months and then burned in turbines or run through fuel cells to generate electricity when wind and solar output is low. By helping the electricity grid ride through the seasonal differences in renewables performance, green electrolytic hydrogen could meaningfully bolster the reliability and resiliency of a very high renewable grid. On the other hand, by making use of excess renewable electricity that would otherwise be curtailed, green electrolytic hydrogen could bolster the cost-effectiveness of a highly clean grid and lower costs for California customers given that power projects would need to recoup less of their investment from electricity customers.

[12] Michael Liebreich, *Separating Hype from Hydrogen – Part Two*; Evans et. al, *In-Depth Q&A: Does the World Need Hydrogen to Solve Climate Change*, CarbonBrief

[13] National Renewable Energy Laboratory, *Answer to Energy Storage Problem Could Be Hydrogen*, June 2020, https://www.nrel.gov/news/program/2020/answer-to-energy-storage-problem-could-be-hydrogen.html#:~:text=An%20analysis%20from%20NREL%20researchers,energy%20storage%20in%20the%20future.&text=They%20developed%20a%20multi%2Dmodel,technologies%20in%20determining%20cost%2Dcompetitiveness.

The visual below provides a helpful summary of hydrogen's potential across the energy sector and ranks applications based on feasibility and economics relative to other available solutions like direct electrification.



Michael Liebreich's "hydrogen ladder" chart identifying the merits of use cases for clean hydrogen. Photo: Liebreich Associates

Figure 2: Hydrogen- The Ladder[14]

In California, a hydrogen roadmap study in line with the directive proposed in SB 18 (Skinner) and discussed in Section V, would be critical in identifying applications where hydrogen would add value relative to other climate solutions.

The inefficiencies of hydrogen use to heat buildings, and why prioritizing direct electrification instead is a sensible strategy.

Hydrogen gas can technically substitute for methane gas in supplying heat to buildings. However, a growing base of evidence demonstrates that hydrogen as a large-scale solution for building heating is likely an inefficient and costly solution relative to readily available and

[14] Leigh Collins, *Liebreich: 'Oil sector is lobbying for inefficient hydrogen cars because it wants to delay electrification'*, Recharge News, June 2021, https://www.rechargenews.com/energy-transition/liebreich-oil-sector-is-lobbying-for-inefficient-hydrogen-cars-because-it-wants-to-delay-electrification-/2-1-1033226

proven solutions like direct electrification. A range of studies estimate that heating a home with green electrolytic hydrogen would require 5 to 6 times more renewable electricity than heating that same home with a highly efficient heat pump.[15] This wide differential is driven by inefficiencies on both the hydrogen production side and the end-use side (Figure 3). Sourcing renewable electricity to produce hydrogen is inefficient compared to directly using this renewable electricity, with more than 20 percent of the electricity lost in the production process. On the end-use side, readily available high-efficiency heat pumps can be up to 4 to 5 times more efficient relative to the still pre-commercial hydrogen boilers. The large efficiency differential has important implications on the costs of a hydrogen-heavy pathway and the required infrastructure buildout; in fact, the UK Committee on Climate Change[16] points out in its review of the future of hydrogen that the required build rates for renewables would be extremely challenging if hydrogen was deployed as a widespread solution in buildings.

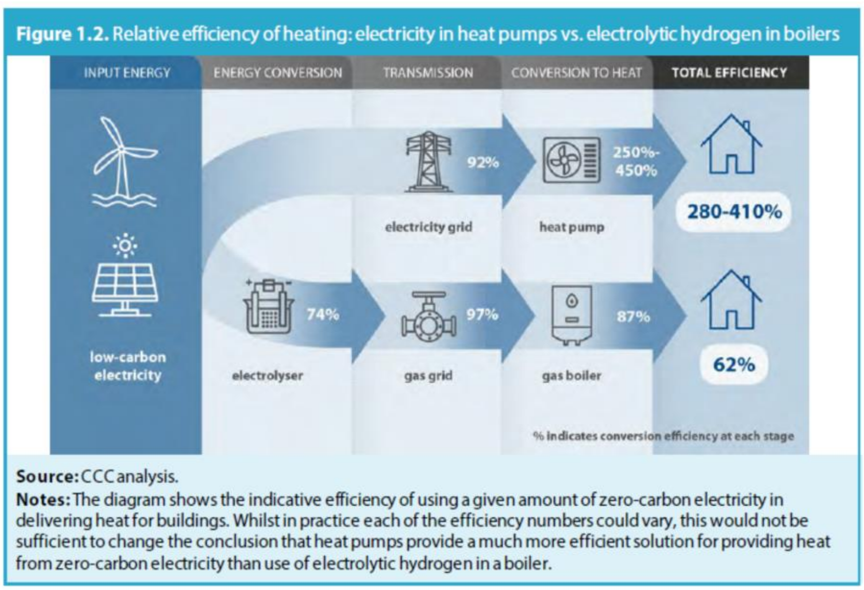


Figure 3: Relative Efficiency of Heating Electricity in Heat Pumps vs. Electrolytic Hydrogen in Boilers- Pulled from the study conducted by the U.K. Climate Change Committee[16]

[15] Jan Rosenow, Heating homes with hydrogen: Are we being sold a pup?, RAP, September 2020, https://www.raponline.org/blog/heating-homes-with-hydrogen-are-we-being-sold-a-pup/ ; Fraunhofer IEE, *Green electrolytic hydrogen or green electricity for building heating?*, July 2020, https://www.iee.fraunhofer.de/en/presse-infothek/press-media/overview/2020/Hydrogen-and-Heat-in-Buildings.html#:~:text=The%20study's%20findings%20are%20clear,equivalent%20number%20of%20heat%20pumps.

[16] UK Climate Change Committee, *Hydrogen in a low-carbon economy*, November 2018, https://www.theccc.org.uk/publication/hydrogen-in-a-low-carbon-economy/ . The CCC is an independent, non-

Prioritizing direct electrification as a readily available and proven to be cost-effective solution to decarbonize buildings heat would be a sensible strategy to avoid imposing unnecessary high costs on Californians, with hydrogen explored in niche contexts.

The issue with the "no-disruption" slogan propagated by some in the gas industry.

Some interests have argued that using hydrogen to heat buildings is a "no-disruption" solution relative to electrification via heat pumps, owing to the potential to utilize the existing gas network to transport the hydrogen. However, this is a misleading claim. Hydrogen is a fundamentally different gas relative to methane gas, and when it is blended with methane gas at high levels, its chemical properties cause embrittlement to steel gas pipelines. Consequently, while blending hydrogen with methane in low proportions (e.g. 5 to 15 percent by volume) could be achieved with minimal investments into the existing gas system, any quantity of hydrogen exceeding this threshold is likely to require either major network upgrades and repurposing measures or the buildout of an entirely new dedicated hydrogen pipeline network.[17] Existing gas boilers and cookstoves would also have to be replaced with hydrogen-compatible alternatives, which remain pre-commercial and require additional demonstration. As of today, there is no blueprint for such investments, and the costs and technical implications remain decidedly uncertain. For all these reasons, and because of the inefficiencies of hydrogen use in buildings relative to electrification, the premise that hydrogen would be a cost-effective solution for buildings due to the capacity to repurpose an existing gas network is false. In fact, the UK Committee on Climate Change recently found that the sunk costs of having an extensive gas grid do *not* give the hydrogen pathway a decisive advantage over electrification.[18] Of course, utilizing some existing assets in lieu of wholesale decommissioning is an attractive proposition, and there may be specific cases where repurposing portions of the existing gas network would be expedient to climate and economic goals. However, it would be prudent to exercise caution in relation to both near-term proposals for hydrogen repurposing efforts and proposals for continued investments in the gas grid that contemplate future repurposing.

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departmental public body, formed to advise the UK and devolved Governments and Parliaments on tackling and preparing for climate change.

[17] M. W. Melaina, O. Antonia, and M. Penev, *Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues*, NREL, March 2013, ,https://www.nrel.gov/docs/fy13osti/51995.pdf

[18] UK Climate Change Committee, *Hydrogen in a low-carbon economy*, November 2018, https://www.theccc.org.uk/publication/hydrogen-in-a-low-carbon-economy/ .

The risks of energy system "supersizing" linked to the widespread use of hydrogen in buildings.

Some in the gas industry also claim that widespread hydrogen use in buildings would deliver supposed savings on electric transmission and distribution infrastructure relative to the electrification of buildings. However, this premise is questionable as it selectively overlooks the broader picture. While it may deliver some savings on electricity infrastructure, a hydrogen-heavy pathway would require large incremental infrastructure elsewhere on the system due to its much lower efficiency relative to direct electrification and the need for a hydrogen-compatible network. In fact, a study by the European Climate Foundation found that the savings on electric network infrastructure in a high hydrogen case would be blown out by increased investments in renewable projects, electrolyzers and storage facilities to produce and store green electrolytic hydrogen, and in the upkeep and refurbishing of the gas network to transport the hydrogen (Figure 4).[19] This energy infrastructure "supersizing" – as characterized by the study – sharply increases energy system costs and household energy bills relative to high electrification cases.

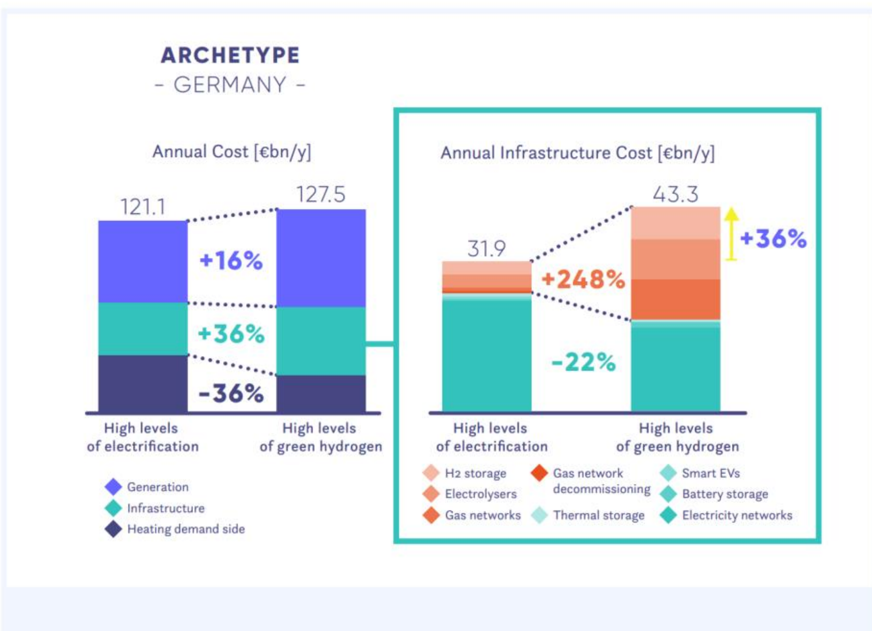

Figure 4: The high hydrogen case reflects more expanded hydrogen use and moderate electrification in both buildings and transportation[20]*. The study estimates a net 36 percent increase in infrastructure costs in the high*

[19] European Climate Foundation, *Towards Fossil-Free Energy in 2050*, March 2019, https://europeanclimate.org/wp-content/uploads/2019/03/Towards-Fossil-Free-Energy-in-2050.pdf

[20] Ibid.

hydrogen case. The 22 percent reduction in electricity network investments is largely outweighed by the 248 percent increase in expenses on electrolyzers, storage facilities and refurbishing gas networks.

Why claims around the benefits of widespread hydrogen use in buildings in lieu of electrification may be harmful to Californians and undermine climate progress.

There is a risk that the promise of hydrogen either dulls necessary near-term investments in proven and readily available solutions or encourages a set of misguided near-term actions. "Tech-crastination" is a coinage to refer to this risk whereby the promise of a future technology derails investments in proven and reliable technologies that should be made today.[21] Pursuing large-scale investments in the existing gas system with future repurposing to hydrogen in mind risks derailing necessary investments in building electrification and locking in Californians into an expensive and inefficient pathway to deep decarbonization. It could also result in the stranding of gas or hydrogen networks, following an ultimate switch to electrification. As noted above, it would be prudent for policymakers to proceed with proven, readily available and cost-effective solutions for buildings like electrification and energy efficiency, and to consider potential niche roles for hydrogen – and associated infrastructure implications – if and when new evidence emerges to warrant such consideration.

IV. HYDROGEN BLENDING AND TRANSPORT

Safeguards are needed to avoid that hydrogen blending initiatives produce lock-in effects into expensive decarbonization pathways.

Hydrogen blending initiatives in the existing gas network are proliferating across the U.S.[22] Blending low shares of hydrogen in the existing gas network could be an effective measure to boost demand for green electrolytic hydrogen production, modestly reduce the carbon emissions of delivered gas, and build the knowledge base in relation to the behavior of hydrogen in existing gas pipes. However, as noted above, blending hydrogen beyond the low threshold of 5% to 15%

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[21] Stian Westlake, *Bionic Duckweed: making the future the enemy of the present*, September 2020,https://stianstian.medium.com/bionic-duckweed-using-the-future-to-fight-the-present-3e471b642c28; Evans et. al, *In-Depth Q&A: Does the World Need Hydrogen to Solve Climate Change,* CarbonBrief

[22] Tom DiChristopher, *How National Grid plans to advance US renewable gas, hydrogen deployment*, S&P Global, January 2021, https://platform.mi.spglobal.com/web/client?auth=inherit#news/article?id=62227805&cdid=A-62227805-12335&KeyProductLinkType=58&utm_source=MIAlerts&utm_medium=scheduledalert&utm_campaign=Alert_Email

by volume would potentially require major network and appliance refurbishing costs.[23] Therefore, and in considering potential future hydrogen blending proposals in California, it would be prudent for policymakers to institute robust guardrails limiting blending to low thresholds warranting little to no investments in network upgrades; similar safeguards are necessary to avoid that blending programs lock-in Californians to an expensive pathway on account of major expenses poured into the gas network. The Renewable Hydrogen Coalition – a hydrogen lobby group in Europe – has recently argued for the avoidance of hydrogen blending altogether, citing the risks that investments in the gas grid to accommodate high blends of hydrogen become stranded.[24]

The need to exercise caution in relation to proposals for the refurbishing of existing gas pipelines or the buildout of dedicated hydrogen networks to avoid lock-in effects into expensive pathways and the stranding of assets.

There are emerging proposals across Europe and recently in the U.S. west to build dedicated hydrogen pipelines and/or repurpose the existing gas network to accommodate hydrogen in anticipation of a growing market.[25] Those would entail large investments in long-lived assets that require a clear near, mid and long-term business case. This is largely lacking as of today, due to the nascency of the hydrogen market, and such investments thereby remain premature – a case of putting the cart before the horse. In particular, there remain many uncertainties in relation to hydrogen's ultimate scope in the economy and the mid and long-term landscape of its supply and demand centers.[26] Recognizing the risks, an increasing group of stakeholders across Europe are now arguing for holding off on large-scale investments in hydrogen pipelines until a clear

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[23] M. W. Melaina, et.al, *Blending Hydrogen into Natural Gas Pipeline Networks: A Review of Key Issues*, NREL

[24] Camilla Naschert, EU hydrogen lobby group calls for guarantees of origin, downplays gas blending, S&P Global, June 2021, https://platform.marketintelligence.spglobal.com/web/client?#news/article?id=65119834&KeyProductLinkType=58&utm_source=MIAlerts&utm_medium=realtime-minewsresearch-newsfeature-energy%20and%20utilities-the%20daily%20dose&utm_campaign=Alert_Email

[25] Enagás, Energinet, Fluxug Belgium, Gasunie, GRTgaz, NET4GAS, OGE, ONTRAS, Snam, Swedegas, Teréga, *European Hydrogen Backbone*, July 2020, https://gasforclimate2050.eu/wp-content/uploads/2020/07/2020_European-Hydrogen-Backbone_Report.pdf

[26] Camilla Naschert, Hydrogen lobbying sets wrong priorities, says BloombergNEF founder, S&P Global, May 2021, https://platform.marketintelligence.spglobal.com/web/client?auth=inherit#news/article?KeyProductLinkType=2&id=64534120 ; Evans et. al, *In-Depth Q&A: Does the World Need Hydrogen to Solve Climate Change*, CarbonBrief

demand pattern has emerged.[27] Other groups have proposed to future-proof near-term investments in hydrogen pipelines or repurposing efforts by focusing on a small-scale buildout of pipelines around what are expected to be secure long-term hydrogen demand centers, and gradually expanding networks if and when an economic and climate case for such an expansion emerges[28]. Considering the possible scale of the investments and the risk that they become stranded, a judicious approach for California policymakers and regulators to consider would be to start by advancing green electrolytic hydrogen use in hubs – or a cohort of hydrogen suppliers and users situated in close proximity such that large-scale hydrogen transport infrastructure is unnecessary – and commission independent assessments investigating where new hydrogen networks or repurposing measures would be cost-effective, secure investments that carry low risks of becoming stranded.

V. RECOMMENDATIONS

A strategic vision for hydrogen deployment must start with a recognition that the hydrogen space is new and that a series of uncertainties still exist across its value chain in relation to the most expedient production, transport and use patterns. In addition, the hydrogen agenda is currently in part driven by vested interests of those with stakes in the technology's indiscriminate deployment, which may not align with the interests of Californians.[29] California policymakers should endeavor to future-proof hydrogen policies and investments by pursuing evidence-based decision-making that roots choices in independent studies and avoids an overeager leap to hydrogen that may engender unintended economic, public health and climate consequences to Californians. The following recommendations constitute the building blocks of a prudent hydrogen strategy:

1. **Identify hydrogen's strengths and limitations by way of an independent, system-wide assessment.**

[27] Camilla Naschert, Hydrogen lobbying sets wrong priorities, says BloombergNEF founder, S&P Global
[28] Agora Energiewende, *No-Regret Hydrogen*, February 2021, https://static.agora-energiewende.de/fileadmin/Projekte/2021/2021_02_EU_H2Grid/A-EW_203_No-regret-hydrogen_WEB.pdf; Climate Action Network Europe, *CAN Europe's Position on Hydrogen*, February 2021, https://caneurope.org/content/uploads/2021/02/CAN-Europe_position-on-hydrogen_February-2021.pdf
[29] Leigh Collins, *Liebreich: 'Oil sector is lobbying for inefficient hydrogen cars because it wants to delay electrification',* Recharge News

While hydrogen could act as a valuable complement to proven and established climate solutions like energy efficiency, renewable energy and electrification, evidence suggests that it will not be the most cost-effective nor efficient decarbonization pathway for many sectors. Therefore, a sensible and strategic hydrogen strategy should begin with a clear-eyed understanding of its strengths and limitations. California policymakers are advised to begin by commissioning independent and rigorous system-wide studies, subject to stakeholder input, evaluating applications where hydrogen offers value relative to other solutions in deep decarbonization pathways and where hydrogen deployment would deliver benefits to Californians and support the achievement of the state's climate goals. Such assessments could then constitute the bedrock of a state hydrogen strategy or roadmap guiding investments in a manner that is aligned with broader economic, public health and climate goals. SB 18 would direct state agencies to proceed with such a roadmap study. Governor Cuomo recently announced a planned collaboration between New York state agencies and the National Renewable Energy Laboratory on a hydrogen strategy study aiming to identify hydrogen opportunities and evaluating how those may be commensurate with broader renewable energy and climate goals.[30]

2. **Ensure that a hydrogen agenda does not derail necessary action on proven, readily available solutions that must be taken today.**

The promise of hydrogen should not delay, let alone be substituted for, necessary near-term steps to decarbonize California's economy. Policymakers are advised to proceed with the implementation of programs and policies targeting the large-scale deployment of clean electricity resources and widespread electrification of end-uses, notably buildings and passenger cars. Those are proven, cost-effective and readily available solutions and will be central pillars of any decarbonization strategy, regardless of the ultimate role of hydrogen.

[30] Office of the Governor, New York State, *Governor Cuomo Announces New York Will Explore Potential Role of Green electrolytic hydrogen as Part of Comprehensive Decarbonization Strategy*, July 2021, https://www.governor.ny.gov/news/governor-cuomo-announces-new-york-will-explore-potential-role-green-hydrogen-part

3. **Orient subsidies and support for hydrogen deployment towards applications where it adds the most value, commensurate with the system-wide assessment.**

State subsidies and support programs for hydrogen should be oriented to channel the deployment of hydrogen toward applications where it adds value relative to alternative solutions, in accordance with the system-wide analysis of deep decarbonization pathways. Policy mechanisms could include financial support for projects aiming to demonstrate and advance the use of hydrogen as a feedstock in steelmaking and chemicals manufacturing, supporting fleet demonstrations for hydrogen heavy duty trucks, and funding demonstrations of seasonal hydrogen storage. Widespread hydrogen deployment in buildings should be avoided on account of the large inefficiencies and potentially challenging infrastructure requirements relative to direct electrification.

4. **Orient investments, policy incentives and subsidies towards green electrolytic hydrogen.**

Blue and biomass-based hydrogen face challenging economics relative to green hydrogen and are linked with a set of critical climate, public health, and supply availability risks. California policymakers should therefore orient policy incentives and subsidies towards the deployment of green electrolytic hydrogen, harnessing the state’s large renewable energy potential.

5. **Exercise caution in relation to proposals for hydrogen blending, the repurposing of existing gas pipelines and the buildout of new hydrogen pipelines.**

California policymakers should exercise caution in relation to near-term proposals for blending hydrogen in the existing gas network, the repurposing of the existing network and the buildout of new hydrogen-dedicated pipelines. In particular, in considering blending proposals, policymakers should implement safeguards to limit hydrogen blending to low thresholds that warrant little to no investments in network upgrades. An equal level of prudence is warranted in considering proposals for the wholesale repurposing of existing pipelines or the buildout of a new hydrogen-dedicated network; as discussed above, such investments are largely premature as of today on account of the chain of uncertainties that permeate the long-term hydrogen vision and risk locking

Californians into expensive pathways or becoming stranded. Considering the risks, California policymakers should start by advancing green electrolytic hydrogen use in hubs, requiring no major hydrogen transport infrastructure. In parallel, policymakers should commission independent and transparent studies identifying future-proof and no-regret pipeline corridors – commensurate with secure future hydrogen demand centers teased out by the system-wide assessment – with the buy-in and meaningful participation of local communities.[31] Hydrogen pipeline networks could then be gradually expanded if and when a techno-economic and equity case for such an expansion emerges. Some European expert groups are now advocating for such sensible, no-regret early investments in hydrogen transport infrastructure.[32]

[31] Camilla Naschert, *Prioritizing heavy industry cuts stranded asset risk for hydrogen infrastructure* , S&P Global, February 2021, https://platform.marketintelligence.spglobal.com/web/client#news/article?KeyProductLinkType=2&id=62620184

[32] Agora Energiewende, *No-Regret Hydrogen*, February 2021, https://static.agora-energiewende.de/fileadmin/Projekte/2021/2021_02_EU_H2Grid/A-EW_203_No-regret-hydrogen_WEB.pdf