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March 25, 2025

California Air Resources Board
1001 I St.
Sacramento, CA 95814

Submitted via CARB's online Comment Submittal Form

Re: SB 1075 Report: Hydrogen Development, Deployment, and Use

The Center for Biological Diversity submits the following comments in response to California Air Resources Board's (CARB) Senate Bill 1075 Technical Analysis Workshop. While we appreciate Energy and Environmental Economics, Inc.'s (E3) overview of analyses being conducted on the feasibility of hydrogen deployment, we have fact-based concerns about the preliminary findings presented, specifically regarding the lifecycle assessment of hydrogen production pathways.

We disagree with E3's assumptions that forest and agricultural biomass feedstocks are carbon neutral and therefore that pairing biomass gasification with carbon capture and storage (CCS) makes this process carbon negative—since these assumptions are not grounded in science. We also disagree with E3's assumptions that CCS will perform in an idealized way, given the abundant real-world data on the repeated under-performance of CCS projects and inevitability of CO_2 leakage. We urge E3 to correct these errors and to thoroughly account for the greenhouse gas emissions, air pollution, high water usage, and environmental justice harms associated with biomass gasification projects to produce hydrogen. Moreover, we disagree with the assertion that biomethane can be a carbon negative feedstock.

E3 is assuming that produced methane is unavoidable, making its use beneficial. However, if biomethane use were instead compared to a regime that encouraged reductions in biomethane production through improved management practices, then the purported benefits of biomethane would likely be greatly reduced or eliminated.

In correcting these assumptions, we expect that E3 will conclude from its lifecycle analyses that electrolysis powered by clean, renewable solar and wind energy using the three pillars is the only carbon neutral, climate friendly method to make hydrogen.

We would like to request a meeting with the E3 modeling team to discuss the concerns that are detailed below.

1. **E3 must correct erroneous assumptions about the lifecycle GHG emissions of biomass gasification projects.**

The E3 modeling team makes two incorrect assumptions with respect to calculating lifecycle GHG emissions for biomass gasification projects: (1) assuming the biomass gasification process is "carbon neutral"; and (2) assuming that the addition of CCS can make biomass gasification carbon-negative:

> "Biomass gasification has a low carbon intensity because CO2 released is then absorbed by plants which are then gasified, leading to a net-neutral cycle. Adding CCS can make it carbon-negative."[1]

These assumptions are not scientifically valid, lead to significant under-estimates of emissions from the biomass gasification process, and must be corrected.

a. Biomass gasification is not "carbon neutral."

E3 assumes carbon neutrality for biomass gasification, stating that the "CO_2 released is then absorbed by plants which are then gasified, leading to a net-neutral cycle." This assumes that that biogenic CO_2 emissions released by gasification equal the biogenic CO_2 emissions that were captured during growth of the feedstock. This assertion of carbon neutrality—that gasification emissions are essentially pre-captured during feedstock growth—is not scientifically defensible and has been repeatedly rejected by scientific assessments.

The Environmental Protection Agency's Science Advisory Board, Intergovernmental Panel on Climate Change (IPCC), and numerous other scientific bodies have established that woody biomass feedstocks should not be assumed to be carbon neutral.[2] The Environmental Protection Agency's Scientific Advisory Board advised the agency that *no* type of biomass should be considered automatically carbon neutral.[3] That Board's opinion comports with assessments of the IPCC which has taken the position that "IPCC Guidelines do not automatically consider or assume biomass used for energy as 'carbon neutral,' even in cases where the biomass is thought to be produced sustainably."[4]

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[1] Analysis of Hydrogen in California for Senate Bill 1075 Report, E3 presentation to CARB, February 25, 2025, at Slide 14.
[2] Letter from John Beddington, et al. to EU Parliament regarding forest biomass (Jan. 9, 2018), http://empowerplants.files.wordpress.com/2018/01/scientist-letter-on-eu-forest-biomass-796-signatories-as-of-january-16-2018.pdf.
[3] Letter from Michael Honeycutt, U.S. EPA Sci. Advisory Bd., to Andrew Wheeler, U.S. EPA Administrator, SAB Review of Framework for Assessing Biogenic CO2 Emissions from Stationary Sources (Mar. 5, 2019), https://cfpub.epa.gov/si/si_public_file_download.cfm?p_download_id=539269&Lab=OAP at 2 ("not all biogenic emissions are carbon neutral nor net additional to the atmosphere, and assuming so is inconsistent with the underlying science").
[4] IPCC, Frequently Asked Questions, Intergovernmental Panel on Climate Change (IPCC) Task Force on National Greenhouse Gas Inventories, http://www.ipcc-nggip.iges.or.jp/faq/faq.html at Q2-10 ("The IPCC Guidelines do not automatically consider biomass used for energy as 'carbon neutral,' even if the biomass is thought to be produced sustainably)

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Rather than being carbon neutral, cutting and gasifying trees and forest residues (i.e. tree parts) releases their stored carbon to the atmosphere, immediately increasing CO_2 emissions and ending trees' future carbon sequestration (i.e., "foregone sequestration"), creating a "carbon debt."[5] To claim biomass energy is carbon neutral, proponents try to discount the released CO_2 by taking credit for the carbon that will be absorbed by future tree growth—claiming the carbon debt will eventually be repaid. This is misleading because forest regrowth takes time and is highly uncertain—there is no guarantee that cut forests will be allowed to grow back or that forests won't be converted to other land uses. Once trees are cut, numerous studies show it may take many decades to more than a century, if ever, to pay back the carbon that was released.[6]

Importantly, research also shows that forest "residues" or "waste" feedstocks—referring to biomass that would otherwise be disposed of—are also not carbon neutral. The combustion or gasification of forest residues leads to a *net increase* of carbon emissions in the atmosphere for decades.[7] One recent study found that combusting all wood types, including forest residues (defined as branches, tree tops and bark) and fire-killed trees, to generate electricity increases carbon emissions in the atmosphere for more than a century compared to generating that electricity with fossil gas,[8] and these conclusions would be similar for gasification since CO_2 is a primary product.

Lifecycle analyses must also fully account for the substantial upstream emissions from the biomass gasification process. These include emissions from the use of heavy machinery to

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[5] John Sterman et al., Does wood bioenergy help or harm the climate?, 78 Bulletin of the Atomic Scientists 128 (2022), DOI: 10.1080/00963402.2022.2062933.
[6] Manomet Ctr. for Conservation Scis., Massachusetts Biomass Sustainability and Carbon Policy Study: Report to the Commonwealth of Massachusetts Department of Energy Resources (2010), https://www.mass.gov/doc/manometbiomassreportfullhirezpdf/download; Hudiburg et al. T.W., Regional carbon dioxide implications of forest bioenergy production, 1 Nature Climate Change 419 (2011), https://doi.org/10.1038/nclimate1264; Law, B.E. & M.E. Harmon, Forest sector carbon management, measurement and verification, and discussion of policy related to climate change, 2 Carbon Mgmt. 73 (2011), https://doi.org/10.4155/cmt.10.40; Mitchell, S.R. et al., Carbon debt and carbon sequestration parity in forest bioenergy production, 4 Global Change Biology Bioenergy 818 (2012), https://doi.org/10.1111/j.1757-1707.2012.01173.x; Schulze, E.D. et al., Large-scale bioenergy from additional harvest of forest biomass is neither sustainable nor greenhouse gas neutral, 4 Global Change Biology Bioenergy 611 (2012), DOI:10.1111/j.1757-1707.2012.01169.x; Holtsmark, Bjart, The outcome is in the assumptions: Analyzing the effects on atmospheric CO_2 levels of increased use of bioenergy from forest biomass, 5 GCB Bioenergy 467 (2013), https://doi.org/10.1111/gcbb.12015; Sterman, John et al., Does replacing coal with wood lower CO_2 emissions? Dynamic lifecycle analysis of wood bioenergy, 13 Env't Rsch. Letters 015007 (2018), https://doi.org/10.1088/1748-9326/aaa512.
[7] Booth, Mary S. Not carbon neutral: Assessing the net emissions impact of residues burned for bioenergy, 13 Env't Rsch. Letters 035001 (2018), https://doi.org/10.1088/1748-9326/aaac88; Sterman, John et al., Does wood bioenergy help or harm the climate?, 78 Bulletin of the Atomic Scientists 128 (2022), https://doi.org/10.1080/00963402.2022.2062933.
[8] Laganiere, Jerome et al., Range and uncertainties in estimating delays in greenhouse gas mitigation potential of forest bioenergy sourced from Canadian forests, 9 GCB Bioenergy 358 (2017), https://doi.org/10.1111/gcbb.12327.

cut and extract trees from forests; the use of fertilizers and pesticides after cutting; transporting biomass often long distances in diesel trucks; and processing biomass through chipping and drying.[9] These upstream emissions, combined with the significant gasification emissions and foregone carbon sequestration resulting from cutting trees, make the gasification process significantly carbon-polluting rather than carbon neutral.

b. Biomass gasification with CCS is not "carbon negative."

The E3 modeling team states that putting CCS equipment on biomass gasification facilities will make biomass gasification "carbon negative." Because hydrogen made from biomass gasification is not "carbon neutral," adding CCS does not make it "carbon negative."[10] We are also concerned that E3 appears to assume that CCS will be effective in capturing and storing CO_2 emissions from biomass gasification, when real-world data shows otherwise, as detailed below.

2. CCS has proven to be ineffective and inefficient based on real-world data.

The E3 team incorrectly assumes that adding CCS will effectively capture and store CO_2 emissions from biomass gasification and livestock/dairy gas SMR and pyrolysis, making these polluting processes carbon negative. However, real-world data demonstrates that CCS has proven to be ineffective and inefficient in practice, despite decades of development and billions of dollars of investment.

First, it appears that the E3 team assumes an idealized 96% carbon capture rate[11] for CCS projects. However, real-world data shows that CCS projects around the world are not meeting their promised 90% to 95% carbon capture targets, often by large margins. According to one estimate, nearly 90% of proposed CCS capacity in the power sector has either failed during implementation or has otherwise been suspended early.[12] An example is the billion-dollar Petra Nova carbon capture facility in Texas which was shuttered after only 4 years. Though it promised a CO_2 capture rate of 90%, when factoring in emissions from the gas-fired combustion turbine used to power the facility, it substantially underperformed this benchmark.[13] Meanwhile,

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[9] Roder, Mirjam et al., How certain are greenhouse gas reductions from bioenergy? Life cycle assessment and uncertainty analysis of wood pellet-to-electricity supply chains from forest residues, 79 Biomass and Bioenergy 50 (2015), DOI: 10.1016/j.biombioe.2015.03.030.
[10] https://www.biofuelwatch.org.uk/wp-content/uploads/BECCS-letter-by-scientists-and-economists-1.pdf.
[11] Analysis of Hydrogen in California for Senate Bill 1075 Report, E3 presentation to CARB, February 25, 2025, at Slide 14.
[12] IEEFA, The carbon capture crux: Lessons learned (Sept. 2022), https://ieefa.org/resources/carbon-capture-crux-lessons-learned.
[13] Mattei, S. and Schlissel, D. The ill-fated Petra Nova CCS project: NRG Energy throws in the towel, IEEFA (October 5, 2022), https://ieefa.org/resources/ill-fated-petra-nova-ccs-project-nrg-energy-throws-towel; IEEFA, The carbon capture crux: Lessons learned (Sept. 2022), https://ieefa.org/resources/carbon-capture-crux-lessons-learned.

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internationally, Chevron, operator of Australia's only commercial-scale CCS project, admitted that it failed to meet its five-year capture target of 80% CO_2 and faced the ire of regulators for allowing millions more tons of CO_2 to be emitted than promised.[14] In short, evidence shows that the idealized carbon capture rates used by E3 are not realistic and substantially under-estimate the carbon emissions from CCS projects.

In fact, studies show that when the lifecycle greenhouse gas emissions of CCS projects are taken into account, the purported climate benefits of CCS evaporate.[15] For one, CCS operations are very energy-intensive given the high energy requirements needed to separate, compress, transport, and inject CO_2—typically requiring at least 15-25% more energy, which results in increased greenhouse gas and air pollution emissions.[16] Analysis from the Institute for Energy Economics and Financial Analysis found that the energy required to capture, transport, and inject carbon underground "materially reduces its net benefit."[17] A lifecycle analysis of the Petra Nova CCS project found that "the [CCS] equipment captured the equivalent of only 10-11% of the emissions they produced, averaged over 20 years."[18]

There is also the inevitable risk that captured CO_2 transported via pipeline, rail, or truck, and then stored underground, will leak back to the atmosphere. CO_2 pipelines have a history of rupturing which not only releases captured CO_2 to the atmosphere but poses serious public health and safety risks.[19] In 2020, for example, residents of rural Satartia, Mississippi experienced a CO_2 pipeline rupture that resulted in more than 300 residents being evacuated and 46

[14] Adam Morton, The Guardian, "'A shocking failure': Chevron criticized for missing carbon capture target at WA gas project" (Jul. 2021), https://www.theguardian.com/environment/2021/jul/20/a-shocking-failure-chevron-criticised-for-missing-carbon-capture-target-at-wa-gas-project.

[15] Jacobson, M.Z., The health and climate impacts of carbon capture and direct air capture, 12 Energy Environ Sci 3567 (2019); Howarth, R.W. & M.Z. Jacobson, How green is blue hydrogen? 9 Energy Science & Engineering 1676 (2021); Grubert, E. & F. Sawyer, US power sector carbon capture and storage under the Inflation Reduction Act could be costly with limited or negative abatement potential, 3 Environmental Research: Infrastructure and Sustainability 015008 (2023); Jacobson, M.Z. et al., Energy, Health, and Climate Costs of Carbon-Capture and Direct-Air-Capture versus 100%-Wind-Water-Solar Climate Policies in 149 Countries, 59 Environ Sci Technol 3034 (2025)

[16] Climate Action Network International, Position: Carbon Capture, Storage, and Utilisation (January 2021), https://climatenetwork.org/resource/can-position-carbon-capture-storage-and-utilisation/; IEEFA, The carbon capture crux: Lessons learned (Sept. 2022), https://ieefa.org/resources/carbon-capture-crux-lessons-learned.

[17] Clark Butler, IEEFA, "Carbon Capture and Storage Is About Reputation, Not Economics" at 4 (2020), https://ieefa.org/wp-content/uploads/2020/07/CCS-Is-About-Reputation-Not-Economics_July-2020.pdf.

[18] Jacobson, M.Z, The health and climate impacts of carbon capture and direct air capture, 12 Energy Environ Sci 3567 (2019).

[19] Pipeline Safety Trust, Regulatory and Knowledge Gaps in the Safe Transportation of Carbon Dioxide by Pipeline (2022), https://pstrust.org/wp-content/uploads/2022/10/CO2-Regulatory-and-Knowledge-Gaps-1.pdf; Dan Zegert, Huffington Post, "The Gassing of Satartia" (Aug. 2021), https://www.huffpost.com/entry/gassing-satartia-mississippi-co2-pipeline_n_60ddea9fe4b0ddef8b0ddc8f; Sarah Fowler, 'Foaming at the mouth': First responders describe scene after pipeline rupture, gas leak, The Clarion-Ledger (February 27, 2020), https://www.clarionledger.com/story/news/local/2020/02/27/yazoo-county-pipe-rupture-co-2-gas-leak-first-responders-rescues/4871726002/.

hospitalized, with victims found gasping for breath, nauseated, foaming at the mouth, and rendered unconscious. Months later, residents continued to suffer from mental fogginess, lung dysfunction, chronic fatigue, and stomach disorders.[20] Such risks are unwarranted for the sake of an unsafe and unproven technology. Carbon capture projects similarly have a history of leakage. For instance, an ethanol CCS project in Decatur, Illinois, run by the Archer Daniels Midland agribusiness company, leaked CO_2 because of the monitoring wells' corrosion-prone steel lining.[21] This is on top of the project already proving to be inefficient, only storing half the emissions the company projected,[22] amounting to a mere 10-12% of the facility's annual emissions.[23]

3. **E3 must thoroughly account for the air pollution, high water usage, environmental justice harms, and forest ecosystem harms from biomass gasification projects to produce hydrogen.**

Biomass gasification not only produces large amounts of climate-heating CO_2, but also health-harming co-pollutants that must be accounted for. Gasification of biomass at high temperatures (800-1200°C) produces a "syngas" containing large amounts of CO_2, as well as methane (CH_4), carbon monoxide (CO), and hydrogen (H_2), in addition to liquid hydrocarbons and tar, solid char and ash residues, and air pollutants.[24] Heath-harming pollutants from biomass gasification including fine particulate matter, NOx, SOx, benzene, toluene and xylenes (BTEX), tars and soot, and persistent organic pollutants such as polycyclic aromatic hydrocarbons (PAHs) (*e.g.*, naphthalene), polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs).[25] Fine

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[20] Dan Zegert, Huffington Post, "The Gassing of Satartia" (Aug. 2021), https://www.huffpost.com/entry/gassing-satartia-mississippi-co2-pipeline_n_60ddea9fe4b0ddef8b0ddc8f.

[21] Annie Snider & Ben Lefebvre, E&E News, "Carbon storage projects hit a hurdle: Corroding steel (Oct. 2024), https://subscriber.politicopro.com/article/eenews/2024/10/09/carbon-storage-projects-hit-a-hurdle-corroding-steel-ee-00182889.

[22] Jonathan Hettinger, Investigate Midwest, "Despite hundreds of millions in tax dollars, ADM's carbon capture program still hasn't met promised goals (Nov. 2020), https://investigatemidwest.org/2020/11/19/despite-hundreds-of-millions-in-tax-dollars-adms-carbon-capture-program-still-hasnt-met-promised-goals/.

[23] Brendan Gibbons, Oil & Gas Watch, "In Illinois, a massive taxpayer-funded carbon capture project fails to capture about 90 percent of plant's emissions (Apr. 2024), https://news.oilandgaswatch.org/post/in-illinois-a-massive-taxpayer-funded-carbon-capture-project-fails-to-capture-about-90-percent-of-plants-emissions.

[24] Shayan, E. et al., Hydrogen production from biomass gasification; a theoretical comparison of using different gasification agents, 159 Energy Conversion and Management 30 (2018), https://doi.org/10.1016/j.enconman.2017.12.096.

[25] Partnership for Policy Integrity, Air pollution from biomass energy, https://www.pfpi.net/air-pollution-2/; Liu, Wu-Jun et al., Fates of chemical elements in biomass during its pyrolysis, 117 Chemical Reviews 6367 (2017), https://pubs.acs.org/doi/10.1021/acs.chemrev.6b00647; Yao, Zhiyi et al., Particulate emissions from the gasification and pyrolysis of biomass: Concentration, size distributions, respiratory deposition-based control measure evaluation, 242 Envtl. Pollution 1108 (2018), https://doi.org/10.1016/j.envpol.2018.07.126; Saxe, Jennie Perey et al., Just or bust? Energy justice and the impacts of siting solar pyrolysis biochar production facilities, 58 Energy Research & Social Sci. 101259 (2019) https://doi.org/10.1016/j.erss.2019.101259; Pang, Yoong Xin et al., Analysis of environmental impacts and energy derivation potential of biomass pyrolysis via piper diagram, 154 J. of Analytical and Applied Pyrolysis 104995 (2021), https://doi.org/10.1016/j.jaap.2020.104995; Li, Simeng, Reviewing Air

particulate matter (PM 2.5) that can penetrate deeply into the lungs, even enter the bloodstream, and cause serious health problems. The formation of liquid tar is an inherent problem in biomass gasification. Tar contains toxic substances such as benzene, toluene, and naphthalene, while tar build-up also lowers energy efficiency, interrupts continuous operation, and increases maintenance costs of gasification processes.[26] Methods to clean tar from equipment would create large amounts of toxic wastewater, with resulting environmental and community harms.[27]

We appreciate that E3 will be evaluating water usage from different hydrogen production methods. Biomass gasification to produce hydrogen has extremely high water usage. One recent study estimated that biomass gasification uses 306 kg water per kg of H_2 produced, which is orders of magnitude more than electrolysis production pathways estimated at 9 to 18 kg water per kg H_2.[28] This would put extra stress on water supplies in areas already suffering from climate crisis-charged drought.

Proposals to produce hydrogen from woody biomass frequently (if not nearly exclusively) target environmental justice communities already overburdened with pollution. For example, in California's Central Valley—which has some of nation's worst air pollution—idled bioenergy facilities in or near communities, such as the Madera biomass facility, are being proposed for conversion to biomass gasification or pyrolysis facilities to produce hydrogen, threatening to worsen environmental injustice for these communities.[29] Another recent proposal envisions a massive build-out of 50 to 100 biomass processing facilities—many of them biomass gasification and pyrolysis facilities—that would be concentrated in the Central Valley, paired with a polluting network of CO_2 pipelines, railcars, and trucking, and the injection of 100 million tons of CO_2 underground each year,[30] with inevitable harms from air pollution, water pollution, noise pollution, CO_2 leakage, earthquake risks, and ecosystem damage.

Incentivizing the production and commodification of hydrogen from woody biomass is likely to increase forest logging and thinning, harming forest ecosystems and their carbon storage. Logging/thinning forests degrades wildlife habitat and results in a net loss of carbon storage and sequestration from forests, at a time when we must reduce deforestation and protect

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Pollutants Generated during the Pyrolysis of Solid Waste for Biofuel and Biochar Production: Toward Cleaner Production Practices, 16 Sustainability 1169 (2024), https://doi.org/10.3390/su16031169.

[26] He, Quing et al., Soot formation during biomass gasification: A critical review, 139 Renewable and Sustainable Energy Reviews 110710 (2021), https://doi.org/10.1016/j.rser.2021.110710.

[27] Luo, Xiang et al., "Biomass gasification: an overview of technological barriers and socio-environmental impact" in Gasification for Low-Grade Feedstock 1-15 (2018), https://www.intechopen.com/chapters/59423.

[28] Mehmeti, Andi et al., Life cycle assessment and water footprint of hydrogen production methods: from conventional to emerging technologies, 5 Environments 24 (2018).

[29] Clean Energy Systems, Clean Energy Systems Enters Into An Agreement to Acquire the Madera Biomass Power Plant (Jul. 12, 2022), https://www.cleanenergysystems.com/clean-energy-systems-enters-into-an-agreement-to-acquire-the-madera-biomass-power-plant.

[30] LLNL and DOE, Getting to Neutral: Options for Negative Carbon Emissions in California (2019), available at https://livermorelabfoundation.org/2019/12/19/getting-to-neutral/.

forest carbon stores.[31] Numerous studies show that broad-scale thinning for wildfire management (e.g., thinning to reduce wildfire severity or amount) results in more carbon emissions than it prevents from being released in a wildfire, leading to a net increase of carbon emissions to the atmosphere and net decrease in forest carbon storage.[32] Logging and thinning forests and gasifying those woody materials for hydrogen production would: 1) increase overall carbon emissions, 2) reduce the forest carbon sink, and 3) require massive public subsidies, reducing resources for truly low-carbon solar and wind energy.

4. The assertion that biomethane can be carbon negative is based upon a faulty premise.

In the workshop, E3 asserts that biomethane can be carbon negative when compared to the alternative of methane from degrading waste escaping to the atmosphere. This assertion presumes produced methane is unavoidable, which need not be the case. For example, much of the manure methane emissions that come from dairies results from the choice to intentionally liquify manure, though that is only one of multiple available manure management methods. Only the liquified manure management method produces the methane gas that is so lucrative under California's Low Carbon Fuel Standard (LCFS) incentives.[33] Evidence suggests other viable manure management methods (e.g., solid-liquid separation, scrape and vacuum collection of manure, composting, and pasture-based practices) are preferable to open-air lagoons and liquid manure for their cost-effective methane emissions reductions, and other environmental and health benefits.[34]

Uplifting biomethane for use in hydrogen production will likely lead to unsustainable reliance upon (and will incentivize the production of) this resource from dairies, landfills, and wastewater facilities. Further, increased methane use to produce hydrogen increases the risks for methane leakage. A study of biogas plants found that leaked methane can be as high as 14.9% of

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[31] Moomaw, William R. et al., Intact Forests in the United States: Proforestation mitigates climate change and serves the greatest good, Frontiers in Forests and Global Change (2019), https://doi.org/10.3389/ffgc.2019.00027

[32] Campbell, J.L. et al., Can fuel-reduction treatments really increase forest carbon storage in the western US by reducing future fire emissions? 10 Frontiers in Ecology and Environment 83 (2012); Bartowitz, Kristina J. et al., Forest carbon emission sources are not equal: putting fire, harvest, and fossil fuel emissions in context, 5 Frontiers in Forests and Global Change 867112 (2022), https://doi.org/10.3389/ffgc.2022.867112; Law, Beverly E. at al., Creating strategic reserves to protect forest carbon and reduce biodiversity losses in the United States, 11 Land 721 (2022), https://doi.org/10.3390/land11050721.

[33] *Animal Agriculture in the U.S. – Trends in Production and Manure Management*, Livestock and Poultry Env't Learning Cmty (2019), available at https://lpelc.org/animal-agriculture-in-the-u-s-trends-in-production-and-manure-management/.

[34] CAL. AIR RES. BD., *Findings and Recommendations: Subgroup 1: Fostering Markets for Non-digester Projects, Senate Bill 1383 Dairy and Livestock Working Group* 3 (Oct. 12, 2018), available at https://ww2.arb.ca.gov/sites/default/files/2020-11/dsg1_final_recommendations_11-26-18.pdf.

total methane production.[35] Another study found that renewable natural gas from intentionally produced methane — as is the case with dairy methane — is always a net greenhouse gas emitter, unless total system leakage is zero.[36] The utilization of 'waste' methane does not guarantee an overall reduction in methane emissions. The only sure way to reduce methane emissions is to eliminate them at the source, such as through reformed agricultural practices and, at the wider scale, the rapid phase out of fossil fuels. To reduce emissions from waste, our focus should be to reduce waste, not to create a profitable market for waste-based biogenic sources, where incentives will likely increase their production and resultant pollution.

Relying upon waste streams for energy feedstocks risks hindering crucial efforts to reduce waste and reuse, recycle, and compost.[37] Incentivizing profit in waste pollution incentivizes its production. We can regulate and otherwise reduce methane emissions without commodifying them (as CARB has been directed to do, per SB 1383 (2016)[38]). Utilizing biomethane for hydrogen production runs directly counter to this aim.

Because E3's lifecycle analysis compares using biomethane for hydrogen production to business-as-usual management practices, it overestimates the potential emissions benefits. If biomethane use were instead compared to a regime of management that encouraged the reduction in biomethane production at the source (e.g. livestock/dairy operations), purported benefits would likely be greatly reduced if not outright eliminated.

5. **Insofar as hydrogen is needed at all, the only carbon neutral method to produce it is using electrolysis powered by clean, renewable solar and wind energy.**

E3's lifecycle analysis compares the use of SMR, gasification, and pyrolysis for hydrogen production to the use of electrolysis and finds in many scenarios that electrolysis underperforms in terms of emissions reductions. This is the case both when the energy mix powering electrolysis is the 2025 grid and the 2045 grid. However, the analysis does find electrolysis to be carbon neutral when solar energy is used, and rightly so. This reflects the benefit of employing the three pillars— hourly matching, deliverability, and additionality — in the process of renewable-fueled electrolysis.[39] When hydrogen production proceeds where hydrogen generators

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[35] Scheutz, Charlotte & Anders M. Fredenslund, *Total methane emission rates and losses from 23 gas plants,* 97 Waste Mgmt. 38-46 (2019), https://doi.org/10.1016/j.wasman.2019.07.029.
[36] Grubert, Emily, *At scale, renewable natural gas systems could be climate intensive: the influence of methane feedstock and leakage rates,* 15 Envtl. Research Letters 8 (2020), https://iopscience.iop.org/article/10.1088/1748-9326/ab9335.
[37] Waste reduction is the preferred management method in the Environmental Protection Agency's waste management hierarchy for decision-making. Env't Prot. Agency, *Waste Management Hierarchy and Homeland Security Incidents,* https://www.epa.gov/homeland-security-waste/waste-management-hierarchy-and-homeland-security-incidents.
[38] SB 1383 (2016), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB1383.
[39] Ricks, Jenkins, *The Cost of Clean Hydrogen with Robust Emission Standards: A Comparison Across Studies,* Princeton University Zero-carbon Energy Systems Research and Optimization Laboratory (2023), https://subscriber.politicopro.com/f/?id=00000187-9bb4-daaa-a5e7-bfbfff120000; Dan Esposito et al., *Smart Design of 45V Hydrogen Production Tax Credit Will Reduce Emissions and Grow the Industry,* Energy Innovation Policy &

are powered by *new* sources of zero-emissions electricity (additionality) that directly supply the grid electrolyzers are connected to (deliverability), within the same hour that generators are running (hourly matching), it is proven to be the cleanest production method. Further, it does not draw much needed renewables from other uses. E3's lifecycle analysis should explicitly name and characterize the three pillars as a required condition of electrolysis-produced hydrogen. With the three pillars, electrolysis-produced hydrogen clearly outperforms other forms of production in terms of overall GHG-emissions avoided.

Yet, even hydrogen produced using clean, renewable energy (i.e., excluding biomass and biogas, and adhering to the three pillars) should play only a limited role in a carbon-free future, given the risks it carries. First, hydrogen is a potent, indirect greenhouse gas with 100 times the warming power of CO_2 over a 10-year period and 33 times over 20 years.[40] As a small molecule, hydrogen is more leakage-prone than methane, posing climate risks across the production and supply chains. Also, transporting hydrogen through pipelines is more dangerous than transporting methane: it is more likely to explode, burns hotter, and is more corrosive to pipelines.[41] And all forms of hydrogen production use massive amounts of water — much more than solar and wind per unit of energy produced — which will put extra stress on water supplies in areas already suffering from climate crisis-charged drought.[42] We appreciate how E3 apparently plans to include such considerations in its final analysis, through which we expect E3 will reach similar conclusions on hydrogen's feasibility as a prominent energy vehicle.

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We are grateful for the opportunity to provide these comments and would appreciate meeting with the E3 modeling team to discuss further.

Sincerely,

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Technology (2023); Ben Haley & Jeremy Hargreaves, *Three-Pillars Accounting Impact Analysis,* Evolved Energy Research (2023), https://www.evolved.energy/post/45v-three-pillars-impact-analysis.

[40] Ocko, I.B. and Hamburg, S. P., Climate consequences of hydrogen emissions, 22 Atmos. Chem. Phys. 9349 (2022).

[41] Pipeline Safety Trust, Hydrogen Pipeline Safety, Summary for Policymakers (2023), https://pstrust.org/wp-content/uploads/2023/01/hydrogen_pipeline_safety_summary_1_18_23.pdf.

[42] DiFelice, M. and Murray, B., Exposing a New Threat to Our Water: Hydrogen Power, Food & Water Watch (2023), https://www.foodandwaterwatch.org/2023/02/07/hydrogen-water-use/.