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Re: Comments on 2022 Scoping Plan Update (Scenario Concepts Technical Workshop) – Considering the Role of Engineered Carbon Dioxide Removal (CDR) Technologies in Modeling Scenarios

To the California Air Resources Board (CARB) team,

The undersigned thank you for the opportunity to provide feedback comments in relation to the development of modeling scenarios that will inform the 2022 Scoping Plan Update. With this letter, we comment on the role of engineered carbon dioxide removal (CDR) technologies in the modeling scenarios, including bioenergy with carbon capture and storage (BECCS) and direct air capture (DAC).

We recommend that modeling scenarios include both BECCS and DAC for the purpose of achieving net-zero emissions by 2045 or sooner, and net-negative emissions thereafter. We recommend that CARB explore a range of options for engineered CDR deployment, including limited deployment to compensate for hard-to-abate sources only, to more extensive deployment that would drive California into meaningful (i.e., 20 $MtCO_2e$ or more) net-negative emission levels per year by 2045. We recommend that CARB quantify the regional economic development, job creation, and environmental benefits of these scenarios. To the extent feasible, CARB should consider the counterfactual fate of biomass waste feedstocks, and measure environmental benefits relative to a business-as-usual scenario.

Recent research has shown that for California to achieve net-zero emissions by 2045, both aggressive emission reductions as well as some engineered CDR will be required. Reports by Energy and Environmental Economics[1] and Lawrence Livermore National Laboratory (LLNL)[2] estimate a need for engineered CDR ranging from a minimum of about 30 $MtCO_2e$ per year to a potential of almost 100 $MtCO_2e$ per year by midcentury. As engineered CDR options are relatively newer, public investment is

[1] Energy and Environmental Economics (2020). "Achieving Carbon Neutrality in California – PATHWAYS Scenarios Developed for the California Air Resources Board". https://ww2.arb.ca.gov/sites/default/files/2020-10/e3_cn_final_report_oct2020_0.pdf
[2] Baker, S., Stolaroff, J.K, Peridas, G. et al. (2020). "Getting to Neutral: Options for Negative Carbon Emissions in California". Lawrence Livermore National Laboratory. https://www-gs.llnl.gov/content/assets/docs/energy/Getting_to_Neutral.pdf

essential to push these technologies down the cost curve; so that they might be a real option for deployment to support California's climate goals.[3] Engineered CDR is also necessary to achieve meaningful and reliable net-negative emissions. There is a compelling ethical argument that developed economies like California should take responsibility for removing such legacy or historic CO_2 emissions from the atmosphere.[4]

At the federal level, both the White House[5] and Department of Energy[6] (DOE) have demonstrated a clear commitment to support the research, development and demonstration of engineered CDR technologies. The $1 trillion bipartisan infrastructure bill includes earmarks of more than $8 billion for carbon capture and storage (CCS) technology, which includes engineered CDR options.[7]

California is extremely well-positioned to partner with the federal government on CCS and CDR. Specifically, in their recent groundbreaking *Net-Zero America* study Princeton University highlighted the opportunity for deploying large-scale CO_2 storage in the Central Valley for the purpose of achieving a national net-zero emissions by 2050 goal.[8] This is because there are no other locations west of the Rocky Mountains that are comparably suitable to geologically store CO_2 safely, effectively, and at scale (Fig. 1). California's world-class geology gives the state the opportunity to position itself as a regional CO_2 storage hub to support deep decarbonization of the American West. CARB could model a range of engineered CDR deployment scenarios on this basis. A number of recent analyses have highlighted the importance of large-scale CCS deployment to support California's mitigation goals.[9,10]

California has favorable attributes for deploying engineered CDR, with the possibility of creating a host of important environmental and social co-benefits.[11] In the case of BECCS, diverting California's abundance of biomass waste streams that are otherwise mostly openly burned, landfilled, or left to decompose in fields could avoid severe air quality and greenhouse gas (GHG) emissions, including of short-lived climate "super pollutants" in the forms of methane and black carbon.[12,13,14] This volume of

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[3] van Vuuren, D.P., Hof, A.F., van Sluisveld, M.A.E. et al. (2017). Open discussion of negative emissions is urgently needed. *Nature Energy* 2, 902–904. https://doi.org/10.1038/s41560-017-0055-2

[4] Batres, M., Wang, F.M., Buck, H. et al. (2020). Environmental and climate justice and technological carbon removal. *The Electricity Journal*. https://www.sciencedirect.com/science/article/pii/S1040619021000932

[5] White House Council on Environmental Quality (2021). Report to Congress on Carbon Capture, Utilization, and Sequestration. https://www.whitehouse.gov/wp-content/uploads/2021/06/CEQ-CCUS-Permitting-Report.pdf

[6] Department of Energy, Office of Fossil Energy and Carbon Management. (2021). Combatting the Climate Crisis with Carbon Capture and Storage Technology https://www.energy.gov/fe/articles/combatting-climate-crisis-carbon-capture-and-storage-technology

[7] Congressional Infrastructure Bill. H.R. 3684, Pages 1491 – 1543. (2021). https://drive.google.com/file/d/1XmTwQj4sk3IU5W5_QqOQBXcGJ_P8790H/view

[8] Larson, E.D., Greig, C., Jenkins, J.D. et al. (2020). "Net-Zero America: Potential Pathways, Infrastructure, and Impacts." Princeton University. https://netzeroamerica.princeton.edu/the-report.

[9] Energy Futures Initiative and Stanford University. (2020). "An Action Plan for Carbon Capture and Storage in California: Opportunities, Challenges, and Solutions." https://sccs.stanford.edu/sites/g/files/sbiybj7741/f/efi-stanford-ca-ccs-full-rev1.vf-10.25.20.pdf

[10] Long, J.C.S., Baik, E., Jenkins, J.D. et al. (2021). "California needs clean firm power, and so does the rest of the world." Issues in Science and Technology. https://issues.org/california-decarbonizing-power-wind-solar-nuclear-gas/.

[11] Uden, S., Dargusch, P. & Greig, C. (2021). Cutting through the noise on negative emissions. *Joule*. https://www.sciencedirect.com/science/article/abs/pii/S2542435121003019

[12] Kammen, D.M., Matlock, T., Pastor, M. et al. (2021). Accelerating the Timeline for Climate Action in California. https://arxiv.org/abs/2103.07801.

waste is anticipated to increase substantially, owing to the state's goal to increase its level of wildfire fuels reduction treatments to one million acres per year by 2025.[13] By collecting the residue byproducts of sustainable forest management and converting them into carbon-negative liquid and gaseous transportation fuels, BECCS strategies can reduce wildfire risk, severity, and emissions in the state.[15] In the case of direct air capture (DAC), it is possible that California could pioneer 'renewable DAC' by coupling the technology with geothermal heat and power at the Salton Sea.[16] This not only presents a major climate leadership opportunity for California, but could also create jobs and enhance local tax revenues in the Imperial Valley to support air quality, public health, and other local priorities in disadvantaged communities. Finally, deployment of CO_2 transport and storage networks could allow at-risk oil and gas workers to repurpose their skills in CO_2 geologic assessment, project siting, drill rig and CO_2 pipeline construction and operation, and synthetic or biofuels refining, distribution and storage.

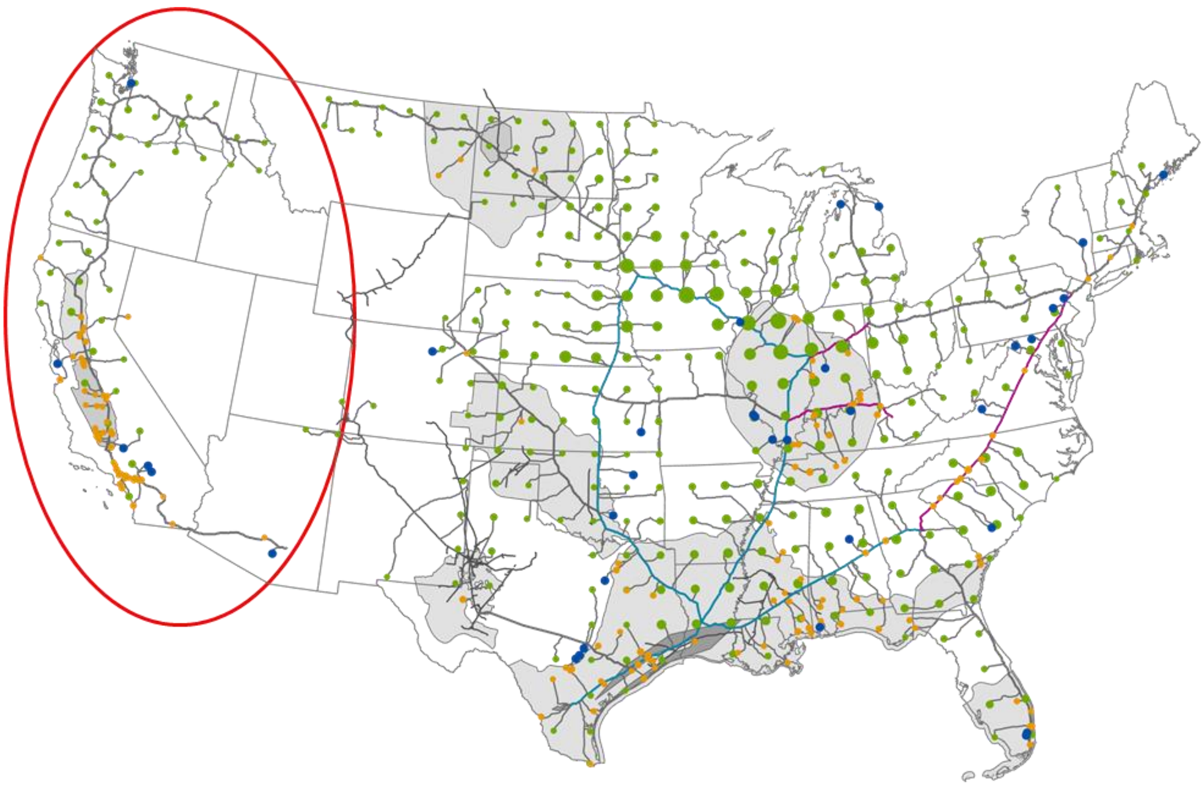

Fig. 1*: This diagram illustrates the extensive CO_2 transport and storage networks necessary to achieve net-zero emissions in the U.S. by 2050. The red circle highlights how the only reliable CO_2 storage sites in the American West are in California (shaded in grey). Due to the Rocky Mountain range, a separate Western States CO_2 transport and storage network is required. Therefore, CA's ability to deploy CCS is not only important for state goals, but also national goals.* ***Source****: Princeton University (2020)*

[13] Governor's Forest Management Task Force. (2021). "California's Wildfire and Forest Resilience Action Plan." https://www.fire.ca.gov/media/ps4p2vck/californiawildfireandforestresilienceactionplan.pdf

[14] California Air Resources Board. (2021). Staff Recommendations: San Joaquin Valley Agricultural Burning Assessment. https://ww2.arb.ca.gov/sites/default/files/2021-02/Staff_Recommendations_SJV_Ag_Burn.pdf

[15] For further information, see the forthcoming Joint Institute for Wood Products Innovation's Collaborative Action on Forest Biofuels Working Group report, which identifies current policy barriers and provides more detailed commentary on how scaling carbon-negative forest biofuels supply chains can align the state's forest treatment, climate mitigation, and air quality goals.

[16] Baker, S., Stolaroff, J.K, Peridas, G. et al. (2020). "Getting to Neutral: Options for Negative Carbon Emissions in California". Lawrence Livermore National Laboratory. https://www-gs.llnl.gov/content/assets/docs/energy/Getting_to_Neutral.pdf

Overall, LLNL estimated that a full-scale build-out of carbon-negative biofuels supply chains plus some renewable DAC at the Salton Sea in California could provide a significant **150 million tons of GHG mitigation per year** to support the state's ambition to achieve net-zero emissions by 2045. This underscores the importance of incorporating engineered CDR into the 2022 Scoping Plan Update modeling scenarios. As it is unclear what combination of mitigation options will prove to be viable for California to achieve its climate goals over time, it is important that as many options as possible, particularly those with substantial potential, are kept on the table.[11]

Summary of Recommendations

We provide a summary of key recommendations in response to the specific proposals provided by CARB staff in the Scenario Concepts Technical Workshop. While this comment letter has focused on the role of engineered CDR, there are additional and related recommendations we provide below:

- **Net-Zero Emissions Time Frame Options (slide 12)** – We recommend that CARB model scenarios that achieve net-zero emissions by 2045, via pathways that both meet and exceed the SB 32 target of 40% below 1990 levels by 2030. We recommend that CARB consider additional scenario(s) that achieve meaningful (i.e., 20 $MtCO_2e$ or more) net-negative emission levels by 2045. This could be part of a net-zero by 2035 scenario(s), or alternate scenario(s). The importance of this scenario is that it sets an explicit ambition for the state to achieve net-negative emissions by 2045.

- **Role of Engineered Carbon Removal (slides 13 and 14) –** We recommend that CARB include both CCS (i.e., paired with existing large emission sources) and CDR (i.e., BECCS and DAC) in modeling scenarios. We recommend that CARB model at least Options B, C, and D.

  Separately, we recommend that CARB consider revising its language that sometimes jointly refers to both CCS and CDR as "carbon removal". This is because CCS typically involves preventing emissions into the atmosphere, while CDR involves physically removing CO_2 from the atmosphere. Both achieve climate change mitigation, however, the way they do so creates different implications (e.g. fossil CCS cannot facilitate economies into net-negative emissions).

- **Carbon Free Electricity Grid (slides 15 and 16)** – We recommend that CARB use "all available technologies" to get to net-zero, including biomass waste-derived green hydrogen, renewable natural gas, and CCS. Due to deep uncertainty in energy transitions, it is a significant risk to rule out proven decarbonization technologies. For example, due to unforeseen limitations in hydro power capacity due to drought coupled with persistently high energy demand in the summer months, California recently approved the construction of five new gas power plants. To be prepared to respond to other unexpected events in the future (and to not generate emissions at the same time), a variety of "firm" carbon-free electricity options should be considered.

- **Petroleum Fuels (slides 21 and 22)** – We recommend that CARB model the production of renewable biofuels from biomass waste that is collected, converted, and refined in-state. Such biofuels can support the transition from fossil-based petroleum fuels in hard-to-abate transportation applications, including aviation, shipping, and some long-haul trucking. We recommend that CARB also consider DAC-to-fuels as part of modeling scenarios.

- **Short-Lived Climate Pollutant Methane (slides 23 and 24)** – We recommend that CARB include biomass-derived fuels from landfills and dairies in modeling scenarios to net-zero emissions.

- **Woody Biomass and Solid Biomass Waste (slides 25 and 26)** – We recommend that biomass waste play a key role in producing low-carbon and carbon-negative energy in California, including notably liquid and gaseous fuels such as green hydrogen, renewable natural gas, sustainable aviation fuel, renewable diesel, cellulosic ethanol, and more. LLNL estimates that more than 50 million bone dry tons of woody forest and agricultural residues and municipal solid waste is produced annually in California. As of today, this waste is mostly open burned, landfilled, or left to decay in fields. Collecting and converting this waste into biofuels presents a significant and sustainable pathway to deep decarbonization in California with important air quality and wildfire co-benefits. CARB should explore modeling scenarios whereby both a significant portion (e.g., 70%) and all (i.e., 100%) of this biomass waste is converted into energy.

- **Environmental Impact Analysis –** To the extent feasible, we recommend that CARB assess the environmental impact of zero or limited engineered CDR scenarios relative to scenarios that include a large-scale deployment of engineered CDR. We recommend that CARB quantify the air quality benefits associated with collecting and converting waste biomass into carbon-negative liquid and gaseous fuels relative to the current status quo of open burning, landfilling, and decay of the waste biomass and fossil fuel use. We recommend that CARB also consider the land-use benefits provided by containing BECCS and DAC within net-zero emission portfolios. Finally, we recommend that CARB consider the wildfire risk reduction benefits associated with producing forest biofuels in California, which can feasibly support the state's ambition to treat one million forested acres per year by 2025 and continuing thereafter.

- **Jobs and Economic Development Analysis –** We recommend that CARB consider the economic development and job creation and retention impacts of BECCS and DAC deployment in California on a regional basis. Such an analysis should track impacts along the supply chain, ranging from biomass collection (including in the case of forest residues, forest treatment work), transportation, biomass plant construction and operation, bio-oil and synthetic fuels refining, CO_2 pipeline and storage site construction and operation, and indirect job creation impacts.

Conclusion

We support the California Air Resources Board's ongoing efforts to develop the 2022 Scoping Plan Update. Comprehensive IPCC[17] and IEA[18] reports routinely highlight the non-negotiable role for BECCS and DAC in achieving a well below 2°C future. California has favorable attributes to demonstrate and scale these engineered CDR technologies for global benefit, and can also unlock a series of social and environmental co-benefits as a result, including the ability to reduce the risk of catastrophic wildfire.

We would be happy to answer any questions or provide further information as required[19].

Respectfully submitted,

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17 Intergovernmental Panel on Climate Change. (2018). "Special Report on Global Warming of 1.5°C". https://www.ipcc.ch/sr15/

18 International Energy Agency. (2021). "Net Zero by 2050: A Roadmap for the Global Energy Sector". https://iea.blob.core.windows.net/assets/beceb956-0dcf-4d73-89fe-1310e3046d68/NetZeroby2050-ARoadmapfortheGlobalEnergySector_CORR.pdf

19 If CARB staff are interested in further discussion, please direct correspondence to Amanda DeMarco (amanda@csgcalifornia.com), who can assist with questions or information requests.