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August 16th, 2021

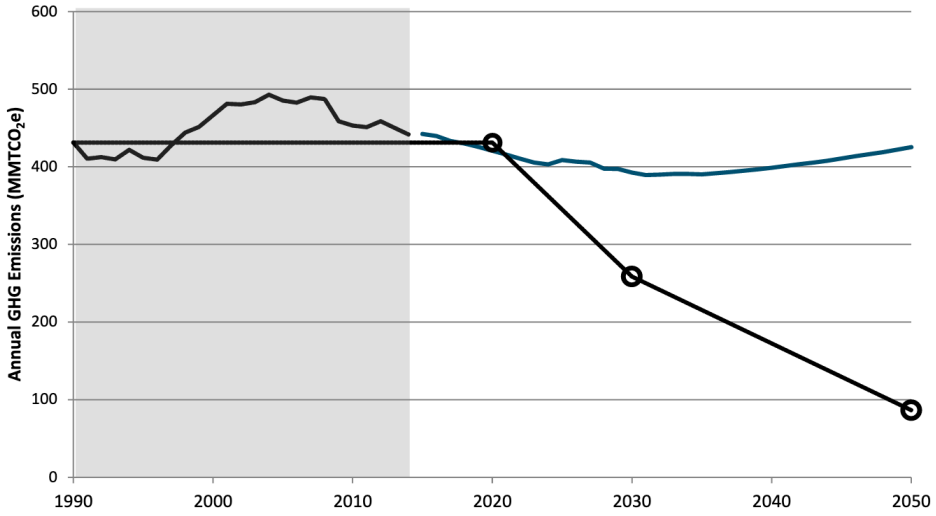
Re: Technical Workshop on Engineered Carbon Removal (2022 Scoping Plan Update)

Dear Ms. Sahota,

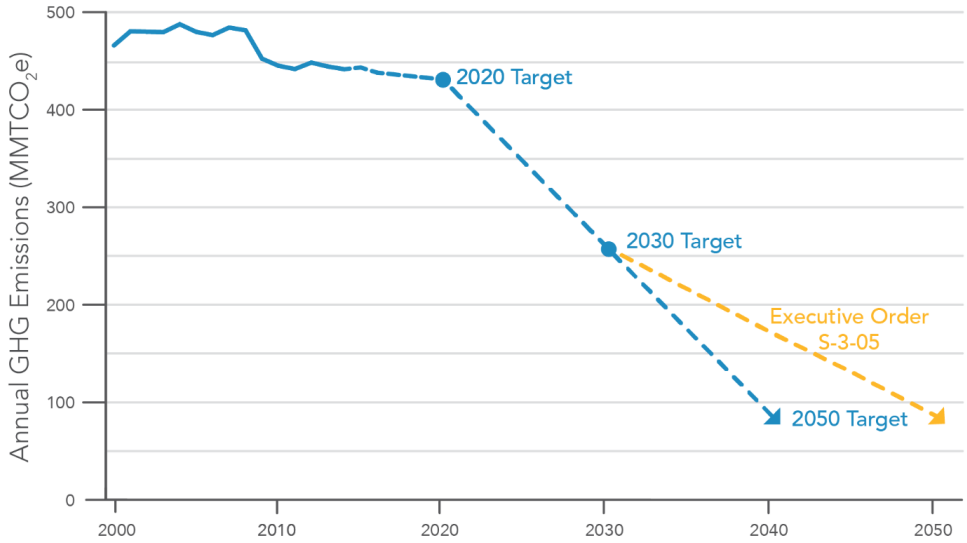
The undersigned thank you for the opportunity to comment on the technical workshop on engineered carbon removal, hosted by the California Air Resources Board (CARB) as part of the 2022 Scoping Plan Update on August 2nd, 2021. We represent a diverse set of stakeholders from industrial, environmental, labor and research sectors. We are tracking this Scoping Plan update process with great interest, as it is the most ambitious and challenging one yet, in light of the state's mid-century climate goals. We offer the comments below on a number of topics that were brought up during the technical workshop presentations and comments.

California can *only* achieve its mid-century goals if it both intensifies existing efforts *and* expands its climate toolkit

California's recent progress in decarbonizing its economy over the past two decades, combined with economic downturns beyond its control, has enabled the state to meet its climate goals to date. However, as the figures below from CARB's Overview Presentation from Day 1 of the June, 2021 Scoping Plan Update workshop and from the August 2nd, 2021 Engineered Carbon Removal Technical Workshop show in stark terms, the bulk of the work still lies ahead:



Illustrative example of Reference Scenario and GHG Mitigation targets



For California to meet its 2030 target under SB32, the rate of progress required is *several times* faster than that achieved since 2010. Maintaining the required rate of reductions beyond 2030 will be even more challenging as emission reduction opportunities are increasingly exhausted and the most challenging applications and sectors remain.

This challenge cannot be overstated. Achieving carbon neutrality no later than 2045 and maintaining negative emissions thereafter will require new strategies in the state's portfolio that go beyond what has been done to date: strategies that can drastically reduce or eliminate emissions from large point sources that do not have many other cost-effective decarbonization options, including deployment of carbon capture and storage (CCS), strategies that can negate any remaining greenhouse gas emissions that cannot be eliminated, and strategies to remove CO_2 from the atmosphere such as deployment of carbon dioxide removal, or CDR, technologies.

The imperative to both capture and store CO_2 from large point sources and to remove it from the atmosphere is due to several factors:

- Some industrial processes crucial to California's infrastructure investment, such as those utilized in cement, iron and steel production, will still emit carbon dioxide even if fully powered by renewable energy sources, which may be mitigated through employment of CCS.
- Eliminating CO_2 emissions from some sectors is extremely challenging and unlikely to be completed by mid-century: some internal combustion passenger vehicles will remain on the road beyond 2045; aviation is far harder to electrify than passenger vehicles; decarbonizing heavy goods hauling will likely have to rely on hydrogen, which can also be produced with carbon capture.
- Non-energy sector emissions, e.g. from ranching, agriculture and natural catastrophes like wildfires, will need to be counterbalanced to some extent with corresponding removals of carbon from the atmosphere.

- Shortcomings in efforts to decarbonize the economy that are possible, or even virtually inevitable due to economic barriers, logistical challenges, lack of political will and/or technological delays, will have to be compensated for.

The need for CCS and CDR has been extensively analyzed and documented, for California specifically, for the U.S., and for the globe. No credible analyses show that mid-century carbon neutrality goals can be met without CCS and CDR. A multitude of independent, expert institutions and individuals have unambiguously spelled out the need for these technologies in the climate portfolio. To mention a few:

- **E3**'s analysis for CARB identified a minimum of 33MtCO_2 that will need to be removed from the atmosphere in California provided all other mitigation efforts are maximized: https://ww2.arb.ca.gov/sites/default/files/2020-10/e3_cn_final_report_oct2020_0.pdf
- The **Lawrence Livermore National Laboratory** and its collaborators have identified pathways for California to achieve carbon neutrality by 2045 or earlier, where natural solutions can only deliver up to 1/5th of the total carbon removal needed and engineered solutions must provide the rest: https://www-gs.llnl.gov/content/assets/docs/energy/Getting_to_Neutral.pdf
- A study by the **Energy Futures Initiative and Stanford University** concludes that California cannot afford to limit its flexibility by eliminating technology options or pursuing unfocused or suboptimal policies that may hinder, rather than accelerate, decarbonization, and lays out an action plan for CCS in the state: https://sccs.stanford.edu/ccs-ca-fullreport-form
- **Princeton University** spells out a clear case for CCS and CDR technologies nationwide in the U.S. in its Net-Zero America study: https://netzeroamerica.princeton.edu/the-report
- The **International Energy Agency** has identified key functions for CCUS in the transition to clean energy: https://ww2.arb.ca.gov/sites/default/files/2020-10/e3_cn_final_report_oct2020_0.pdf
- The **White House Council on Environmental Quality** within the Executive Office of the President has documented the need and utility for CCS and delivered recommendations for its responsible deployment that reduces other air pollution and provides well-paying jobs: https://www.whitehouse.gov/wp-content/uploads/2021/06/CEQ-CCUS-Permitting-Report.pdf
- **Greig and Uden** have spelled out three different types of value for CCS in the climate portfolio related to its absolute need for reaching net-zero goals, its role in reducing compliance costs, and the risk of missing goals entailed when excluding it from the portfolio: https://www.sciencedirect.com/science/article/abs/pii/S1040619021000956
- **Nagabhushan et al.** have analyzed the utility of CCS in the U.S. power sector and the opportunities and utility in using the technology globally: https://www.sciencedirect.com/science/article/abs/pii/S1040619021000889
- **Williams et al.** found all lower cost pathways to net zero or negative emissions for the U.S. economy in 2050 require geologic carbon sequestration: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2020AV000284

- **Peridas and Schmidt** summarize the urgency of stabilizing emissions and removing CO_2 from the atmosphere, spell out the utility of CCS and CDR, and identify the reasons why it has not been deployed more broadly to date: https://www.sciencedirect.com/science/article/pii/S1040619021000877
- **Clack et al.** analyzed "Wind Water Solar-only" decarbonization approaches and found that inclusion of additional decarbonization measures reduced overall costs and improved grid reliability. Similarly, groups of leading energy experts have collaborated on multiple occasions to state that WWS-only approaches are sub-optimal and that leading academic studies promoting WWS-only suffered from significant flaws: https://www.pnas.org/content/114/26/6722 https://blogs.scientificamerican.com/plugged-in/landmark-100-percent-renewable-energy-study-flawed-say-21-leading-experts/
- **The Intergovernmental Panel on Climate Change** in its 1.5°C special report found that "[a]ll pathways that limit global warming to 1.5°C with limited or no overshoot project the use of carbon dioxide removal (CDR) on the order of 100–1000 GtCO2 over the 21st century. CDR would be used to compensate for residual emissions and, in most cases, achieve net negative emissions to return global warming to 1.5°C following a peak (high confidence)." https://www.ipcc.ch/sr15/chapter/spm/

The list goes on, and each year that goes by on our current trajectory, the dimensions of stabilizing the climate are becoming increasingly stark: in its latest release last week of the Physical Science Basis report, the Intergovernmental Panel on Climate Change stated that "[t]he scale of recent changes across the climate system as a whole and the present state of many aspects of the climate system are unprecedented over many centuries to many thousands of years", and that "[g]lobal surface temperature will continue to increase until at least the mid-century under all emissions scenarios considered".[1] CCS and CDR are not substitutes for other mitigation efforts that serve special interests or perpetuate today's fossil-fueled economy. They are critically needed complements to all other efforts to reduce emissions and shift towards a clean-energy economy.

Responsible CCS and CDR can improve - not worsen - local air pollution

A large number of comments during the Technical Workshop revolved around the apparent conflict between deploying CCS and CDR and resolving chronic local air pollution problems.

We do not wish to diminish or sidestep the plea for eliminating this pollution and improving air quality for communities that have been disproportionately burdened. There are also several

[1] IPCC, 2021: Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change[Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)]. Cambridge University Press. In Press. https://www.ipcc.ch/report/ar6/wg1/#FullReport

historical and other legitimate factors that can create a perceived association between local air pollution and CCS/CDR deployment.[2]

However, the choice is a false one. California is faced with two serious problems: local air pollution problems and the climate crisis. The state can - and indeed must - address both. Whether CCS and CDR deployment decreases or increases air pollution is not predetermined, but is controlled by the policies and regulations that govern it and on how specific projects are designed. In fact, the technologies involved have the potential to decrease existing emissions of certain air pollutants.

California cannot afford to exclude these technologies from its climate portfolio, and in fact they could help with also addressing its local air pollution problem, as we explain below. We whole-heartedly agree with the presentation by Ms. Suarez during the Technical Workshop, which emphasized the need to assess the merits or lack thereof of CCS and CDR on an individual project level. Prejudging those, or weighing them generically or based on ideology is incorrect and incompatible with California's needs and with science.

Adding carbon capture to existing industrial sources can decrease criteria air pollutant emissions. This is an area that has not been widely studied and communicated, and which we believe is important for California's climate discussions. We are happy to report that studies on this topic will be made public in the coming months.[3]

For example, in the context of what is likely to be one of the most commonly-used carbon capture technologies - amine scrubbers used to remove CO_2 from flue gases - air quality improvements can likely be expected because certain air pollutants degrade the amine solvents. Capture units often add pretreatment steps or upgrade existing controls as a cost-saving measure to protect the amine solvent from degradation. For example, if an industrial source emits sulfur dioxide (SO_2), the SO_2 emissions from adding carbon capture fall to near zero. Either the polishing scrubber added to protect the amine removes the SO_2, or what little reaches the capture unit is removed by the amine.

Emissions of particulate matter also decrease, but the degree is application-specific.

Nitrogen oxide (NO_X) emissions are more complex. NO_x is a general term for nitric oxide (NO) and nitrogen dioxide (NO_2). NO does not react with the amine and therefore is not captured by the amine. NO_2 (which is generally less than 10% of total NO_x emissions, but can be considerably more) is water-soluble and reacts with the amine solvent. Like SO_2, carbon capture projects will generally reduce NO_2 either because the pretreatment added to protect the amine reduces the NO_2 or because what little NO_2 reaches the capture unit is captured by the amine. However, the extra fuel burned to run the capture unit can offset this reduction and could potentially increase total NO_x emissions. The impact is plant-specific and depends on the

[2] For an in-depth analysis of these factors, see Batres et al., and Peridas and Schmidt.
[3] The Clean Air Task Force is currently working on such a study, which is to be released in the coming months. See also CEQ, 2021.

amount of NO_x emissions from the plant, the source of electricity for the capture unit, and whether the operator upgrades the NOx controls when CCS is added to the plant.

VOC emissions can, in theory, rise from adding CCS to a plant because some amine is lost from the top of the capture unit's absorber. However, this can be kept at very low levels. At the Petra Nova coal-fired power plant CCS demonstration project, additional VOC emissions were small and well below permitted levels.

Responsible CCS and CDR can result in workforce and equity benefits

As we highlighted in joint comments to the opening workshop for the Scoping Plan Update, CCS and CDR technologies can contribute towards the direct maintenance of continuity of family-sustainable, fully-benefitted employment.[4] The opportunities that expediting and employing CCS and CDR technologies offers will place California more firmly on a pathway to better-paying jobs that are more equitable than those that will be lost as we transition further into a clean energy economy, particularly in sectors that will incur large transitional job losses, such as the fossil fuel industry.

In addition, CCS and CDR technologies, by virtue of diversifying the state's climate portfolio, can reduce the cost of meeting mid-century targets and thus shield ratepayers - and in particular the poorest among them - from any resulting rate increases.[5,6,7]

Conclusion

We believe that the climate case for including CCS and CDR in California's portfolio is unequivocal and well established, supported by multiple credible and independent expert analyses. Without those technologies, the state will be unable to achieve its climate goals. In addition, these technologies do not have to increase local air pollution, and in fact can reduce such pollution. They should be evaluated on their merits as well as on an individual project basis, and not prejudged. Moreover, CCS and CDR can help with workforce maintenance and

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[4] John Larsen et al., "The Economic Benefits of Industrial Carbon Capture: Investment and Employment Opportunities for Eastern and Western States", Rhodium Group, January 28, 2021. https://rhg.com/wp-content/uploads/2021/01/The-Economic-Benefits-of-Carbon-Capture-State-Investment-and-Employment-Estimates_Phase-II.pdf#page=15

[5] See, for example, relevant report by the CPUC: "Utility Costs and Affordability of The Grid of The Future - An Evaluation of Electric Costs, Rates And Equity Issues Pursuant To P.U. Code Section 913.1" https://www.cpuc.ca.gov/-/media/cpuc-website/divisions/office-of-governmental-affairs-division/reports/2021/senate-bill-695-report-2021-and-en-banc-whitepaper_final_04302021.pdf

[6] See also: Long, Jane C.S., Ejeong Baik, Jesse D. Jenkins, Clea Kolster, Kiran Chawla, Arne Olson, Armond Cohen, Michael Colvin, Sally M. Benson, Robert B. Jackson, David G. Victor, and Steven P. Hamburg, "Clean Firm Power is the Key to California's Carbon-Free Energy Future", Issues in Science and Technology (March 24, 2021), https://issues.org/california-decarbonizingpower-wind-solar-nuclear-gas/

[7] Energy Futures Initiative and Stanford University. "An Action Plan for Carbon Capture and Storage in California: Opportunities, Challenges, and Solutions." October 2020. https://sccs.stanford.edu/ccs-ca-fullreport-form

transition during the shift to a clean-energy economy, and also ease the burden on the most vulnerable ratepayers and help make this transition more equitable.

CARB's job in navigating all of these scientific and socioeconomic issues is both challenging and important to the state. We strongly support CARB's reliance on the widely available body of sound science that supports consideration of CCS and CDR technologies in the 2022 Scoping Plan Update as part of the state's climate portfolio, and accompanying modeling that relies on an appropriate mix of strategies for meeting California's 2045 carbon neutrality goal. We urge CARB to include language in the 2022 Scoping Plan Update that demonstrates its intent to pursue the statutory and regulatory changes necessary to support responsible and appropriate deployment of these technologies. We also support further work to both study and ensure positive air quality impacts, workforce and job impacts, and equity benefits from responsible CCS and CDR deployment.

We thank CARB once again for the opportunity to comment and engage in this Scoping Plan Update process, and stand ready to provide further information on these technologies for the purpose of this update and beyond.

Respectfully submitted,

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