ENGINEERED CARBON REMOVAL
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We all hope that carbon capture will be very effective, free from side effects, and scalable. However, the technology is still disappointing in many ways, despite decades of research. These comments are designed to encourage further evaluation and innovations in this field and to help CARB achieve its mission.

"CARB's mission is to promote and protect public health, welfare, and ecological resources through effective reduction of air pollutants while recognizing and considering effects on the economy. CARB is the lead agency for climate change programs and oversees all air pollution control efforts in California to attain and maintain health-based air quality standards."

Implementation of some of the following recommendations will require collaboration with other agencies or the legislature. Because one of your primary objectives is to improve public health, consider consulting with the CA Dept. of Public Health to screen policy options for the Scoping Plan. Health Impact Assessments may be required to evaluate carbon capture.

Three kinds of carbon capture technologies (CCT) that are commercially available will be analyzed. These are smokestack carbon capture storage (CCS), which includes carbon capture use and storage (CCUS), biomass energy CCS (BECCS), and Direct Air Capture (DAC). CCT has the following problems and limitations.

Recently, CET technologies have an operating cost of about $100/MT to $300/MT of CO2. This excludes the cost of agricultural and forest management emissions (for some BECCS), mining, manufacture, maintenance, transportation, subterranean injection, storage monitoring for fugitive emissions, building a power plant to operate CCT, land for equipment and storage, disposal and recycling of used equipment and materials, regulation, permits, and insurance. Decades of research have discovered some promising innovations, but none are close to being cost-effective.

Lifecycle analysis research of CCT operations was not reported in the workshop. If methodologically sound studies that include the above variables have been published, please post these on the CARB website. If none are available, please conduct such and post your results on the CARB website. Without such research, it is unknown whether GHG emissions from CCT exceed the amount of CO2 captured. Research has not been published that evaluates net CO2 capture over the lifecycle. Net capture means subtracting the lifecycle CO2e emissions of a CCS facility from CO2 captured.Research should also include cost per MT, GHG and toxic emissions, water requirements, job creation, GDP effect, public health (medical expenditures, mortality, morbidity), Social Cost of Carbon, and EJ impacts. Research should contrast the results of CCT with renewable energy generation to prevent GHG emissions (1,2).

For BECCS (e.g. bio-oil from pyrolysis), the effects should be contrasted with C storage via mulch, composting, and regenerative agriculture. Any kind of CCT should be contrasted with natural sequestration in oceans (e.g., via marine algae and phytoplankton) and on terrestrial habitats with high sequestration potential (forests, peat, and wetlands) (3) Growing biomass for electricity and using smokestack CCS (BECCS) removes less CO_2 than leaving the biomass free to grow (conservation) and has much lower lifecycle emissions and costs than BECCS. Sequestration by botanicals stores C in the soil. If the soil is undisturbed, C remains therein for many centuries. Unlike BECCS, growth does not emit toxic co-pollutants. We agree with the 2020 LLNL report recommendation that only waste be eligible for BECCS (4)

Evaluation of claims about the efficacy of smokestack CCS is important to measure in real-time commercial operations. The lack of such evidence may increase misleading claims as well as emissions of toxins and GHGs in our economy. The majority of smokestack CCS power plants have failed and the primary reason is that they are neither cost-effective nor do they have proven positive net capture. The fossil fuel industry has concluded that CCS does not improve profit, when fossil firms pay the entire cost of CCS. So, for decades in various nations, industry associations have requested government tax credits for CCS installation (5,6).

CCS technologies do not remove toxic co-pollutants from combustion of fossil fuels, biogas, biofuels, or biomass. The single exception is that some sulfer oxides may be extracted. However, many other co-pollutants are more toxic than SO_x. Coal plants with CCS emit 100 - 300 times more toxins than wind turbines over the lifecycle of each. (7,8) Worldwide, annually, 8.7 million people were killed by fossil fuel air pollution in 2018.(9). This is primarily due to toxic co-pollutants rather than GHGs. Toxics are at least as effective as climate change for destroying the web of biologic life. The primary cause of EJ violations that create sacrifice zones is neighborhood airborne toxic emissions from combustion of fossil fuels.

CCT requires many kinds of energy inputs over its lifecycle. Adding CCS to a coal plant uses 25 - 50% more energy than the plant without CCS, with commensurate increases in emissions and costs (10). When CCS powered by NG is added to a coal plant, 11 - 30% of the CO_2 is captured. When CCS powered by a wind turbine is added to a coal plant, 37 - 44% of the CO_2 is captured. 50% of CO_2 emissions are prevented by replacing half of the NG electricity with wind turbine electricity. Replacing all of the NG with wind avoids the costs of installing NG and CCS equipment. (10,11,12,13,14). Blue hydrogen production uses smokestack CCS. Research of such a facility powered by NG was conducted. Net CO_2 emissions from the operating phase were 20% higher than net CO_2 emissions from combustion of NG (without CCS) (15).

DAC operated with renewable energy is in operation in15 locations (e.g., Greenland and Switzerland), but it is pricey ($170 - $300/MT). DAC consumes water in warm climates, but water is created in cool/humid climates (16, 17). DAC should be situated near suitable geologic repositories. DAC should only be permitted if powered by renewable energy. Failing to require this would increase use of grid electricity, which is about 65% dirty - defeating the purpose of DAC.

Due to resource limitations, cost, and low efficacy, current CCT is probably not capable of being scaled up sufficiently to make substantial contributions to the decarbonization of our atmosphere (18,19,20). Many other climate solutions do not have the cost and scalability limitations of current CCT technology (21).

MORAL HAZARDS OF CCT

Side effects of CCT are likely to be more severe as it becomes more effective and is more heavily subsidized. Carbon intensive industries are more likely to defer low-emissions innovations. Politicians and regulators may be tempted to delay other policies to decarbonize our economy. Investors, e.g., pension funds, may invest more in carbon-intensive industries. This perpetuates sacrifice zones and violations of EJ. Public health would deteriorate from increased toxic emissions. As more government funding is allocated to CCT, fewer resources are available for distributed renewable energy, low-GWP products, natural sequestration, conservation, all-electric building codes, microgrids, and efficiency (21).

There is a hazard of deferring use of CCT until more proof of efficacy is available. Between smokestack CCS and deferral is a middle path of renewable DAC. Though it is not as cost effective as preventing lifecycle emissions (by replacing fossil energy with renewables), this has the least side effects of any form of CCT.
CARB should frequently survey the energy policy landscape. If CCT proponents, or greenwash about CCT, prevents climate legislation from being passed and enacted, government support for CCT should be withdrawn and replaced by mitigation policies with lower risks and side effects. Mitigation includes more stringent emissions regulation, halting permits for new fossil fuel infrastructure, decreasing fugitive emissions from wells and pipelines, 30 x 30 conservation, regenerative agriculture, and scaling up renewable energy generation.

STORAGE

CO2 pipeline systems have fugitive emissions, as NG pipeline systems do.
Our NG pipelines, carrying 70 - 90% methane, are leaky. In CA alone, over 1,800 leaks are reported daily. Until the fossil industry pays for maintaining
pipelines that allow no fugitive emissions, no other GHG pipelines should be built - especially with taxpayer funds. Pipeline emissions can be monitored via satellites.
EPA is working on a systematic monitoring protocol using NASA satellites. Establish clear regulations re. CO2 pipelines and storage, set initial and annual permit fees to operate such, and require the CCT and CO2 storage industry to post indemnity bonds

and obtain insurance naming the State of CA as an insured. Industry should be required to draft annual reports that tally the lifecycle GHG emissions and net CO_2e capture from their businesses.

CO_2 is toxic to humans and aquatic life in air as well as water. It is converted into carbonic acid which lowers pH. Because CO_2 in pipelines is stored at about 1,000 p.s.i., leaks can quickly release high volumes of the gas. When CO_2 is stored in geological repositories there is risk of CO_2 contaminating aquifers.

Converting CO_2 gas, from smokestack CCS, into solid calcium carbonate for lasting storage has not been tested outside of laboratories. This is also true for bio-oil produced via pyrolysis. Converting CO_2 from a gas to a solid or viscous liquid will likely provide storage with lower risks of fugitive emissions. Depleted oil wells have been proposed as suitable long-term storage repositories for CO_2. This has not been tested commercially. Fugitive emissions, especially CH_4, from idle and abandoned wells are common nationwide. More effective capping methods and more frequent emissions monitoring are needed before CO_2 storage is attempted. Wells wherein hydraulic fracturing has been used present special challenges. Fracking creates fissures in the shale which allow access to deposits that are deeper and more distant from the wellhead. Thus, fugitive emissions may be released from some kinds of geologic formations (e.g., karst, aquifers, or caverns) that are hundreds of meters from the wellhead. Seismic activity may cause fugitive emissions from geologic storage and pipelines. More research is needed on permanent storage before further CCTdevelopment is planned (22, 23).

RESPONSIBILITY FOR COSTS OF CCT

75 - 80% of anthropogenic GHGs are from the use of fossil fuels in Scopes 1, 2, and 3. Fossil fuel companies should be paying for all kinds and applications of CCT (cement factories, metal manufacturing, fossil fueled power plants, refineries, DAC, etc.). CCT should be used only to store CO_2, not for industrial purposes with high risk of releasing captured CO_2 (e.g, EOR and carbonated beverages).

Polluters should pay for all costs of CCT. Taxing the public misses the point of the costs, which is to make the perpetrator pay for the harm, not penalize consumers who may have little choice or little information as to which products they can choose. When carbon taxes and abatement equipment costs are borne by polluters, this incentives the polluter to mitigate their operations. Such incentive doesn't exist when the public is taxed to pay for CCT equipment.

Smokestack CCS should not be subsidized by the government because it perpetuates fossil fuel combustion, is not very effective, fails to extract toxins, damages public health, perpetuates sacrifice zones, siphons resources away from solutions that prevent GHG emissions, the majority of taxpayers have only slightly exacerbated climate change, and it disincentivizes the transition from fossil to renewable energy.

Some technologies have failed. Smokestack CCS may be one of them. At minimum, CCS should not be considered for Scoping Plans until lifecycle studies prove net CO_2e capture and its side effects of damage to EJ and public health are solved and eradicated by design innovations to CCS equipment.

Even if it pays for all costs of CCT, industry should be required to pay a fee for using captured CO_2 for EOR and other potential industrial uses (plastics, carbonated beverages, biofuels). Much of the CO_2 from some of these uses is released back into the atmosphere. The fee should rise annually until companies no longer use the CO_2 for “leaky” products..

Direct Air Capture should be subsidized by general tax revenue only if it is powered by renewable energy and the CO_2 is immediately and permanently stored. We disagree with the recommendation in the LLNL report released in 2020 that NG should be the first choice for powering DAC and the declaration that NG is “emissions free” (4). Instead of carbon offset programs, which are difficult to verify, carbon-intensive companies should be given the opportunity to pay for the cost of constructing and operating publicly-owned DAC with adjacent zero-emission renewable electricity generation on public lands. Suitable locations would be in areas where there is little demand for development or recreation. First Nation tribes should be given the option to have DAC located on their lands. This would create many construction and ongoing maintenance jobs. Firms would receive allowance credits annually until our grid delivers 100% renewable electricity. At that point, the DAC credit program would be re-evaluated

Subsidies for DAC should be commensurate with evidence of efficacy.

Subsidy	Evidence
Minimal	Gross capture, e.g., gCO_2/MJ
Low	Net positive capture based on operating phase only
Moderate	Net positive capture based on lifecycle analysis
High	Net positive capture based on lifecycle analysis that is greater than CO_2 emissions prevented by replacing fossil fuel electricity with renewable electricity

As yet, there is only evidence of gross capture. Data sources include companies that own the stations and studies that estimate operating phase capture, but do not study commercial DAC stations (24, 25).

CARB’s Low Carbon Fuel Standard includes energy products made with CCS. Those that require CCS to meet emission and eligibility requirements should be excluded from the LCFS.

CCT may never be cost-effective. However, if the price of emissions (carbon taxes) is raised sufficiently, this could pay for all costs of CCT (26).

The Whitehouse CCT policy report calls for a vast build up of taxpayer-subsidized CCT and CO2 pipelines (27). For a long list of reasons, this plan will exacerbate climate change..

ALTERNATIVE ATMOSPHERIC DECARBONIZATION POLICIES

Mitigation (prevention) is more effective than adaptation and remediation for attenuating climate change. This favors emissions regulation, replacing high GWP products with low GWP products, natural sequestration via conservation, regenerative agriculture, discontinuing permits for new fossil fuel infrastructure, plugging wells and pipelines that have fugitive emissions, and scaling up renewable energy generation and storage. None of these incentivize continued dependence on fossil fuel energy. CCT should be contrasted with other proven measures for decreasing atmospheric GHGs. Some of these have very low costs and are readily verified, e.g.,discontinuing permits and fortifying emissions regulation. The lifecycle costs and net GHG and toxic emissions of cement plants and power plants powered by NG with smokestack CCS exceed the costs and emissions of replacing NG/CCS with renewable energy generation.

Smokestack CCUS is the kind of CCT that is most likely to prolong the longevity of carbon-intensive industries, disincentivize innovations that decarbonize industry, and prompt lobbying efforts to subsidize CCUS (28, 29, 30, 31).CCS presents the greatest risk of exacerbating our climate crisis (31).

PUBLIC EDUCATION

The public is not well-informed about CCT and the alternatives. This presents the risk of greenwash being accepted as valid. To enable the public to make better decisions about CCT policies, post information on the CARB website about lifecycle analyses of CCT and alternative ways of decreasing atmospheric GHGs.

Endnotes

These references do not contain incontrovertible evidence that proves each of the points of the above text. They do contain some evidence corroborating the points, risks, efficacy, and limitations of each technology or policy. Most contain research references or links to such. Recommendations are based on the evidence and likelihood that a technology may be significantly scaled up before 2030. We have finite resources to contend with the climate crisis, including funds, time, and labor. In light of the precautionary principle, it is prudent to allocate resources to RD&D of the best current technologies that have the highest lifecycle benefit/cost, benefit/risk, lowest side effects of harming public health and environmental justice, and use resources that are plentiful in CA. Water, for example, is in short supply and technologies that are water-intensive should receive a smaller role in Scoping Plans. If we fail to significantly decarbonize our economy by 2030, we may not be able to implement effective measures for the latter half of the century. Public health should be prioritized over generation of the maximum GW of electricity, driving GDP to record highs, and increasing the profits of carbon-intensive industries .

Some of the references are more suited for the general public and some are more scientifically specialized. Scoping Plans should contain some of each.

1.Frontiers | A Guideline for Life Cycle Assessment of Carbon Capture and Utilization | Energy Research (frontiersin.org)

2.8 Life-Cycle Assessment of Carbon Utilization | Gaseous Carbon Waste Streams Utilization: Status and Research Needs | The National Academies Press (nap.edu)

3. Fact Sheet: Bioenergy with Carbon Capture and Storage (BECCS) | American University, Washington, DC

4. https://www.llnl.gov/news/moving-carbon-neutrality-one-year-later

5.http://priceofoil.org/2021/06/17/carbon-capture-five-decades-of-industry-false-hope-hype-and-hot-air/

6. https://www.eca.europa.eu/Lists/ECADocuments/SR18_24/SR_CCS_EN.pdf

7.https://web.stanford.edu/group/efmh/jacobson/Articles/Others/19-CCS-DAC.pdf

8, https://web.stanford.edu/group/efmh/jacobson/WWSBook/WWSBook.html

9. Deaths from fossil fuel emissions higher than previously thought (harvard.edu)

10 https://www.youtube.com/watch?v=xvFkkGayE7s

11. https://docs.google.com/document/d/1ghKjPm9gSq8_CMoXbO95DTUyp2onCs-T3iGWiGV7hOQ/edit#heading=h.rrmxo3i702xy

12 Top 5 Reasons Carbon Capture And Storage (CCS) Is Bogus – Food & Water Watch (foodandwaterwatch.org)

13. https://www.ciel.org/reports/carbon-capture-is-not-a-climate-solution/

14 https://www.youtube.com/watch?v=xvFkkGayE7s

15. https://onlinelibrary.wiley.com/doi/10.1002/ese3.956

16. Direct Air Capture – Analysis - IEA

17. https://www.wri.org/insights/direct-air-capture-resource-considerations-and-costs-carbon-removal

18,**https://newrepublic.com/article/160754/carbon-capture-not-climate-savior**

19.https://ieefa.org/it-all-comes-down-to-cost-analysts-argue-carbon-capture-simply-too-expensive/

20.https://www.globalwitness.org/en/campaigns/fossil-gas/world-cannot-meet-climate-targets-relying-carbon-capture-and-storage/

21..https://www.ethree.com/achieving-carbon-neutrality-in-california-e3-presents-draft-report-at-california-air-resources-board-public-workshop/

22..**https://theconversation.com/climate-scientists-concept-of-net-zero-is-a-dangerous-trap-157368?fbclid=IwAR0IlyanZ8hs6pE-aNHBWu8vUjpthqlZmtzLYsA82oouZO0zSZH06RP14-8**

23..https://foe.scot/wp-content/uploads/2021/01/CCS_REPORT_FINAL.pdf

24. Emergency deployment of **direct air capture** as a response to the climate crisis.

25. https://climatecrocks.com/2021/08/14/could-this-carbon-capture-idea-catch-on/

26. Carbon capture technology: Why we aren't further along (cnbc.com)

27. https://www.whitehouse.gov/wp-content/uploads/2021/06/CEQ-CCUS-Permitting-Report.pdf

28. 5de8d4800733d3e769408aaa49eb7edf3a2ee11794c2c869dd6e9f804&esrc=subscribe-page&utm_term=TNY_ClimateCrisis

29. Exxon's (XOM) Carbon Capture Project Stalled in Climate Change Setback - Bloomberg

30.https://www.ciel.org/reports/fuel-to-the-fire-how-geoengineering-threatens-to-entrench-fossil-fels-and-accelerate-the-climate-crisis-feb-2019/

31 .https://vimeo.com/586083689