November 22, 2022

To: California Air Resources Board
RE: Public Workshop for SB 596 Cement Sector Net-Zero Emissions Strategy (SB596-wkshp-Oct20-ws)

Submitted via CARB's online Comment Submittal Form with references attached as .zip file

To whom it may concern:

The Center for Biological Diversity appreciates CARB's consideration of various pathways as it develops a plan to decarbonize the cement industry per the mandate in Senate Bill 596 ("SB 596"). We are concerned, however, that CARB may unnecessarily rely on carbon capture and storage ("CCS") as part of its plan, when in fact, CCS is a false solution that overpromises and underdelivers on its greenhouse gas ("GHG") capture potential, all while putting communities and the environment at risk. Instead, CARB should focus on the suite of viable strategies—such as alternative inputs, electrification, fuel-switching, and nature-based carbon dioxide removal—that, when deployed together, could achieve SB 596's both short- and long-term goals for the industry.

Please note that we have attached references cited in this letter in a .zip file titled, "Ctr. Biol Div Refs Cement 11.22.22," for CARB's consideration and for inclusion in the public record.

I. CCS Pipelines Are Prohibited in California for the Foreseeable Future, Meaning CARB Must Not Rely on CCS for Cement Decarbonization

There can be no CO_2 pipelines in California until 2025 (at the earliest), making reliance on CCS for cement decarbonization strategy plainly out of sync with Senate Bill 596's ambitious timeline requiring CARB create a plan by July 1, 2023.

Senate Bill 905 ("SB 905"), passed and signed into law in 2022, places a moratorium on most CO_2 pipelines until the Pipeline and Hazardous Materials Safety Administration ("PHMSA") completes its planned rulemaking.[1] PHMSA is not on track to release even a *draft* proposed rule before mid-2024, and no Notice of Proposed Rulemaking yet appears in the regulatory agenda. Once the rule is proposed, it will need to go through public notice and comment before a final rule is published. For cement facility operators wanting to use CCS—especially those located outside the "suitable" geography of the Central

[1] SB 905, section 71465(a), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB905 ("Pipelines shall only be utilized to transport carbon dioxide to or from a carbon dioxide capture, removal, or sequestration project once the federal Pipeline and Hazardous Materials Safety Administration has concluded the rulemaking (RIN 2137-AF60) regarding minimum federal safety standards for transportation of carbon dioxide by pipeline (Parts 190 to 199, inclusive, of Title 49 of the Code of Federal Regulations) and the carbon dioxide capture, removal, or sequestration project operator demonstrates that the pipeline meets those standards."); *see also* PHMSA, *PHMSA Announces New Safety Measures to Protect Americans From Carbon Dioxide Pipeline Failures After Satartia, MS Leak*, (May 26, 2022), https://www.phmsa.dot.gov/news/phmsa-announces-new-safety-measures-protect-americans-carbon-dioxide-pipeline-failures ("To strengthen CO2 pipeline safety, PHMSA is undertaking the following: initiating a new rulemaking to update standards for CO2 pipelines, including requirements related to emergency preparedness, and response").

Valley—the pipeline moratorium of SB 905 means that they will not only need to wait until PHMSA completes its rulemaking (which would likely be sometime in 2025 or later), but they would then need to wait for *California* to determine that their pipeline proposal "meets [the] standards" of the new federal rule.[2] This timeline does not even take into account legal challenges that could delay a final federal rule, a proposed CO_2 pipeline, or both.

CARB must also note that transportation of compressed CO_2 by truck and rail is highly expensive and polluting, meaning these transport options are not a viable alternative to pipelines. A study by the Intergovernmental Panel on Climate Change ("IPCC") found that "truck and rail options cost more than twice as much as a pipeline."[3] Further, truck and rail traffic operating to transport captured CO_2 will, in turn, increase harmful air pollution.[4] CARB recognized in the Final 2022 Scoping Plan that "[h]eavy-duty trucks are the largest source of diesel particulate matter, a toxic air contaminant that is directly linked to a number of adverse health impacts."[5] And use of diesel trucks is not changing in California anytime soon, as the State is aiming to decarbonize commercial trucks only "where feasible by 2045."[6]

In sum, the uncertainties and drawn-out timelines associated with bringing CO_2 pipelines online in California caution against CARB relying on CCS as part of the decarbonization strategy for cement. Alternative means of transporting captured CO_2, such as truck and rail, are also not viable given that they are expensive and would increase harmful air pollution in the State.

II. CCS Is Dangerous, Unproven, and Expensive, and Should Not Be Part of California's Cement Decarbonization Strategy

In order to meet the cement decarbonization targets outlined in SB 596, CARB must recognize that any proposal incorporating CCS is bound to fail and put communities and the environment at risk. CCS is a distraction from other proven and necessary steps and would, at best, achieve GHG reductions only on paper, but not in reality.

A. CCS is risky and environmentally unjust

CCS is rife with risks that even with a robust regulatory system cannot be eliminated entirely. We urge CARB to consider these risks and reject CCS as part of a strategy to decarbonize cement.

One such health and safety risk arises from transporting CO_2 via pipelines. CO_2 leaks from pipelines are dangerous to people and animals as "CO_2 is denser than air and can therefore accumulate to potentially dangerous concentrations in low lying areas," and "any leak transfers CO_2 to the atmosphere."[7]

The Pipeline Safety Trust, in a statewide workshop on CCS earlier this year, noted that even strong regulations could never eliminate the risks associated with CO_2 pipelines. Their 2022 report, "CO_2 Pipelines: Dangerous and Under-Regulated," further notes that because CO_2 has different physical properties from products typically moved in hazardous hydrocarbon liquid or natural gas transmission

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[2] SB 905, section 71465(a), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB905.
[3] IPCC, *Special Report on Carbon Dioxide Capture and Storage, Chapter 4: Transport of CO2* at 184 (2005), https://www.ipcc.ch/site/assets/uploads/2018/03/srccs_chapter4-1.pdf.
[4] CARB, *Overview: Diesel Exhaust & Health*, https://ww2.arb.ca.gov/resources/overview-diesel-exhaust-and-health.
[5] CARB, *Final 2022 Scoping Plan Update* at 185 (Nov. 16, 2022), https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp.pdf.
[6] *Id.* at 39.
[7] IPCC, *Special Report on Carbon Dioxide Capture and Storage*, *supra* note 3 (noting that CCS "will require a large network of pipelines.").

pipelines, CO_2 pipelines "pose unique safety hazards and greatly increase the possible affected area or potential impact radius upon a pipeline release that would endanger the public."[8] In other words, CO_2 pipeline ruptures "can impact areas measured in miles, not feet."

These risks became reality in February 2020, when a CO_2 pipeline ruptured in Satartia, Mississippi, requiring the evacuation of hundreds and hospitalization of dozens,[9] with harms including extreme disorientation, unconsciousness, and seizures.[10] The federal pipeline agency is seeking nearly $4 million in fines connected to the rupture from pipeline owner.[11] Among the violations cited, federal investigators said the company "significantly underestimated the affected area that could be impacted by a release."[12]

California's Central Valley has long been touted as an area ripe for storage of captured CO_2.[13] Having already suffered the harms of environmental racism resulting from the fossil fuel industry and large-scale agriculture, it would be unconscionable to then relegate high-stakes, life-and-death risks of CO_2 transport and storage from any industry, including cement, to these Central Valley communities.

Further exacerbating environmental injustice, CCS operations can emit a wide array of criteria and hazardous air pollutants. Air pollution across the CCS life cycle comes from several main sources: (1) the industrial facility, (2) the site of CO_2 injection, (3) upstream, and (4) CO_2 transport. One Stanford study that examined the total lifecycle costs of carbon capture from a coal plus CCS power plant, including emissions resulting from the energy penalty, found that CCS "reduces only a small fraction of carbon emissions, and it usually increases air pollution."[14] While this study examined CCS on power plants, the general principal that CCS carries a high energy penalty is applicable across industries.

CARB's presentation included CCS as a potential strategy under Pathway 1. Situated in that pathway, CCS would be used at the process-emissions (i.e., pre-combustion) stage of cement manufacturing. But while CCS proponents tout how the technology reduces air pollution, these claims are not borne out. One review concluded that pollution from pre-combustion CCS is uncertain and not well-studied: SOx, PM, and NOx could increase or decrease with the addition of CCS.[15] A 2022 study that

[8] Pipeline Safety Trust, *CO2 Pipelines – Dangerous and Under-Regulated* (March 30, 2022), https://pstrust.org/wp-content/uploads/2022/03/CO2-Pipeline-Backgrounder-Final.pdf.
[9] *Pipeline Ruptures in Yazoo County, Dozens Rushed to the Hospital*, Miss. Emergency Mgmt. Agency (Feb. 23, 2020), https://www.msema.org/news/pipe-ruptures-in-yazoo-county-dozens-hospitalized/.
[10] *"Foaming at the mouth": First responders describe scene after pipeline rupture, gas leak*, Clarion Ledger (Feb. 27, 2020), https://www.clarionledger.com/story/news/local/2020/02/27/yazoo-county-pipe-rupture-co-2-gas-leak-first-responders-rescues/4871726002/.
[11] Donnelle Eller, *A carbon dioxide pipeline burst in Mississippi. Here's what happened next*, Des Moines Register (Sept. 11, 2022), https://www.desmoinesregister.com/story/money/agriculture/2022/09/11/here-minute-details-2020-mississippi-co-2-pipeline-leak-rupture-denbury-gulf-coast/8015510001/.
[12] *Id.*
[13] *See, e.g.*, California Energy Comm'n, *California Energy Commission's R&D Activities in CCS for California* at 6 (Feb. 12, 2016), https://www.arb.ca.gov/cc/ccs/meetings/cec_presentation_2-12-16.pdf.
[14] Taylor Kubota, *Stanford Study casts Doubt on Carbon Capture*, Stanford News, Oct. 25, 2019, https://news.stanford.edu/2019/10/25/study-casts-doubt-carbon-capture/, citing Jacobson, Mark Z., *The health and climate impacts of carbon capture and direct air captur*e, 12 Energy Env't Sci. 3567 (2019), https://doi.org/10.1039/C9EE02709B (Stanford Report Summary).
[15] Koornneef, Joris et al., *The impact of CO2 capture in the power and heat sector on the emission of SO2, NOx, particulate matter, volatile organic compounds and NH3 in the European Union*, 44 Atmospheric Env't 1369 (2010), https://doi.org/10.1016/j.atmosenv.2010.01.022.

modeled pre-combustion CCS in California found that PM 2.5 and SOx emissions would *increase*, leading to more pollution-related health harms and mortality.[16]

Facilities using oxy-combustion similarly cannot be said to reduce air pollution. A scientific review of oxyfuel combustion concluded that criteria and hazardous air pollutants have not been well studied and there is a "lack of attention to potential health effects."[17] The study further found that air pollution control devices may not perform the same in oxy-fired systems as they do in air-fired systems, little is known about the formation of hazardous air pollutants in oxy-combustion boilers, and "[c]ombustion under oxyfuel conditions could produce emissions posing different risks than those currently being managed by the power industry."[18] On top of air pollution, these systems generate solid and liquid waste streams that may pose health and environmental hazards.

B. CCS is energy and water intensive—two impacts that are a bad fit for California

CARB must take these additional energy demands into account when considering CCS, especially given the grid demands in recent years that have led to blackouts.[19] As the Institute for Energy Economics and Financial Analysis ("IEEFA") notes, the energy required to capture, transport, and inject carbon underground "materially reduces its net benefit."[20] For example, coal-fired power plants with carbon capture have an energy penalty of 25% or more, with the efficiency penalty as high as 15%.[21] These "penalties" mean more fuel has to be burned to produce the same amount of power, which means higher energy costs, greater emissions of non-CO_2 air pollutants, and increased demand on the grid.[22]

In addition to being a costly and energy intensive process, CCS is also water intensive.[23] With the addition of CCS, power plant water usage is expected to increase by 33-90% for absolute and per net MW basis due to the additional demand for cooling and the carbon capture process itself.[24] Another study

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[16] Li, Yin et al., *Future emissions of particles and gases that cause regional air pollution in California under different greenhouse gas mitigation strategies*, 237 Atmospheric Env't 118960 (2022), https://doi.org/10.1016/j.atmosenv.2022.118960. Specifically, the study noted that "PM2.5 emission increase (+2.5%) suggest[s] potential air quality disbenefit associated with the CCS future especially around the Bio-IGCC-CCS power plant locations." Further, "SOx emissions increase in the CCS scenario because the Bio-IGCC plants emit more SOx than other electricity generation processes even though the accompanying CCS section removes more than half of the increased SOx." *Id.* at 4.

[17] Senior, Constance et al., *Emissions and risks associated with oxyfuel combustion: State of the science and critical data gaps*, 63 J. of the Air & Waste Mgmt. Ass'n 832 (2013), https://doi.org/10.1080/10962247.2013.791892. The limited data that is available is from "pilot-scale studies that reflect only limited conditions and do not encompass the variability in conditions that would be encountered at commercial scale." *Id.* at 841.

[18] *Id.* at 832.

[19] Alicia Victoria Lozano, *California warned to brace for another summer of energy blackouts*, NBC News (May 27, 2021), https://www.nbcnews.com/news/us-news/california-warned-brace-another-summer-energy-blackouts-n1268879.

[20] 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.

[21] *CAN Position: Carbon Capture, Storage, and Utilization*, Climate Action Network Int'l at 9 (2021), https://climatenetwork.org/resource/can-position-carbon-capture-storage-and-utilisation/.

[22] *Id.*

[23] Rosa, Lorenzo et al., *Hydrological limits to carbon capture and storage*, 3 Nature Sustainability 658 (2020), https://doi.org/10.1038/s41893-020-0532-7.

[24] EPRI, *Cooling Requirements and Water Use Impacts of Advanced Coal-fired Power Plants with CO2 Capture and Storage* (2011), https://www.epri.com/research/products/1024495.

shows that carbon capture through amine absorption, a common method, would nearly double the water consumption intensity, thereby posing a potentially unsustainable strain on water resources.[25]

CCS may further impact water availability through the risk of groundwater contamination. When CO_2 is pumped underground, only a small amount can be absorbed by the present water given the fact that CO_2 is only soluble in water to a limited degree.[26] What this means is that instead of water absorbing the CO_2, it will be displaced by the CO_2. The displaced water will then be forced to travel either vertically or horizontally, eventually impacting overlying freshwater aquifers. Additionally, studies have uncovered several potential impacts from the injection of CO_2 underground including storage leakage, brine displacement, and pH depression.[27] Leakage of CO_2-rich fluids into groundwater also could mobilize hazardous inorganic constituents or trace metals.[28]

CARB cannot ignore these potentially significant impacts on energy demand and water quality and quantity from promoting CCS as a solution to decarbonizing the cement industry in California. Given California's precarious grid demand and reliability situation, as well as years of ongoing drought cycles, promotion and adoption of CCS risks exacerbating these crises.

C. CCS technology does not achieve the carbon reduction goals industry promises

Powerplants with carbon capture have drastically failed to meet their CO_2 capture targets. CARB and the public should not be endorsing and supporting a strategy that is unproven and could entrench the State in a false solution, rather than making real progress through investments in genuinely clean and renewable technologies, such as wind and solar.

According to one calculation of the lifecycle emissions associated with CCS projects used with energy production from fossil fuels, CCS equipment captured "the equivalent of only 10-11 percent of the emissions . . . averaged over 20 years."[29] This research also considered the social cost of carbon capture—in other words, the resulting air pollution, potential health problems, economic costs and overall contributions to climate change—and concluded that these costs are similar to or higher than a fossil fuel plant *without* carbon capture, meaning "it is always better to use the renewable electricity instead to replace coal or natural gas electricity or to do nothing."[30]

Even when the lifecycle of a project is not taken into account, real-world CCS projects are repeatedly failing their carbon capture promises. July 2021, Chevron, operator of Australia's only commercial-scale CCS project, admitted that its self-described "world's biggest CCS project" failed to meet its five-year capture target of 80% CO_2, and is now seeking a deal with regulators on how to make

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[25] Zhai, Haibo et al., *Water use at pulverized coal power plants with post-combustion carbon capture and storage*, 45 Envt Sci. & Tech. 2479 (2011), dx.doi.org/10.1021/es1034443.
[26] V. Kennedy, *This sounds like an eco-friendly solution, but it's really a bad idea,* Modesto Bee, July 31, 2022, https://www.modbee.com/article263904387.html#storylink=cpy.
[27] Newmark, Robert L. et al., *Water challenges for geologic carbon capture and sequestration*, 45 Env't Mgmt. 651 (2010), https://doi.org/10.1007/s00267-010-9434-1; Keating, Elizabeth H. et al., *The challenge of predicting groundwater quality impacts in a CO2 leakage scenario: Results from field, laboratory, and modeling studies at a natural analog site in New Mexico, U.S.A.*, 4 Energy Procedia 3239 (2011), https://doi.org/10.1016/j.egypro.2011.02.242.
[28] Keating et al., *supra* note 27.
[29] Stanford Report Summary.
[30] *Id.* (noting that the social cost of coal with carbon capture powered by natural gas was about 24 percent higher, over 20 years, than the coal without carbon capture, and only when wind replaced the fossil fuel did the social cost decrease).

up for millions of tons of CO_2 it failed to store.[31] Estimates are that the Liquified Natural Gas facility captured only 30% of its CO_2 emissions.[32] In the US, the Petra Nova coal-fired powerplant in Texas achieved only a 50% CO_2 capture rate, when the fossil fuels needed to capture and store the carbon were taken into account.[33]

III. CCS Is Not Needed to Decarbonize Cement in California

The cement industry can be decarbonized without CCS by employing a suite of strategies across the cement lifecycle that do not pose dangers to communities, public health, the environment, and the climate. Meeting SB 596's goal can be accomplished using near-, mid-, and long-term strategies. The near- and mid-term strategies collectively can meet the goal of SB 596 to reduce emissions 40% below 2019 levels by 2035.

Near-term strategies for decarbonization include reducing process emissions by using sustainable supplementary cementious materials (Pathway 1); increasing energy efficiency through waste heat recovery and using electricity sourced from clean, renewable energy (Pathway 3); and increasing construction efficiency.

In the mid-term, the use of alternative cements can decrease process emissions while the electrification of kilns would have significant decarbonization benefits by eliminating fossil fuel combustion emissions (Pathway 2). In the long-term, meeting SB 596's goal for the industry to achieve net-zero emissions by 2045 is more challenging but could be accomplished by fully deploying these strategies combined with nature-based carbon dioxide removal to compensate for remaining emissions.

A. Near-Term Strategies

One of the most important and immediate ways to decarbonize cement production is to reduce the amount of clinker in cement, particularly because process-related CO_2 emissions from clinker production account for the majority (~59%) of cement emissions. At present, clinker can be substantially replaced by widely available supplementary cementious materials ("SCMs") while maintaining the integrity and performance characteristics of cement. SCMs, if substituted in optimized proportions, can reduce clinker content by up to 50% without negatively affecting cement's properties, while reducing GHG emissions by up to 30 to 40%.[34] Cement produced in the U.S. and California has one of the highest clinker-to-cement

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[31] IEFFA, C*hevron admits failure of $3 billion CCS facility in Western Australia* (July 19, 2021), https://ieefa.org/chevron-admits-failure-of-3-billion-ccs-facility-in-western-australia/.
[32] Adam Morton, *"A shocking failure": Chevron criticised for missing carbon capture target at WA gas project*, The Guardian (July 19, 2021), https://www.theguardian.com/environment/2021/jul/20/a-shocking-failure-chevron-criticised-for-missing-carbon-capture-target-at-wa-gas-project.
[33] IEEFA, *Reality of carbon capture not even close to proponents' wishful thinking* (Aug. 8, 2019), https://ieefa.org/reality-of-carbon-capture-not-even-close-to-proponents-wishful-thinking/.
[34] Sanchez Berriel, S. et al., *Assessing the environmental and economic potential of limestone calcined clay cement in Cuba*, 124 Journal of Cleaner Production 361 (2016), http://dx.doi.org/10.1016/j.jclepro.2016.02.125; Miller, Sabie A. et al., *Achieving net zero greenhouse gas emissions in the cement industry via value chain mitigation strategies*, 4 One Earth 1398 (2021), https://doi.org/10.1016/j.oneear.2021.09.011; *see also* Franks, Daniel et al., *Low-Carbon Cement Adoption in the Pacific Region-Limestone Calcined Clay Cement (LC3), Univ. of Queensland Sustainable Minerals Inst*., https://smi.uq.edu.au/project/low-carbon-cement-adoption-pacific-region-limestone-calcined-clay-cement-lc3; École Polytechnique Fédérale de Lausanne
Laboratory of Construction Materials (LMC), *Why LC3*, https://lc3.ch/why-lc3/; Schokker, Andrea et al., *Limestone Calcined Clay Cement Makes Inroads in Reducing Carbon Emissions*, Concrete Int'l (Sept. 1, 2022), https://www.concrete.org/publications/internationalconcreteabstractsportal.aspx?m=details&id=51737200.

ratios globally of 0.90, compared with the lowest ratio of 0.58 used in China, meaning that there is substantial opportunity to reduce clinker content in cement and concrete production in California.[35]

The most sustainable materials to use as SCMs are ground limestone and calcinated clay. Ground limestone is the dominant SCM currently used by cement plants in California,[36] and there is an important opportunity to increase its use in cement and concrete production. Currently, the proportion of ground limestone in cement in California is less than 15%, but this could be increased to 25-35% while retaining similar performance characteristics.[37] Limestone is typically readily available because it is the same raw material used for clinker, and because it is easier to grind than clinker, there is no energy penalty when replacing clinker with limestone.[38] One currently available product is Portland Limestone Cement ("PLC") which is blended cement that allows an additional 10% limestone content relative to Ordinary Portland Cement ("OPC") resulting in a substitution level of 15%.[39] PLC reduces process emissions by 10% relative to OPC due to the lower proportion of clinker.[40] While PLC use reduces emissions, California can achieve even greater emissions reductions by requiring the production of cement with higher substitution levels of limestone of ~25-35%. Furthermore, a blend of ground limestone and calcined clay, known as limestone calcined clay cement or ‘‘LC3,’’ can replace even higher levels of clinker (up to 50%) and reduce GHG emissions by 30%.[41] Another promising SCM is recycled cement and concrete removed from the built environment at the end-of-life in construction and demolition waste. For example, Fine Recycled Concrete (FRC) made from end-of-life concrete has proven to be a feasible SCM widely available in the U.S. that can reduce cement's carbon intensity.[42]

Fly ash and ground-granulated blast-furnace slag ("GGBFS") should not be used as SCMs in California. These materials pose toxicity hazards due to organic pollutants, heavy metals, and radioactive elements[43]; they are produced by polluting, energy-intensive processes that are being phased out; and they are not locally available in California.[44] Toxic fly ash is primarily produced by coal-fired power plants and its production is declining as coal is being phased out. Because there is only one remaining coal-fired power plant in California (the Argus Cogeneration Plant in Trona, San Bernardino County), transporting fly ash from other states into California increases its carbon intensity and cost. GGBFS is produced in steel plants that use blast furnaces which are extremely carbon-intensive and are being replaced by electric arc furnaces which have a carbon intensity that is 75% lower. There is no GGBFS production in

[35] Hasanbeigi, Ali and Springer, Cecilia, *Deep Decarbonization Roadmap for the Cement and Concrete Industries in California*, Global Efficiency Intelligence (2019), https://www.climateworks.org/wp-content/uploads/2019/09/Decarbonization-Roadmap-CA-Cement-Final.pdf at 22.
[36] *Id.* at 25.
[37] *Id.*
[38] *Id.*
[39] *Low-carbon cement tested at Oregon State approved for California highway projects*, Oregon State University (Feb. 7, 2022), https://today.oregonstate.edu/news/low-carbon-cement-tested-oregon-state-approved-california-highway-projects.
[40] *Id.*
[41] Miller, Sabie A. et al., *supra* note 34 at 1402.
[42] Rocha, J.H.A. et al., *Sustainable alternatives to CO_2 reduction in the cement industry: A short review*, 57 Materials Today: Proceedings 436 (2022), https://doi.org/10.1016/j.matpr.2021.12.565;
Shah, Izhar Hussain et al., *Cement substitution with secondary materials can reduce annual global emissions by up to 1.3 gigatons*, 13 Nature Commc'ns 5758 (2022), https://doi.org/10.1038/s41467-022-33289-7.
[43] U.S. Envtl Protection Agency, *Coal Ash Basics* (last updated March 6, 2022), https://www.epa.gov/coalash/coal-ash-basics; Physicians for Social Responsibility, *Coal Ash: Hazardous to Human Health*, https://psr.org/wp-content/uploads/2018/05/coal-ash-hazardous-to-human-health.pdf.
[44] Hasanbeigi and Springer, *supra* note 35 at 23-25.

California as the sole steel plant uses the electric arc furnace process; meanwhile importing GGBFS increases its carbon intensity and cost.

Energy efficiency measures can impact about ~40% of cement CO_2 emissions. In the short-term, one important efficiency measure which is not currently being implemented in California's cement plants is waste heat recovery. Waste heat recovery, which uses the excess heat from kilns to power the facility, has been shown to save up to 20% of fuel consumption and reduce ~8% of CO_2 emissions.[45] In addition, requiring the electricity used by cement plants to be generated from clean, renewable solar and wind energy could reduce cement production GHG emissions by another 5%.[46]

Lastly, as the cement industry's scale is largely responsible for its significant emissions, construction efficiency can result in substantial GHG emissions reductions. The optimization of construction designs, the use of high strength concrete only when necessary, and replacing site-mixed concrete with ready-mixed concrete can reduce GHG emissions by up to ~50%.[47]

B. Mid-Term and Long-Term Strategies

In the mid-term, the use of alternative cements that can fully or partially replace Ordinary Portland Cement can be an effective way to reduce process emissions. These alternative binders, including reactive belite portland cement, belite ye'elimite ferrite cement, carbonatable calcium silicate cement, magnesium oxide cement, and calcium sulfoaluminate-belite cement have been shown to result in lower GHG emissions and lower environmental impacts relative to the Portland Cement.[48] Electrification of kilns for the heating and calcination process, for example through roto dynamic heaters powered by clean, renewable energy, [49] would have significant decarbonization benefits by eliminating the combustion emissions from the coal, petroleum coke, and other fossil fuels currently being used to power kilns.

In the long-term, meeting SB 596's goal for the industry to achieve net-zero emissions by 2045 could be accomplished by fully deploying these strategies combined with nature-based carbon dioxide removal to compensate for remaining emissions.

IV. Biomass Should Not Be a Part of Fuel-Switching to Decarbonize Cement

In order to truly achieve the decarbonization goals of SB 596, CARB must not recommend any strategy that involves biomass-derived fuel as part of Pathways 2 or 3. This is because biomass is highly

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[45] Salas, D.A. et al., *Environmental impacts, life cycle assessment and potential improvement measures for cement production: a literature review*, 113 J. of Cleaner Production 114, 119 (2016), https://doi.org/10.1016/j.jclepro.2015.11.078 .
[46] Hasanbeigi and Springer, *supra* note 35 at 11.
[47] UN Envt et al., *Eco-efficient cements: Potential economically viable solutions for a low-CO_2 cement-based materials industry*, 114 Cement and Concrete Research 2 (2018); Dunant, Cyrille F. et al., *Good early stage design decisions can halve embodied CO2 and lower structural frames' cos*t, 33 Structures 343 (2021), https://doi.org/10.1016/j.istruc.2021.04.033; Watari, Takuma et al., *Efficient use of cement and concrete to reduce reliance on supply-side technologies for net-zero emissions*, 13 Nature Commc'ns 4158 (2022), https://doi.org/10.1038/s41467-022-31806-2.
[48] Miller, Sabbie A. et al., *Environmental impacts of alternative cement binders*, 54 Envtl. Science and Tech. 677 (2020), https://pubs.acs.org/doi/10.1021/acs.est.9b05550.
[49] Concrete Products, *Cemex to pilot high temperature electric device for cement kiln phase* (May 18, 2022), https://concreteproducts.com/index.php/2022/05/18/cemex-to-pilot-high-temperature-electric-device-for-cement-kiln-phase/.

GHG intensive, and its use to generate power also leads to emissions of other harmful air pollutants. Instead, CARB must rely only on true low- and zero-carbon renewables, such as wind and solar.

Incinerating biomass to generate electricity emits more CO_2 per kilowatt-hour than what is generated from fossil fuels, including coal.[50] As a result, biomass power plants are much more climate polluting than other electricity sources in California. According to 2018 data pulled from the Air Resources Board, the GHG emissions of biomass powerplants range from around 2,500 to over 19,000 lbs CO_2e per MWh, and average 3,500 pounds CO_2e per MWh for non-cogeneration facilities.[51]

The myth of biomass as "carbon neutral" persists because its proponents erroneously claim that cutting and incinerating trees is inherently "carbon neutral"—i.e., that it does not cause net GHG emissions.[52] Published scientific research has thoroughly debunked this false claim. As a result, the IPCC, federal Environmental Protection Agency's Science Advisory Board, and numerous other scientific bodies have established that woody biomass energy should not be assumed carbon neutral.[53] Cutting and burning trees for bioenergy releases their stored carbon to the atmosphere, immediately increasing CO_2 emissions and ending trees' future carbon sequestration, creating a "carbon debt."[54] To claim biomass energy is carbon neutral, biomass proponents try to discount the carbon released by biomass power plants 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 lost from cutting and incinerating them.[55]

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[50] 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.
[51] Total CO2e emissions for each facility in 2018 come from California Air Resources Board Mandatory GHG Reporting Emissions data, available at *Mandatory GHG Reporting – Reported Emissions,* Cal. Air Res. Bd., https://ww2.arb.ca.gov/mrr-data (last visited Nov. 10, 2022). Data on net MWh produced by each facility in 2018 come from *California Biomass and Waste-To-Energy Statistics and Data*, Cal. Energy Comm'n, https://ww2.energy.ca.gov/almanac/renewables_data/biomass/index_cms.php (last visited Nov. 10, 2022) (select 2018 in the "Go to a Different Year" dropdown menu). Total CO2e produced by the 9 electricity only, non-cogeneration active woody and agricultural biomass facilities with available data totaled 2,127,693 metric tons, and net MWh in 2018 from these 9 facilities totaled 1,334,346 MWh, for an average of 1.59 metric tons CO2e per net MWh, equal to 3,515 pounds CO2e per net MWh. The average of 3,515 pounds CO2e per MWh includes electricity-only plants; cogeneration plants are excluded because some of their CO2 emissions are from heat-related fuel consumption. The high CO2e rate-per-MWh is similar for biomass facilities without cogeneration.
[52] *Id.*
[53] IPCC, *Frequently Asked Questions, Task Force on National Greenhouse Gas Inventories,* http://www.ipcc-nggip.iges.or.jp/faq/faq.html (last visited Nov. 10, 2022) 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); 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");
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.
[54] Sterman, John et al., *supra* note 50.
[55] *See, e.g.*, Sterman, John et al., *Does replacing coal with wood lower CO_2 emissions? Dynamic lifecycle analysis of wood bioenergy*, 13 Envtl. Research Letters 015007 (2018), https://doi.org/10.1088/1748-9326/aaa512.

V. Conclusion

We appreciate CARB consideration of various pathways as it develops a plan to decarbonize the cement industry. We urge the agency to reject CCS as part of any pathway given that CCS will only produce GHG reductions on paper, while facilities in real life using CCS will fail to meet their carbon capture targets and further contribute to the climate crisis. Moreover, CCS is dangerous and stands to put vulnerable communities—particularly environmental justice communities in the Central Valley—at risk of serious health and safety impacts. CCS is also energy and water intensive, making it a poor fit for California. We also urge CARB to reject fuels such as biomass as part of any pathway given that fuel's high GHG emissions.

Instead, CARB can achieve the decarbonization of cement production through strategies that are safe for communities, the environment, and the climate by reducing process emissions through the use of sustainable supplementary cementious materials and alternative cements (Pathway 1); eliminating combustion emissions through the electrification of kilns (Pathway 2); increasing energy efficiency through waste heat recovery and using electricity sourced from clean, renewable energy (Pathway 3); and increasing construction efficiency.

Thank you,

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