June 24, 2022

Comments on Elements of the Draft Scoping Plan 2022

350 Silicon Valley's technical experts have prepared comments on the following sections of the draft Plan:

Thanks very much for considering these comments. If you have any questions, please let me know and I will direct you to our subject matter expert.

Sincerely,

Janet Cox
Legislation Director
350 Silicon Valley
janet@350siliconvalley.org
415 902 1795

Proposed Strategies for Carbon Removal and Sequestration

Attempts to jump to industrial scale for carbon capture and storage (CCS) technology have failed everywhere they have been tried, and there is no reason to think that CARB's high expectations will be borne out in actual practice. In the 2022 legislative session, the Senate floor analysis of SB1101 (Caballero and Newman), Carbon sequestration: pore space ownership and Carbon Capture, Utilization, and Storage Program makes this point:

> "Despite calls for more CCS, development and deployment of CCS technology has been slow. Between 2010 and 2017 the number of facilities across the globe that actively invested in CCS technology declined from 77 to 37. Most demonstration projects have failed to transition into fully operating plants in part due to fluctuating markets and insufficient financial support. Several of the most recent projects have also suffered from failures in achieving promised sequestration goals, such as the Gorgon facility in Western Australia, which only stored 5.5 million metric tons of CO2 over 3 years of a promised 12 million, or the Petra Nova facility in Texas which, before its closure in 2020, missed its sequestration targets by 17%."

The thermodynamics of carbon capture, utilization, and storage (CCUS) are daunting because a large amount of energy is required to separate the carbon dioxide from the process waste stream and compress and pump it into permanent storage. This energy burden cannot be avoided and must be included in calculations of the Scopes 1, 2, and 3 GHG emissions associated with the process.[1]

We advocate for restrictions to be placed on the technologies used to capture and store CO2 unless pilot scale projects prove efficacy:

Because CCS is the most costly method for decarbonizing cement, for example, it should only be used as a last resort after all other decarbonization technologies have been implemented in a project, such as:

a. Use equivalent cement substitutes, which require lower energy inputs
b. Require use of 100 percent non-carbonaceous, combustion-free energy (which is cheaper than fossil energy in over 85 percent of the world)
c. Require mineralization (via additives or surfactants) to enhance the natural capture by air-exposed concrete. This would not require transport, geologic storage, or additional equipment to remove airborne toxics from the smokestack flue stream of the cement factory)

See Senator Josh Becker's bill, SB-778 Buy Clean California Act: Environmental Product Declarations: concrete, for one example.

[1] Comments on the Council for Environmental Quality's "Carbon Capture, Utilization,

Direct Air Capture and Carbon Removal Targets

We ask CARB to return to the drawing board and only include proven technologies in Scoping Plan 2022. The strategies and approaches we adopt in the next eight years must be free from disabling constraints and deleterious side effects. They must be as cost-effective as reduction of emissions. In preparing Scoping Plan 2027, CARB may review the peer-reviewed and independent research on engineered capture and reconsider it at that time. Until then, we must focus on scaling proven solutions and avoid squandering resources on wishful thinking and theoretical projections of optimistic inventors. Please investigate other capture technologies as well, e.g., mineralization.

There is widespread consensus among climate scientists that

a) Removal of greenhouse gasses (GHGs) from the atmosphere is necessary to conquer the climate crisis

b) Natural carbon sequestration is important but likely incapable of extracting a sufficient volume of GHGs to significantly abate the problem

c) Removal is an adjunct to (but not a replacement for) emissions reduction

d) Over time, and as GHG levels rise in the atmosphere, capture technologies will be able to extract greater volumes of CO2 per amount of energy input

Due to d), carbon capture technologies are understood to be more suitable for scaling 20 to 30 years in the future.

The IPCC Sixth Assessment report, released April 2022, is often described as proclaiming that large scale development of engineered capture technologies is necessary. The Panel's statements are qualified, however; and the qualifications are rarely mentioned. While the IPCC states that engineered capture is one of our best potential options for sectors that are difficult to decarbonize, this will only be true if engineered capture can be shown to be effective.

Smokestack CCS has not been proven effective, while direct air capture (DAC) has been shown to work on a small scale. The IPCC goes on to caution us, however, that the cost and energy requirements for these are enormous. They recommend prioritizing the development of clean energy to power 100 percent of our grid and all other sectors— until engineered capture technologies are proven to be effective.

In 2021, global emissions of CO2 were over 36 gigatons—an all-time high despite decades of climate policies. The scale of development of engineered capture required to make even a tiny impact on atmospheric levels of carbon is massive. Per the International Energy Agency (IEA), all of the capture equipment currently functioning on the planet has the potential to capture 40 million tons of CO2 annually. And this estimates gross capture, not net capture. Currently, even gross capture does not decrease atmospheric CO2 levels significantly and net capture has not been demonstrated.

Furthermore, current engineered capture equipment only captures CO2. It does not capture toxic co-pollutants, many of which have GHG properties. Nor does it capture black carbon or methane, which have 20 year GWPs over 4,000 times and 85 times higher than CO2, respectively. CCS increases local toxic pollutants and degrades environmental justice in sacrifice zones.

Because CCS and CCUS have not been proven effective, do not extract toxic co-pollutants, present long-term public liability risks, and because there are numerous constraints on sufficient energy supply, scaling, and affordability, this is not a wise choice as a pillar of carbon neutrality policy. Though DAC is effective, it is marred by the other limitations of CCS and CCUS and is also a less-than-substantial pillar.

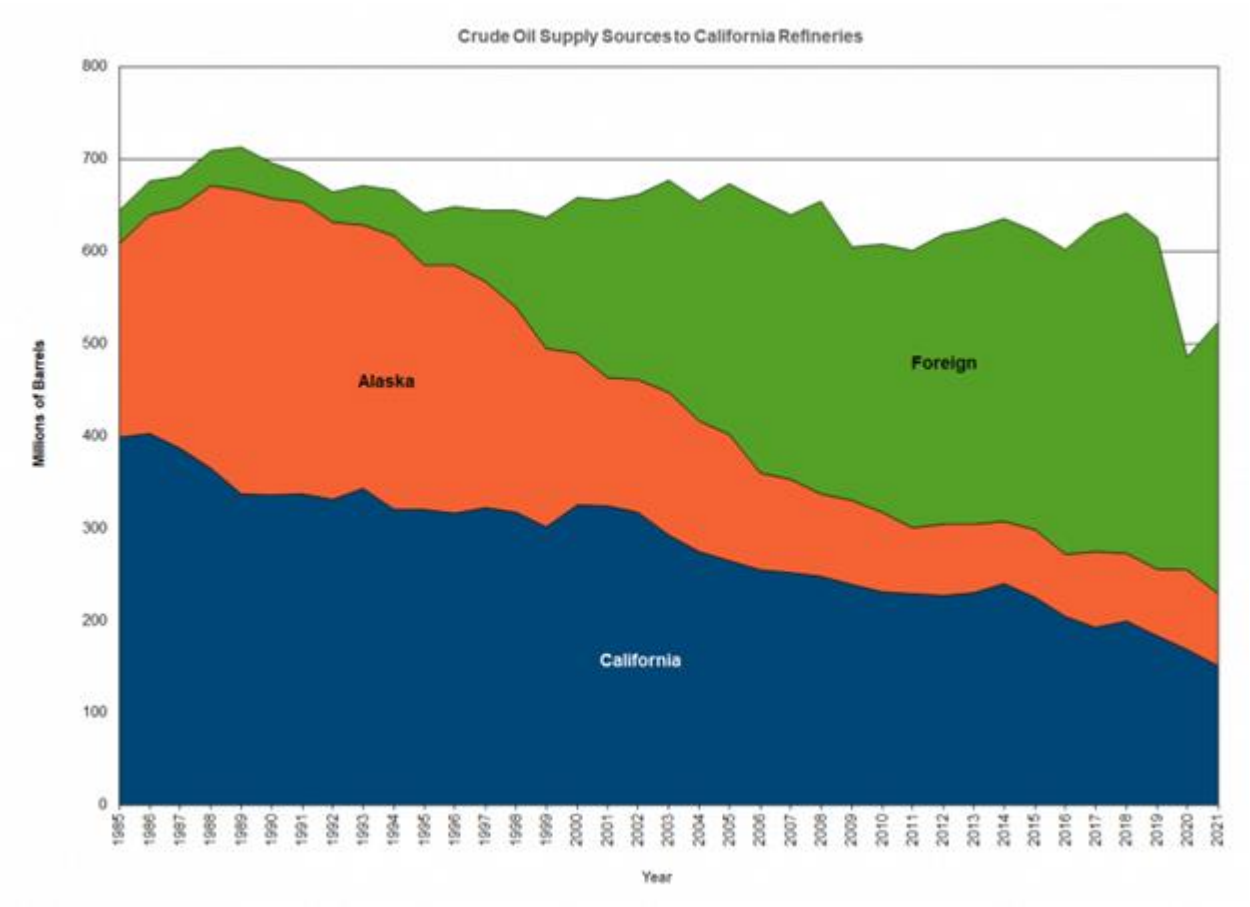
Oil and Gas Extraction

The Scoping plan begins from the assumption that there is no plan A to get to net zero by 2045—but rather, that the transport sector will require the burning of fossil fuels well past that date. With the Earth's climate at stake and the IPCC telling us that we have less than a decade to eliminate carbon dioxide emissions to the atmosphere to have any hope of staying close to a 1.5C rise in global temperature, failure to plan properly to do this is a moral and ethical failure by CARB. The bottom line is that we MUST phase out all carbon combustion by 2035 at the latest (and we MUST figure out how to do it). This should be the starting assumption of this section of the Scoping plan and to work backward to set proper timelines for achieving it. We cannot afford to wait for the next scoping plan update, as suggested by CARB, for better ideas.

- California should halt acceptance of permit applications for new fossil fuel infrastructure by July 2023. This includes wells, pipelines, storage tanks, hydrogen from steam methane reforming, and refineries.
- We must plan scaling of ample clean energy infrastructure in ways that most swiftly replace fossil fuel energy use in all sectors, while improving environmental justice and avoiding imports of fossil fuels.
- Cost-benefit analyses for new energy projects should include complete lifecycle GHG and toxic emissions from Scopes 1, 2, and 3 as well as "Scope 4" (avoided emissions, including recycling and site remediation). Public health effects should include premature mortality, acute illness, and chronic morbidity. Out-of-state supply chain emissions should be included. For example, if a CA factory plans to import coal-sourced electricity from another state, the emissions from generating this electricity should be factored in. A factory owner may choose clean energy imports and should be incentivized to do so by permit denial for projects that plan to import dirty energy. (We realize that double-counting of emissions is to be avoided when tallying nationwide emissions. However, when the tally is limited to CA, out-of-state emissions and offset credits should be counted.)
- Prohibit operators from extracting fossil fuels from active wells until they have sealed and plugged idle wells and pipelines in their portfolios.
- By July 2023, prohibit all forms of fracking (hydro, chemical, horizontal drilling), EOR, venting, and flaring. Annually, double the production tax on fossil fuels and use the revenue to fund clean energy innovations in all sectors.

The plan also incorrectly says that because California's in-state crude production will be declining over time, this will necessarily reduce refinery output. Unfortunately, yearly data from the California Energy Commission, CEC Crude by Source in California , shows that only about 1/3 of the state's crude came from in-state sources in 2020. That fraction has been steadily decreasing over the last 30 years.

Isn't this the kind of "leakage" that AB32 is intended to avoid?


Crude Oil Supply Sources to California Refineries
Millions of Barrels
800
700
600
500
400
300
200
100
0
Alaska
Foreign
California
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
2019
2020
2021
Year

Petroleum Refining

We read this section as pure fear mongering. It posits as a straw man the need for more refined fuels than extant California refineries could provide in 2045, thus justifying the construction of new marine terminals or pipelines to bring refined fuel into the state. How can this be considered anything less than laughable when no light duty combustion vehicles will be sold in the state after 2035 and no heavy-duty vehicles after 2045 according to current legislation?

In fact, the ambition of our legislature is increasing in this regard as demonstrated by Senator Nancy Skinner's SB-1010 Air pollution: state contracting: zero-emission vehicles, in the current session. The bill has passed the Senate and is now being considered in the Assembly. It requires that all new light, medium and heavy-duty vehicles purchased by the state be ZEV by 2027. Why is CARB digging in its heels to preserve a carbon combustion economy that is destroying our climate?

BIOFUELS

Refining of biofuels should be allowed only if peer-reviewed lifecycle research shows that it has significantly lower toxic and GHG emissions than refining petroleum. This includes Scopes 1, 2, 3, and 4 (avoided emissions, or reverse logistics, including recycling and site remediation). The specific emissions profile will depend upon the kind of biomass used (e.g., corn, compost, or switchgrass) and the distance between its source and the refinery, and mode of transport.

Because the viscosity and carbon intensity of most oil produced in California is higher than that of tar sands oil, the lifecycle emissions of importing less-viscous oil should be studied. Imports entail more transportation emissions, but avoid the higher emissions of California oil extraction.

Economic and Health Evaluations

The draft scoping plan update assumes an average 3 percent growth in GDP until 2045. In fact, this is difficult to predict and the actual percentage may be quite different. As we have learned from the COVID-19 era, pandemic lockdowns are a drag on economic growth. Zoonotic pandemics and vector-borne communicable diseases are projected to rise as climate change intensifies - jeopardizing GDP and public health. GHG emissions and toxic co-pollutants rise during economic expansions and decline during contractions. A growth rate of 3 percent annually may not be sustainable, especially if our decarbonization plans differ only slightly from a dirty BAU trajectory. Planning for an average annual 1 percent GDP increase would improve the probability of reaching carbon neutrality sooner. Higher target GDP rates should only be sought if we take a swift decarbonization pathway starting in 2023. This is consistent with the precautionary principle, which CARB has failed to consider. If CARB's chosen alternative fails, there is no Planet B to migrate to.

Unfortunately, CARB staff are endorsing Alternative 3, a gradual, heavily deferred plan that targets carbon neutrality by 2045, instead of by 2035 as in Alternatives 1 and 2. The primary justification for selecting Alternative 3 is that it has the lowest cost, which staff appears to equate with "feasibility." We appreciate staff's efforts to weigh economic factors, but disagree with the reasoning, modeling, and conclusion. The gross cost of each of the four alternatives is a tiny percent of GDP and the difference in costs of each of the four is slight. **A plan with the lowest gross cost does not necessarily have the lowest net cost.** The actual net cost requires an accurate estimation of the value of benefits of decarbonization. CARB has failed to provide an accurate estimate of this. The public health component of benefits is most underestimated as addressed below.

Whether to select a pricey or economical alternative policy should be up to the Office of Planning and Research, the Legislature, and the Governor. The role of CARB should be to follow its mission statement and promulgate policies that improve air quality and public health. Providing accurate benefit to cost analyses is an important part of CARB's role, but CARB should favor an alternative based only on air quality, climate change, and public health.

The consensus of research on mitigation of climate change shows that maximizing near-term investments in decarbonization have a higher ROI than investments made in later decades. Nearly all peer-reviewed and independent research indicates that delaying investment in decarbonization will increase the future costs of mitigation and adaptation. No amount of investment in adaptation will yield mitigation results. Maximizing investments in mitigation will decrease the amounts we are forced to spend for adaptation [2], [3]

I. NONENERGY BENEFITS

Premature Mortality

In 2018, 8.7 million people suffered premature mortality from fossil fuel industry particulate matter (PM) emissions.[4] A 2021 study estimated 10.2 million.[5] Estimates of the number of annual premature deaths from fossil fuels-related particulate pollution (PM) in the US range from 335,000 and 355,000. Using 340,000 and dividing this by the population of the US in 2018 (327 million) equals 0.1 percent. The California population in

[2] Vijay S. Limaye, et. al. "Estimating The Costs Of Inaction And The Economic Benefits Of Addressing The Health Harms Of Climate Change." https://doi.org/10.1377/hlthaff.2020.01109

[3] https://www2.deloitte.com/content/dam/Deloitte/dk/Documents/about-deloitte/Deloitte-Global-Turning-Point-2022.pdf

[4].https://www.seas.harvard.edu/news/2021/02/deaths-fossil-fuel-emissions-higher-previously-thought

[5] Karn Vohra, et al., "Global mortality from outdoor fine particle pollution generated by fossil fuel combustion: Results from GEOS-Chem" https://doi.org/10.1016/j.envres.2021.110754

2018 was 39 million. 0.1% of 39 million is 39,000. The value of a statistical life in the US is $10,000,000. Thus, the annual total value of lives lost is $390 billion (39,000 times ten million).

Combustion of fossil fuels emits about one dozen toxics. Mortality from the other toxic co-pollutants was not estimated. Many of these toxics are also GHGs, which are the foremost cause of climate change. Let's consider the 20-year global warming potential (GWP) of a few.

CO2	1	
Methane	85	(from fugitive emissions and venting)
NOx	nearly 300	
Black carbon	4,400	(this is part of PM)

The toxic impact of each of the above on morbidity and mortality should be included in benefit / cost analyses. The GHG impact of each of the above on climate change should also be included in benefit / cost analyses. All of these are part of the Social Cost of Carbon.

What is the death toll from climate change (that is not due to toxic airborne pollution)?

One estimate is 150,000 annually. This is a very conservative estimate because cause-of-death records rarely mention air pollution.There is a high probability that premature mortality from climate change, as well as toxic co-pollutants, will continue to increase as long as FF combustion continues. Between 2030 and 2050, over 250,000 deaths per year are projected to be caused by weather extremes .Notice how small these numbers are when contrasted with premature mortality from fossil fuels-related particulate pollution.

RESILIENCE

Most people's work (at an office, job site, or home) requires a continuous supply of electricity. During power outages, people still depend upon electronic medical devices. Without clean distributed energy resources such as rooftop or community solar, when the power goes out people will fire up their fossil-powered generators—releasing medically-harmful toxic pollutants. Loss of productivity should be included in benefit / cost analyses.

For more on this topic, see https://e360.yale.edu/features/three-myths-about-renewable-energy-and-the-grid-debunked

SOCIAL COST OF CARBON

Polluters have been using our atmosphere as a trash can for many decades. The cumulative costs are in the $trillions, but polluters have paid a tiny fraction of this. It is time for them to pay a price that propels the transition from dirty to clean energy forward at a pace that increases our chance of survival.

How to set that price? There are several options.

- Instead of using discount rates ranging from 2.5 to 5 percent, a range of discount rates from zero percent to negative percentages could be used. This maximizes intergenerational benefits for our children and grandchildren, who currently have little or no influence over public policy. Discount rates higher than zero are inconsiderate.

  Compared to a discount rate of 5 percent, a zero percent rate is projected to decrease CO2 emissions (and perhaps other GHGs) by 41 percent. See https://iopscience.iop.org/article/10.1088/1748-9326/ac228a. A discount rate of 5 percent would raise gasoline prices by about 50 cents per gallon. A necessary part of decarbonization planning is to increase the price of fossil fuels. This will drive down the price of both clean electricity and devices powered by clean electricity.

- An alternative is to use a target-consistent cost of GHG emissions. GHG taxes, paid primarily by polluting industries, would be raised annually until the targets are achieved.

- A third alternative is to set the price of CO2 emissions at the current price of removing CO2 from the atmosphere. Only one technology has been proven effective for this task. The cost of using Direct Air Capture is presently $600/MT. This does not include costs of transporting CO2 to storage or maintaining storage repositories. (CCS does not remove CO2 or toxins from the atmosphere; it only removes CO2 that is being emitted from industrial smokestacks. CCS has not been proven effective and there are numerous unresolved problems about its use.)

The E3 modeling paradigm selected by CARB is based on a 2017 report by Global CCS Institute, a CCS industry association. Using a model from a peer-reviewed scientific panel or association would provide more accurate guidance. The E3 estimates of the cost of scaling CCS and managing its hazards is unrealistically low. CCS should be removed from all four alternatives until such time as it is proven effective by peer-reviewed and independent research.

We note that the draft Plan does not incorporate most of the input from EJAC. Please do so in your next update. Individuals living in sacrifice zones pay the highest Social Cost of Carbon.

II. BENEFIT-TO-COST MODELS IN THE DRAFT SCOPING PLAN

This section of the draft plan has been critiqued by many able commenters. It is a subject that would take a textbook-length document to cover. Here is a very brief summary:

Modeling and methodology assumptions and premises should be presented before the results of using the models are presented. Instead of using estimated benefits only from two months in 2045, cumulative benefits of all months in each year between 2023 and 2045 should be used and reported. Cumulative totals should be weighed against cumulative costs.

The IMPLAN model is based on questionable assumptions.

- It assumes that job losses from decarbonization will not be replaced by job gains in clean versions of sectors. This clashes with Professor Pollin's just transition report and the CA 2030 report by Energy Innovation.
- It assumes that mitigation costs will decrease household income. Actually, mitigation will increase only dirty energy based expenses while driving down clean energy based expenses. The ratio of dirty to clean will decrease over the years of mitigation policies, resulting in annual increasing net savings on clean energy and consumer goods. See https://peri.umass.edu/publication/item/download/969_3900ffcb89b3b2d9ac94c79fe37ee96f

CARB models include a very limited selection of the known impacts of GHGs and toxic co-pollutants. The focus is almost entirely on the acute effects of acute exposure. Accurate estimation requires an analysis of acute and chronic effects of acute and chronic exposure. This includes premature mortality and chronic morbidity. CARB includes the effect of only a few airborne emissions. Accurate benefit to cost analyses require inclusion of the effects of all kinds of emissions. The annual cost of medical care for those with chronic diseases is excluded from CARB's modeling. In California, the annual cost of medical care for someone with chronic cardiovascular disease is about $16,000.

III. MEDICAL EFFECTS OF EMISSIONS

Though the emissions profile of combustion of biomass, biofuels, and fossil fuels is quite similar, the following list includes the kinds of emissions from combustion of fossil fuels and the medical risks of exposure to each:

Harmful Effects of Fossil Fuel Emissions, including fine particulates, toxic gases, and GHGs

Emissions from fossil fuel extraction and combustion have been proven to decrease longevity, induce shortness of breath, exacerbate chronic respiratory disorders, increase risk of cardiovascular disorders (e.g., heart attack), trigger allergic reactions, decrease lung function, increase upper respiratory infections, diminish cognitive function, decrease alertness, and lower endurance. The combination of emissions impairs heart, liver, and lung capacities to expel toxins.

Heavy metals, which are toxic and fatal in sufficient doses, increase oxidant damage, cancer, cardiovascular disease, organ damage, and neurodegenerative disorders (e.g., Parkinson's and Alzheimer's).

Benzene increases risk of birth defects, leukemia, anemia, bone marrow damage, cancer, drowsiness, and immune impairment.

Nitrogen oxides increase risk of chronic respiratory disorders (e.g., cancer), cardiovascular disease, and diabetes mellitus.

Sulphur oxides induce shortness of breath and decrease longevity.

Carbon dioxide exposure may temporarily cause headache, dizziness, shortness of breath, and fatigue; chronic impairment of visual acuity, cognitive function, and kidney function; and cancer as well as brain damage.

Carbon monoxide, fatal in high doses, causes confusion, shortness of breath, diminished endurance, impaired cognitive function, and brain damage.

Formaldehyde temporarily induces wheezing and fatigue; and increases risk of cancer, birth defects, and asthma.

Aldehyde increases risk of cancer, liver damage, and cilia impairment.

Volatile organic compounds (ROG) induce fatigue and shortness of breath; increase risk of respiratory disorders, cancer, cardiovascular disorders, liver dysfunction, kidney dysfunction, cognitive impairment, and dementia. ROG increases smog formation.

Methane temporarily induces shortness of breath, weakness, and drowsiness; increases ground-level ozone (which kills 1 million people annually).

1, 3 butadiene irritates respiratory passages and increases risk of cardiovascular disease and cancer

Fine particulate matter (PM<2.5um) pollution may be carried hundreds of miles by wind and remain airborne for weeks. PM increases risk of preterm birth disorders and mortality, cancer, mutagenesis, cardiovascular disease, chronic kidney disease, exacerbation of respiratory disorders, and increases risk of Alzheimer's Disease. There is no exposure below which there is no harm. Any amount of exposure is harmful. Some PM may contain heavy metals. The smallest PM enters air sacs as a doorway to blood in the circulatory system. PM contains black carbon, which has a 20-year GWP exceeding 4,000. PM from fossil fuel combustion causes over 9 million premature deaths annually.

MEDICAL IMPACT OF NWL ALTERNATIVES

These alternatives presume that increased forest management will decrease wildfire incidence and scope. Though some research corroborates this, other research finds no relationship and there is no consensus on the issue amongst ecology and forestry scientists. It is important to inform the public about the uncertainties and inconsistencies in this research and to caution the public to be cognizant of biasing influences from traditions who have used unproven burning practices, utilities guarding their transmission lines, the logging industry, and a public that is desperate for reassurances that we know how to fix this problem.

There is consensus that the best fix is to reverse climate change. Biomass-removing management methods must be repeated every five years to be effective. The cost of scaling this to a sufficient acreage is many $billions annually.

It is established that in the wildland-urban interface, understory vegetation removal, but not logging of deceased or growing trees, decreases risk of wildfires invading residential areas. Home hardening measures are quite effective in decreasing fire damage to housing. These two measures are likely to have medical benefits. Your estimates of avoided medical costs and mortality would be valuable. During winters in the Bay Area, the largest source of PM emissions (containing black carbon) is residential fireplace use. If research indicates that there are cost-effective PM reduction devices or that a winter moratorium on use decreases emissions, conduct demonstration projects in some WUI and large urban areas and include this measure in local air district policies or the next Scoping Plan.

It is also well-established that unmanaged old-growth forests are at lower risk of wildfire than any kind of managed forest. This is especially true for immature forests and forests impaired by logging.

Because the temperature used for prescribed burning is lower than the temperature of wildfires, combustion is less complete. This releases more toxic co-pollutants. Adverse medical effects from prescribed burns are more severe than the effects of wildfire. If vegetation removal is done, only cutting should be used - preferably with manual or zero-emission tools. This prevents anthropogenic release of GHGs and toxins. Burning should not be used in forests or on agricultural lands until climate change has been conquered.

IV. RECOMMENDATIONS

- The table on page 118 of the draft scoping plan displays medical impacts of the proposed alternative. **CARB should add columns that quantify the impacts of the other three alternatives.** Impacts for each alternative would be a helpful addition to many other graphs and tables in the draft that now display only data on the proposed alternative. Contrasting the four alternatives should be in the summary, rather than in the appendices.
- Eradicate the NWL medical impacts section that addresses combustion-based management measures this year and reconsider adding it in 2026 when drafting SP 2027. Keep each SP focused only on well-proven mitigation measures.

PUBLIC HEALTH APPENDIX

This was well done. Kudos! The sections on Active Transport and Urban Greening are especially informative. In the Scoping Plan 2027, please provide quantitative estimates of medical effects and the economic benefit of policies to implement these concepts.

RESOURCES

Value of life - Wikipedia

How Much Is a Human Life Actually Worth? | WIRED

https://www.consumerwatchdog.org/sites/default/files/2022-05/CostOfOil.pdf

In An Unusual Step, a Top Medical Journal Weighs in on Climate Change

Transportation

The transportation section of the draft 2022 Scoping Plan falls far short of meeting California's climate goals. With transportation comprising 50 percent of our emissions, much more aggressive targets are needed across all vehicle segments: light duty (LD) passenger autos and trucks, medium duty trucks, and heavy-duty trucks.

1.0 Light Duty (LD) Passenger Sector

The draft Scoping Plan assumes a 2035 date for the end of fossil-fueled new vehicle sales—the same target proposed by CARB in the current draft of the Advanced Clean Car II rule (ACC II). However, the 2035 proposal is inadequate for achieving either GHG emissions goals, or the NOx reductions needed for an ozone control strategy in the State Implementation Plan (SIP). California is currently forecasted to experience "extreme" ozone nonattainment areas by the federal Clean Air Act's 2037 deadline. The current draft ACC II is not adequate to provide for attainment.

An accelerated ACC strategy is needed that will require all new LD vehicles to be zero emission beginning in 2030. This, combined with a transport carbon model (TCM) strategy designed to gradually phase out use of gasoline-powered vehicles; a similar program for heavy-duty vehicles; and anticipated EPA standards for ships, locomotives, and aircraft engines, should provide for ozone season attainment in the South Coast Air District by 2037.

2.0 Medium and Heavy-Duty Trucks

The draft Scoping plan assumes a 2035 target date for all zero-emission sales of medium-duty vehicles and drayage trucks, and 2040 for heavy duty trucks. Because of the longevity of these vehicles and CARB's draft Advanced Clean Fleet (ACF) rule, the current Scoping Plan would allow even the largest fleets to operate dirty and outdated diesel trucks past 2050. This abjectly fails to meet legislative, executive, and scientific emission reductions targets.

For the ACF to effect a swift and meaningful transition to zero-emission medium- and heavy-duty (MHD) trucks, it must require all new MHD vehicle and drayage truck purchases to be 100 percent zero-emissions as soon as possible—2030 at the latest. Accelerating the milestone timeline is technically feasible, economically sound, and would yield additional health and climate benefits for our state.

The Scoping plan needs more aggressive plans to meet the state goals, and to draw down GHG emissions much faster than is currently planned.

Clean Electricity Grid

This section of the Draft Scoping Plan is well conceived as it attempts to plan for the decarbonization of the electric grid by 2045. However, the references to the continued need to use fossil gas and methane from biomass need to be scrutinized more carefully.

Both of these sources contribute significantly to global warming, not only when they are burned but also when they leak methane, due to the high global warming potential (GWP) of methane compared to CO2. For example, the Draft Scoping Plan implies the need to not only continue using natural gas power plants, but to add 10 gigawatts of additional plants.[6] This was made crystal clear in a CARB slide presentation at March 15, 2022 CARB workshop, "[i]n Alt 3 scenario, model builds ~90 GW of solar and ~40 GW of batteries to meet SB100 retail sales target. All gas remains online and ~10 GW of new gas is built."[7]

If the Board continues to favor a net-zero target of 2045 for the entire economy, **you must set earlier target dates for sectors that are the most feasible to decarbonize sooner**. Numerous analyses, including those by Energy Innovation, conclude that California can achieve at least 85 percent clean electricity by 2030 and 100 percent by 2035. CPUC set a target of 80% carbon-free electricity by 2030, exceeding the SB 100 target by 20 percent.[8] Set a target of 100 percent clean electricity by 2035, and adjust the "Clean Electricity Grid" section of the Plan to accommodate the load.

The consensus of research on mitigation of climate change indicates that the highest benefit-to-cost ratio is achieved by maximizing investments in decarbonization in the near term. Energy and non-energy benefits include public health and consequent increases in productivity, increased net job growth in the energy sector, increased income tax revenue, increased GDP, decreased cost of electricity, environmental justice gains, avoidance of fossil fuel "shortages" and price spikes, deceleration of climate change, more food security, and a more sustainable economy. With decarbonization, the influence of the fossil fuel industry upon climate legislation will diminish. There is probably a massive economic value of this curtailed influence, but research is needed to quantify this.

MORE FREQUENT SCOPING PLAN REVIEWS, AND INTERIM TARGETS FOR CLEAN GENERATION AND STORAGE

Because there is no proof that government plans will reverse climate change, achieve clean energy targets, or reach criteria pollutant goals, more timely and frequent assessments of emissions and energy are warranted. The delay between emissions inventory reporting by CARB and the year of emissions is over two years. Decrease this delay to one year, even if a range of estimates is used in the initial release. Conduct a Scoping Plan revision every four years and set targets for emissions curtailment and percent of clean energy in the grid for every two years over the forthcoming ten years.

DEFINING CLEAN ENERGY

The draft Plan's use of "clean energy" excludes two renewables as defined by CARB: a) biomass combustion, and b) nuclear.[9] Like hydrogen produced from methane and grid electricity, each emits greenhouse gases and toxics with greenhouse gas properties, over its lifecycle.

---

[6] Draft Scoping Plan, Figure 4-5, p. 162 (indicating new gas in graphic of "Projected electricity resources needed by 2045 in the Proposed Scenario").

[7] Mahone, et al, CARB Draft Scoping Plan: AB32 Source Emissions Initial Modeling Results, March 15, 2022 Workshop Presentation at Slide 26, https://ww2.arb.ca.gov/sites/default/files/2022-03/SP22-Model-Results-E3-ppt.pdf

[8] https://www.utilitydive.com/news/reliably-hitting-85-clean-electricity-has-huge-implications-for-california/623442/

[9] NuclearVsWWS (stanford.edu)

Biofuels, including those qualifying for the Low Carbon Fuel Standard program, are biomass energy. Biofuels research that uses a narrow definition of "lifecycle" (e.g. GREET model) shows that biofuels are about 10 to 20 percent less carbon intensive than gasoline. However, lifecycle research encompassing Scopes 1, 2, and 3, shows biofuels to be more carbon intensive than gasoline. Successful mitigation of climate change will require replacement of carbon-intensive energy sources with technologies that have a carbon intensity over the complete lifecycle that is at least 80 percent lower than fossil fuels. California should develop only these and phase out dirtier energy sources.

Nuclear power is not clean energy. Reactors can emit radioactive tritium gas during operational upsets, create heat pollution from their cooling water in rivers and the oceans where they operate, and regularly create radioactive fuel waste that remains deadly to all life for millennia. As we know, the U.S. still has no permanent storage for these ultra-hazardous wastes after a half century of effort. Finally, nuclear power plants take over a decade to license and provide the most expensive source of electricity regardless of the region they serve. [10]

We hold that clean energy includes geothermal, wind, solar, existing (but not new) hydroelectric, and green electrolytic hydrogen made with clean electricity. Because hydrogen combustion using turbines spews toxic emissions (some of which have GHG properties), only chemical combustion - using fuel cells - should be regarded as clean.[11] We urge CARB to adopt a definition of "clean energy" that replaces, and clarifies, the use of "renewable" in statute and rulemaking.

CLEAN FIRM SOURCES

Geothermal is a plentiful source in CA that provides 24/7 electricity, and so should be scaled ahead of all others. Our state has extensive geothermal potential. The co-development of geothermal energy and lithium extraction from the same regions is being studied by The Lithium Valley Commission of the CEC. Especially needed during protracted droughts, when hydropower is deficient, co-develop geothermal generation in nearby states with natural geothermal resources—and increase clean electricity imports to displace fossil energy imports.

STORAGE

Significant energy storage is required to maintain the resilience and reliability of the clean power supply that must displace dirty energy. Storage increases the capacity factor of intermittent clean energy. At a minimum, the draft Plan must prepare our state to:

- Scale proven storage technologies, including pumped hydro, compressed air, electrolytic hydrogen made with 100 percent clean electricity, and a multiplicity of batteries.
- Plan sufficient clean generation and storage to displace all fossil-generated electricity and fossil gas peaker plants by 2035.
- Set a target of 90 percent clean energy by 2030 - exceeding SB 100 by 30 percent. (See the INTERIM TARGETS section below.)
- No new fossil power plants or fossil gas pipelines should be permitted, beginning in 2023. Permits should be revoked for this new fossil infrastructure if construction has not yet begun.

Policies to incentivize behind-the-meter storage are sorely needed. Buildings equipped with PV rooftop solar should have storage batteries. (While rooftop solar is required on most new houses, batteries should also be

[10] Wikipedia link on nuclear electricity costs
[11] https://web.stanford.edu/group/efmh/jacobson/WWSBook/WWSBook.html

https://e360.yale.edu/features/three-myths-about-renewable-energy-and-the-grid-debunked

mandatory.) Rooftop solar & batteries should be required for all kinds of buildings, Including industrial, commercial, government, single-family housing, and multi-family residential. Fast-track permitting of clean energy projects will increase our chance of meeting clean targets.

CARB should encourage, and perhaps incentivise, electric auto makers to develop and deploy vehicle-to-grid technology on all BEVs sold.

ENERGY EFFICIENCY AND CONSERVATION

Conservation and energy efficiency improvements are well accepted as the most cost-effective approaches to decreasing power sector emissions.

- All-electric vehicles, appliances, and buildings are significantly more efficient than dirty equivalents.
- To encourage conservation, tiered and time-of-use rates should be mandatory for all customers. We suggest expanding the tier structure to five tiers. The cost per unit for the highest tier should be five times higher than the cost of the lowest tier for electricity and ten times higher for fossil gas.

DECREASING THE COST OF CLEAN ELECTRICITY

Policies that increase the cost of dirty electricity, decrease the cost of clean electricity, or both will drive down the cost of clean electricity. The cost of electricity varies by source. The cost of wind and solar electricity is lower than the cost of fossil-sourced electricity in over 85 percent of the world. Let's contrast monthly utility bills for customers receiving 100 percent clean energy and those receiving an equal number of kW from a 100 percent dirty source.

Clean	Dirty
$100	> $120 from fossil with CCS
$100	$300 to $1500 from nuclear reactors

Over 80 percent of customers, nationwide. prefer clean energy. If the cost of clean electricity continues to fall relative to dirty electricity this percentage will rise. **CARB should establish a eight-to-ten-year schedule of more stringent emissions regulations for the energy sector.** Government costs of implementing such a schedule can be very low. This will drive up the price of dirty energy.

In collaboration with CAISO, CPUC, and CEC, CARB should establish a clean electricity performance plan (CEPP). This would provide incentives to shareholder-owned utilities and CCAs to increase clean generation and decrease dirty generation. A CEPP is part of the infrastructure bill proposed by President Biden: If dirty energy is generated or procured, there would be no penalty; if clean energy is generated or procured, a tax credit of about 6 percent would be available. Such a plan could be fortified by requiring providers (not customers) to pay a carbon tax on dirty energy.

Avoid the use of exorbitantly expensive smokestack CCS on fossil and biomass power plants because lifecycle research has shown that these do not achieve a) net GHG reductions, b) diminished emissions of toxic co-pollutants. A CCS-equipped plant requires at least 20 percent more energy input to produce the same amount of electricity that a plant without CCS does. Thus, these plants likely emit at least 20 percent more toxic co-pollutants. Use of CCS inevitably increases environmental and energy injustice. While this negatively impacts all CA residents, the most severe effects are in sacrifice zones. Permits for smokestack CCS construction should be issued only if the equipment and the entire CA grid is powered by 100 percent clean energy. The final 2022 Scoping Plan should include only proven technologies that are free of deleterious side effects and do not raise the cost of electricity. To date, there is much more research proving that CCS is ineffective than effective. Mineralization capture, but not CCS, should be studied more intensively.

Utility energy pricing must be transparent, disaggregating externalities from the cost of power and showing consumers that fossil energy is more costly than renewable electricity. Make clear through utility bills how conservation of energy and increased efficiency drives down cost by decreasing demand.

- Establish a higher fossil fuel production tax (The current tax is far lower than the tax rate in other states.)
- Increase sales taxes on all fossil fuels and bio-energy

Rapidly phase out the use of nuclear reactors and of biomass electricity. The former has a cost per kW that is 3 to 15 times higher than that of clean energy while the latter has a cost per kW that is about 50% higher than that of renewables. Each is heavily subsidized.[12]

Reform Cap & Trade to increase demand and drive down the price of clean electricity.

- Raise the floor price of allowances to the cost of CO2 removal (currently $150 - $600 per MT).
- Retire banked allowances on an aggressive schedule.

When the cost differential between clean and dirty energy is wide enough, consumers will switch, even to upgrading to all-electric housing, EVs, and electric appliances. The auction price will be sufficiently high only when it drives dirty energy companies to switch to clean technologies.

TRANSMISSION INFRASTRUCTURE

In most cities, the load-handling capacity of the grid significantly limits the electrification potential of buildings, industry, and transport. Local grid retrofits can facilitate the adoption of complete electrification measures in cities. CARB and CEC should develop and fund retrofit programs that assist municipalities to realize 100% electrification.

One of the lowest-cost transmission networks is Vehicle Grid Interface (VGI), which auto makers should enable in the next few years. New buildings should be required to have VGI ports. Wide deployment of this technology should reduce the need for fossil-powered generators during power outages.

Fast-track permitting is critical for reaching target date milestones.

Regionally, we should continue to increase the symbiotic integration of all states in the western power grid, and discontinue the import of dirty electricity into California by the end of 2023.

Policies to expedite the scaling of utility-scale energy, and the transmission infrastructure demanded by greatly increased distributed energy resources (DER) are complementary. Though the gross cost/kW of utility-scale clean electricity is significantly less than the cost of small-scale behind-the-meter clean electricity, the latter has the lowest transmission and land use costs. Construction of long-distance transmission infrastructure entails more GHG and toxic emissions than the construction of local transmission infrastructure. The development of a "smart grid" is essential to this vision.

DISTRIBUTED ENERGY RESOURCES (DER)

The Scoping Plan should incentivize partnership opportunities for nearby multi-city, adjacent multi-county, or Community Choice Aggregator (CCA) DER projects. Planning assistance, adoption of common building code standards (that meet or exceed CA codes), facilitation of fast-track permitting, and financing options should be

[12]Severin Borenstein and James Bushnell, "The mispricing of energy–implications for electrification." Energy Institute Webinar, Energy Institute at Hass, August 24, 2021. https://haas.berkeley.edu/energy-institute/events/energy-institute-webinar-borenstein-bushnell/
See also Legal Petition Seeks Federal Trade Commission Investigation of Energy Utility Abuses - Center for Biological Diversity

available to coalitions of local government stakeholders. For example, a geothermal facility or wind farm could be developed to serve multiple adjacent counties. Each participating municipality would have exclusive rights to receive a certain percentage of the jointly owned electricity. These projects could be large enough to interest union-scale labor in constructing and maintaining these DER. If multi-local government DER requires more transmission lines, these governments should be permitted to construct, own, and maintain transmission infrastructure - free of any surcharges or penalties being imposed by the regional utility company.

Facilitate collaboration and integration of existing and new CCAs to maximize benefit / cost, realize economies of scale, increase local government autonomy, improve resilience, clean up the grid, and ensure freedom from regional utility intervention. Commonly owned DER should include generation, storage, microgrids with demand-response functions, and transmission. Volume discount arrangements for multiple counties to purchase energy efficient appliances, building materials, VGI-enabled electric vehicles, EV charging stations, controls, and labor services (e.g., retrofits of buildings), should be orchestrated by CEC.

Public banks and privately-owned community banks could be suitable sources of financing. Joint public-private financing options should be available.

Multi-county DER infrastructure projects that generate revenue should be encouraged. One example is surplus generation and storage that could be sold to other counties. This would increase local job opportunities, which could be integrated with housing development planning that enables workers in the DER economy to live near the DER infrastructure. This is especially needed in communities that have a dwindling economy, e.g., those dependent upon dirty biomass electricity or logging. Work with other agencies (e.g., CalGEM) to halt permits for new fossil fuel infrastructure while fast-tracking permits for development of DER projects.

SITING OF DER

Brownfields are land that has no reliable utility for agriculture, development, habitats, or sequestration. These are, however, suitable for solar farms, as demonstrated in many communities.

Solar panels may be situated over irrigation canals; there is a plan developed by U.C. Santa Cruz to test this in California. Like brownfields, this does not use up land that has other uses; and conserves water by decreasing the rate of evaporation. Other locations for PV solar siting that avoid land use issues are over parking lots, driveways, freeways, and streets in commercial zones. These urban solar canopies would provide shade and decrease heat island effects.

THE MACRO-ECONOMIC APPROACH

One way to decrease emissions and usage of electricity is to retard economic growth to zero or less. At some point this may be necessary to solve climate change. In the near future it would help to decrease the growth rate to 1% and transition from an infinite growth paradigm to a sustainability paradigm. Using voluntary educational and financial incentives, the population of CA should be stabilized at its present level or less. These economic and population stabilization goals are two of the many proven policies that are necessary if one adheres to the precautionary principle of managing the climate crisis.[13]

[13] Richard Heinberg, Power: Limits and Prospects for Human Survival. New Society Publishers, 2021. Excerpted in https://www.commondreams.org/views/2021/09/15/reducing-energy-consumption-only-long-range-solution-climate-change

Carbon Dioxide Removal

This section opens with the IPCC Sixth Assessment Report's clear statement of the huge problem facing us:

> The deployment of CDR to counterbalance hard-to-abate residual emissions is unavoidable if net zero CO2 or GHG emissions are to be achieved. The scale and timing of deployment will depend on the trajectories of gross emission reductions in different sectors. Upscaling the deployment of CDR depends on developing effective approaches to address feasibility and sustainability constraints especially at large scales.

Unfortunately, the draft Plan does little to address the clear need to encourage a strong research program in direct air capture and storage as well as pilot plant scale projects to verify the technology. Rather, the scoping plan reverts to a discussion of the need to do carbon capture and storage at biogas ("renewable natural gas") production facilities, which is NOT direct air capture.

Sources of biogas are either landfills or confined animal feeding operations—which are trying to greenwash the anaerobic fermentation of their industrial waste by capturing it and eventually burning it. Although this is better than releasing the methane into the biosphere, a better approach would be to avoid the anaerobic fermentation in the first place by securing the waste under aerobic conditions where it can properly compost as nature intended.

Engineered smokestack CDR technologies have not been proven to achieve net capture of CO2. In fact, even if effective smokestack CDR technologies are developed in the future, they will not decrease atmospheric CO2—but they will justify industry's continuing use of dirty energy.

The best-proven technology for capturing CO2 from the atmosphere is direct air capture. This should be researched and tested instead of studying CCS and CCUS. Novel technologies that capture CO2 from the atmosphere, e.g. mineralization, should be researched - beginning with a literature review.

The wrongness of these claims is highlighted by the draft Plan's rosy evaluation of the Low Carbon Fuel Standards program (LCFS) in reducing global warming:

> California is paving a path forward on a science-based carbon management infrastructure policy that can serve as an example for other jurisdictions. The LCFS, which reduces the carbon intensity of transportation fuels, includes a protocol for select carbon management projects to become certified and generate LCFS credits.

Just one recent example of the bankrupt ideology of LCFS is Messer LLC's hydrogen-from-methane LCFS pathway scheme. The company proposes to take fossil methane feedstock and use steam reforming to create hydrogen, before transporting the liquefied hydrogen 414 miles by truck to a light-duty vehicle fueling station. The carbon intensity of this pathway is calculated to be 153 grams carbon dioxide equivalent per megajoule, which is 50 percent higher than California gasoline (CARBOB). Yet this "fuel" receives a LCFS credit of $1.29 per gallon of gasoline equivalent, when a credit is worth $196 when used to fuel a light duty vehicle because of the assumed Energy Economy Ratio of 2.5. See the CARB LCFS credit calculator How can this make any sense when it is emitting 50 percent more GHGs than the equivalent megajoule energy of gasoline? What is CARB thinking???

I. THE IMPORTANCE OF RAPID ACTION TO ABATE METHANE AND HFCs

"We have to win the sprint to slow warming in the near term by tackling the short-lived climate pollutants, so that we can stay in the race to win the marathon against CO2."[14]

The draft Scoping Plan recognizes the importance of SLCP abatement but not the importance of moving very quickly. Although it references statements by the IPCC AR6 Workgroup I that the importance of short lived climate pollutants (SLCPs) as drivers of global warming nearly as potent as carbon dioxide, the draft fails to show accurately the importance of rapid abatement of sources of methane, high GWP gases, and black carbon (soot). The following quote is from a 2022 study of how mitigating SLCPs works with mitigating CO_2:

> [P]airing decarbonization with mitigation measures targeting CH_4, BC, HFC, and N_2O (not an SLCP due to its longer lifetime) independent from decarbonization are essential to slowing the rate of warming by the 2030s to under 0.3 °C per decade, similar to the 0.2 °C to 0.25 °C per decade warming prior to 2020…. By 2050, the net avoided warming from the targeted non-CO_2 measures is 0.26 °C, almost four times larger than the net benefit of decarbonization alone (0.07 °C).[15]

The importance of rapid methane abatement:

> Pursuing all mitigation measures now could slow the global-mean rate of near-term decadal warming by around 30%, avoid a quarter of a degree centigrade of additional global-mean warming by midcentury, and set ourselves on a path to avoid more than half a degree centigrade by end of century. On the other hand, slow implementation of these measures may result in an additional tenth of a degree of global-mean warming by midcentury and 5% faster warming rate (relative to fast action), and waiting to pursue these measures until midcentury may result in an additional two tenths of a degree centigrade by midcentury and 15% faster warming rate (relative to fast action).[16]

The importance of rapid high GWP gas abatement:

> Emission of HFC refrigerants into the atmosphere, along with other short-lived climate pollutants, will cause 30% of the warming between now and 2050.[17] HFCs are the fastest growing source of greenhouse gas emissions, doubling every 5-7 years.[18] Although at the time of the 1990 Montreal Protocol phasing out CFCs the global warming potential of HFCs was

---

[14] Gabrielle Dreyfus, chief scientist for the Institute for Governance & Sustainable Development and lead author of: Dreyfus, Gabrielle B., Yangyang Xu, Drew T. Shindell, Durwood Zaelke, and Veerabhadran Ramanathan. "Mitigating climate disruption in time: A self-consistent approach for avoiding both near-term and long-term global warming." *Proceedings of the National Academy of Sciences of the United States of America* 119, no. 22 (2022): e2123536119. https://www.pnas.org/doi/full/10.1073/pnas.2123536119 This article is the most current and comprehensive on the forcing role of C02, SLCPs and aerosols.

[15] Ibid. Our emphasis.

[16] Ocko, Ilissa B., Tianyi Sun, Drew Shindell, Michael Oppenheimer, Alexander N. Hristov, Stephen W. Pacala, Denise L. Mauzerall, Yangyang Xu, and Steven P. Hamburg. "Acting rapidly to deploy readily available methane mitigation measures by sector can immediately slow global warming." *Environmental Research Letters* 16, no. 5 (2021): 054042. https://iopscience.iop.org/article/10.1088/1748-9326/abf9c8?addl_info=2021%0AThe%20fastest%20way%20to%20slow%20warming

[17] Daniel M Kammen, Teenie Matlock, Manuel Pastor, David Pellow, Veerabhadran Ramanathan, Tom Steyer, Leah Stokes, Feliz Ventura, *Accelerating the timeline for climate action in California, March 2021, https://arxiv.org/abs/2103.07801*

[18] Sovacool, et.al. op cit.

known, manufacturers greatly expanded HFCs as a CFC replacement. The Kigali Amendment and the AIM Act are too little too late. The EPA has pointed out that the Kigali phasedown, if successful, would still result in a 5-fold increase in radiative forcing from HFCs (i.e. from 0.025 to 0.13 W/m2, 2016-2050).[19] Other experts estimate Kigali will only eliminate 60% of HFC emissions.[20]

Rapid reductions of SLCPs reduce the rate of warming. Two recent studies show the critical impact of fast action.

> Reducing methane emissions by half, reducing soot emissions by 80% with soot-free vehicles such as electric vehicles, replacing currently used HFCs with zero- to low-warming potential refrigerants, and decreasing sources of methane emissions such as leaks from natural gas pipes, food, and other landfilled organic waste, if implemented now, can cut the rate of warming over the next 2 to 3 decades by half.[21]

> "We find that mitigation measures that target only decarbonization are essential for strong long-term cooling but can result in weak near-term warming (due to unmasking the cooling effect of coemitted aerosols) and lead to temperatures exceeding 2 °C before 2050. In contrast, pairing decarbonization with additional mitigation measures targeting short-lived climate pollutants and N2O, slows the rate of warming a decade or two earlier than decarbonization alone and avoids the 2 °C threshold altogether. These non-CO2 targeted measures when combined with decarbonization can provide net cooling by 2030 and reduce the rate of warming from 2030 to 2050 by about 50%, roughly half of which comes from methane, significantly larger than decarbonization alone over this time frame."[22]

The rate of warming is particularly important because, contrary to common sense, it is the rate of warming rather than the actual temperature that governs extreme weather events.[23]

The draft Scoping Plan documents the lack of ambition and slowness of current SLCP emissions reductions while obfuscating the need for rapid reduction of short-lived emissions. It is important to present the draft Plan's own

---

[19] New York State Department of Environmental Conservation. Letter to U.S. Environmental Protection Agency, July 6, 2021 regarding Docket ID No. EPA-HQ-OAR-2021-0044-0039. This letter also states: "EPA should encourage the replacement of HFCs with natural alternatives where they are available, rather than encouraging the relevant industries to adopt transitional replacements with higher GWPs or other negative environmental impacts. This would increase the likelihood that the HFC phasedown is successful, avoid a lock-in to undesirable alternatives, and reduce overall exposure rates to the chemicals used in their production." Unfortunately the current CARB rules have not followed this advice, setting standards designed to accommodate synthetic HFCs or HFOs rather than the very low GWP natural refrigerants.

[20] The AIM Act was passed in December of 2020 and essentially will bring the US into compliance with the Kigali Treaty on HFCs, which aims to reduce their manufacture and trade by 85% by 2040. Unfortunately, it is projected that this will only reduce actual emissions by 61% worldwide. Lena Höglund-Isaksson, Pallav Purohit, Markus Amann, Imrich Bertok, Peter Rafaj, Wolfgang Sch√∂pp, Jens Borken-Kleefeld, Cost estimates of the Kigali Amendment to phase-down hydrofluorocarbons, Environmental Science & Policy, Volume 75,2017, Pages 138-147,ISSN 1462-9011,https://doi.org/10.1016/j.envsci.2017.05.006. CARB did an analysis in 2017 of several scenarios assuming Kigali limits, and even in the best-case CA would not reach the SB 1383 coal of a 40% reduction until nearly 2040. https://ww2.arb.ca.gov/sites/default/files/2018-12/CARB-Potential-Impact-of-the-Kigali-Amendment-on-HFC-Emissions-Final-Dec-15-2017.pdf

[21] Kammen, Daniel M., Teenie Matlock, Manuel Pastor, David Pellow, Veerabhadran Ramanathan, Tom Steyer, Leah Stokes, and Feliz Ventura. "Accelerating the timeline for climate action in California." *arXiv preprint arXiv:2103.07801* (2021). https://theclimatecenter.org/wp-content/uploads/2021/10/Kammen-et-al-Accelerating-Californias-timeline-for-climate-action-Mar-2021.pdf

[22] Dreyfus, Gabrielle B., Yangyang Xu, Drew T. Shindell, Durwood Zaelke, and Veerabhadran Ramanathan. "Mitigating climate disruption in time: A self-consistent approach for avoiding both near-term and long-term global warming." *Proceedings of the National Academy of Sciences of the United States of America* 119, no. 22 (2022): e2123536119. https://www.pnas.org/doi/full/10.1073/pnas.2123536119

[23] Fischer, E. M., Sebastian Sippel, and Reto Knutti. "Increasing probability of record-shattering climate extremes." *Nature Climate Change* 11, no. 8 (2021): 689-695.

assessment of where we are. SB 1383 set goals of 40 percent reduction from 2014 levels for methane and HFCs; the goal for black carbon is 50 percent as is the goal for organic waste disposal (increasing to 75 percent in 2025). The draft Scoping Plan says:

> The state is expected to achieve roughly half of the SB 1383 targeted emissions reductions by 2030 through strategies currently in place (See Figure 4-11).

To restate this in plain language: SB 1383 passed in 2016. In the 14 years between then and 2030 California is on track to reduce only 20 percent of targeted emissions. The provisions in the draft Scoping Plan show only a modest improvement on this situation by 2045.

Recent science tells us to drastically cut short-lived climate pollutants by 2030. In this context, the draft Scoping Plan is a prescription for how to squander the little time given us for capturing the opportunity SLCPs provide. In considering the draft Scoping Plan the Board and EJAC should make it very clear to staff that the next iteration of the plan should include near-elimination of SLCPs by 2030. If legislation is necessary to make this happen, it should be made clear to key climate legislators so that it can be considered in this Legislative session. Fortunately, costs for abating SLCP are in general far less than for reducing emissions of carbon dioxide.[24]

II. SPECIFIC PROPOSALS TO BE IMPLEMENTED BEFORE 2030

1. Reduction of 90% to 100% of HFC emissions by 2030

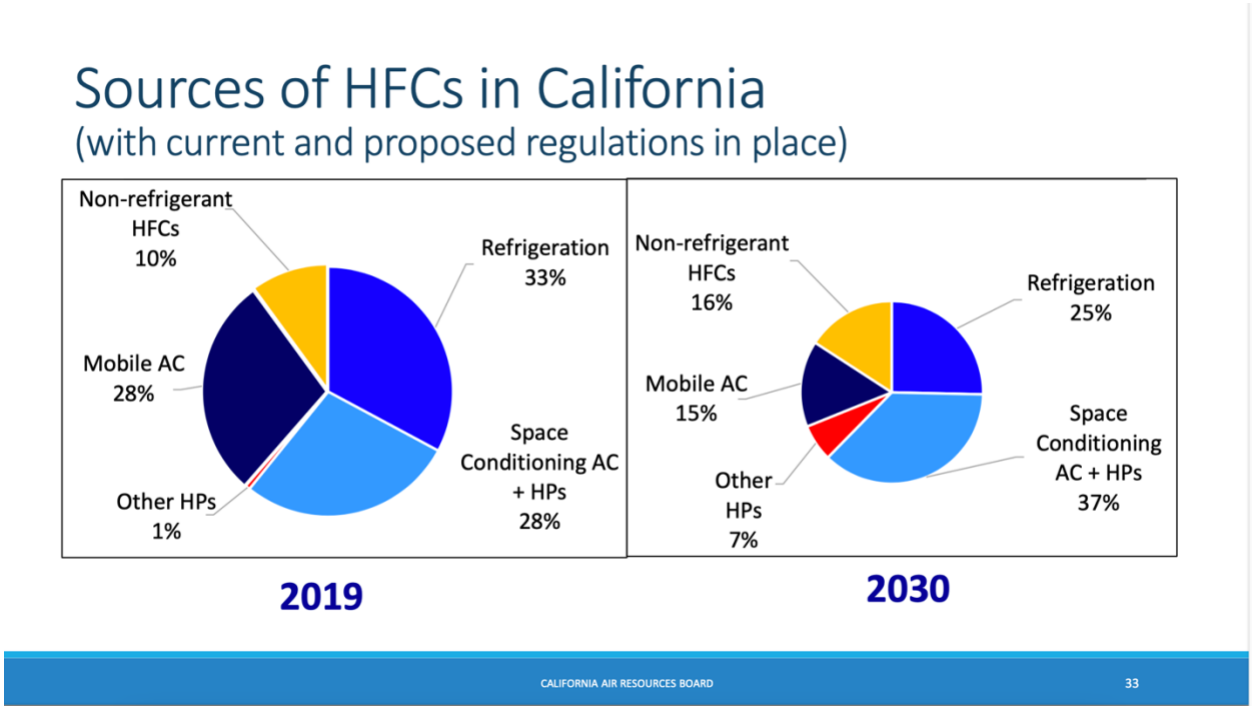
   Abatement of HFCs must begin with a target for 2030. The existing SB 1383 target of 40 percent reduction of 2014 levels is far too modest. The goal should be a reduction of 90 percent of emissions of HFCs by 2030.

   In order to have a target for HFC emissions reductions we need a baseline. SB 1383 used 2014, for reasons that are not clear. The baseline needs to be zero since we are aiming to eliminate high GWP emissions. CARB data does not show when emissions were zero in the past. But by 2000 they equaled 15.9 million metric tons of CO2e; by the year before the "baseline," in 2013, they already equaled 40.1 million metric tons of CO2e. If our goal is zero emissions then clearly the SB 1383 target of 40 percent below the 2014 level is completely inadequate to our task.

   There are three general approaches to abating HFC emissions: a) limiting their availability as the Kigali Amendment and the AIM Act do, b) sector-specific replacement of HFCs with very low GWP alternatives, and c) prevention of leaks during operation and at end of life. Because it is likely that all three of these approaches will require replacement of equipment before its natural end of life, a fourth necessary approach is incentives.

   We have already seen that Kigali and the AIM Act, which replicates Kigali limits in the US, are inadequate, still leaving (at least) 40 percent of HFC emissions. SB 1206 (Skinner) in the 2021-22 session started out being an addition to this approach, requiring bulk purchases of HFCs be limited to a GWP of 1400 in the year 2025 and a GWP of 750 in 2030. The bill was watered down in Senate Appropriations, so that it will add little to the EPA's implementation of the AIM Act. So, one vital step is to amend SB 1206 or pass similar legislation with a limit on sales of refrigerants set at GWP 15 by 2030.

[24] "The Contribution of Non-CO2 Greenhouse Gas Mitigation to Achieving Long-Term Temperature Goals, Journal: Energies, : 2017, ISSN: 1996-1073"



a. Set sector-specific limits on GWP that require new, and eventually existing, sources to switch to very low GWP refrigerants as soon as feasible. The graph above shows these sectors.[25] Here are specific goals, based on existing alternatives with GWP of 15 or less.

- The main sources of transportation refrigeration are refrigerated trucks, trailers, and shipping containers. Actually emissions come from 1) the engines (usually diesel) running the refrigerators and 2) from the refrigerants. Cryonics eliminates both in a process using liquid nitrogen or carbon dioxide. It has zero GWP. It is commercially available in Europe and has been implemented in California on a trial basis.[26] CARB has a unit that has been working on TRU and cryonics for several years. So the technology to wipe out this whole sector of emissions exists and would also benefit environmental justice communities by eliminating the diesels. It needs a regulatory mandate and some incentive money, for both manufacturers and operators.
- The biggest source of emissions is due to leaks from the commercial refrigeration section – 33 percent of emissions. The equipment to convert all HFC refrigeration systems to refrigerants under GWP of 15 exists and is widely used in Europe and Japan. It is increasingly

[25] California Greenhouse Gas Emissions for 2000 to 2019: Trends of Emissions and Other Indicators. July 28, 2021. https://ww2.arb.ca.gov/sites/default/files/classic/cc/ca_ghg_inventory_trends_2000-2019.pdf

[26] "Cryogenic TRU systems for trailers have been commercially available in Europe since at least 2002.Cryogenic TRU systems were historically used for temperature-controlled trucks (truck) because trucks have a smaller volume to cool than trailers and cooling capacity is limited by the size of the cryogenic storage tanks. Tanks for trucks can be smaller, lighter, and more economical than the larger tanks required for trailers. Cryogenic TRU systems are used where the cryogen is readily available, as demonstrated by the commercial implementation of 43 trailers using the Boreas direct-injection cryogenic TRU system in Tracy, California since 2011. No new commercial deployments of cryogenic TRU systems for trailers exist in the U.S. Other manufacturers with commercially available cryogenic TRU systems offer their products only in Europe. These companies include Cryotherm, Thermo King, and Valeo-Transfrig." https://ww2.arb.ca.gov/sites/default/files/2022-05/DRAFT%202022%20TRU%20Tech%20Assessment.pdf

used in the United States but is still just a small proportion of all stores. What is needed is a regulation that will set limits on GWP in a series of steps over time. CARB has already done this, but the limits are far too high. It is also crucial to provide assistance to supermarkets making the transition as the whole refrigeration system needs to be replaced in each store, not just parts or the refrigerants. An estimate from a non-profit group working on refrigerants reform is the cost would be up to $12 billion dollars for California's 4000 supermarkets. The amount of incentives would be far less, but they will still be expensive. Since HFCs, using the appropriate 20-year GWP, make up 10 percent of our emissions, we should be putting a comparable percentage of our climate funding into abating them. There is nothing in climate mitigation that provides a bigger bang for the buck.

- Currently CARB only monitors and regulates refrigeration systems with a charge of 50 pounds or more. This leaves thousands of convenience stores unregulated. Since the degree of charge is less and they are less likely to leak, they are a smaller problem. But CARB needs to do a rulemaking in order to switch these facilities to the new propane self-contained units with zero GWP. More generally it needs to bring smaller charges under reporting and regulation.

- Chillers, which usually cool large buildings, use much less refrigerant, tend to leak less than supermarkets (up to 15 percent)—and 80 percent of installations already use very low GWP ammonia. CARB rules, not yet in effect, will allow HFCs up to 2200 GWP. However, low GWP chillers are being developed, especially in Europe. For example, Efficient Energy in Germany has a chiller that uses water and is carbon neutral. [27] Since the lifetime of a chiller is 15 to 20 years, it is important to head off HFC installations to the extent possible. CARB should consider the worldwide market for chillers with very low GWP in revising the upcoming rules. If it exists commercially in Europe or Asia it could exist commercially in California within three years, given incentives to manufacturers.

- Air conditioning will be the largest source of HFC emissions worldwide as people attempt to cool their increasingly unlivable environments. In the developed world heat pumps, which are highly efficient, will replace gas for building heating and cooling, but they employ refrigerants with a GWP of 750 or more. The likely solution for both applications, at least until one or more of the highly experimental thermal technologies[28] can reach scale, is hydrocarbons. These are widely used (all new US home refrigerators use them) but because of flammability concerns uses have to meet strict safety standards. California's Building Standards Commission processes are too slow and excessively cautious. The International Energy Commission has just approved a much larger charge for hydrocarbon heat pumps and air conditioners. (They could be used to heat or cool a 1250 square foot house or apartment.) Legislation is needed to require the Building Standards Commission to consider alternative refrigerants as soon as the IEC has approved them. In addition, CARB should ban single split air conditioners that use HFCs since the new propane standard means GWPs under 10 are easily obtainable.

- California should also ban the export of used or obsolete refrigeration equipment to developing countries. A report from the NGO CLASP has shown that air conditioners which do not meet electrical efficiency standards in developed countries are being exported to Africa. In addition, these units frequently use R22, which depletes the ozone layer, or high GWP refrigerants no longer permissible in Europe or California. While i China is the main

[27] *Cooling Post.* February 24, 2922. A search for very low GWP chillers at coolingpost.com turns up an extensive list.
[28] For example, in the Global Cooling Prize competition, one of the eight finalists was the University of Cambridge which designed a system that is solid state, no refrigerants are used. https://globalcoolingprize.org/barocal-ltd/

exporter,[29] a ban from California will create an example and moral pressure to stop other countries from exporting obsolete dangerous air conditioners. California should use its political heft to argue for the same ban by the US Department of Commerce.

- Foams and aerosols make up almost 10 percent of HFC emissions. Consumer aerosols (like hairsprays or spray paint) could be limited today to non-HFCs. The market is moving that way and EPA has banned some very high GWP HFCs but California does not ban all HFC aerosols. They should be banned, especially HRC-152.[30] Similarly EPA is banning some HFCs for use in foams (like those used in some insulations). There are alternatives, so they could be phased out entirely in California by 2030 at the latest but actually are projected to increase by 2030.[31]
- Vending machines need to be required to use CO2 or hydrocarbons, with the Building Standards Commission required to act quickly to permit them in any place, including halls and places where people congregate. Many years of experience in other countries makes it clear that the building code restriction is too conservative. After all, we have millions of home refrigerators and freezers that use hydrocarbons.
- Innovation is happening rapidly but not being implemented at a similar pace.[32] CARB needs to stay on top of the innovation in refrigerants and conduct frequent rulemakings that will prohibit specific higher GWP HFCs within three years of alternatives being commercially available. We are providing links to two documents that track alternatives to HFCs for multiple uses. The first was created in 2021 by the Environmental Investigation Agency called Pathway to Net Zero Cooling Product List. The second was created by Daniel Chandler, Ph.D. of 350 Humboldt. It shows very new products and those that have very low GWPs but are not necessarily natural refrigerants. It is here. Incentives are needed to get companies in overseas markets to enter the California market.

b. Stop leaks by a) repairing leaking equipment and b) eliminating end of life emissions. There is a continuum of HFC applications. HFCs in supermarkets leak at roughly 25% per year. With considerable effort and expense this can be brought down to around 10%. Since this is not supportable, supermarkets need to be switched to very low GWP refrigerants as soon as possible. On the other end, our home refrigerators (many of which still contain HFCs) rarely leak, so the only issue is end of life capture. For equipment that does not require replacement, incentivizing repair technologists is the crucial action.

- Refillable containers of auto air conditioner refrigerants should be banned, as they are in the State of Washington.[33] CARB data show that 1.3 million pounds of R134a replacement refrigerants in small cans were sold in 2020.[34] Despite a long effort to regulate the cans (and get them returned and reclaimed), CARB reports many problems and widespread lack of

[29] CLASP, June 2020. Support was given by the Institute for Governance & Sustainable Developmenthttps://www.clasp.ngo/research/all/environmentally-harmful-dumping-of-inefficient-and-obsolete-air-conditioners-in-africa/

[30] See https://www.epa.gov/sites/default/files/2016-12/documents/transitioning_to_low-gwp_alternatives_in_aerosols.pdf

[31] https://ww3.arb.ca.gov/cc/inventory/slcp/data/slcp_fgas_20yr1.pdf

[32] However, CDP a research firm for investors, published a report in 2020 arguing that the industry as a whole is a) investing far less in innovation than is necessary or common in similar industries, and b) continues to make products with far greater GWP impact than leaders in the field. https://cdn.cdp.net/cdp-production/cms/reports/documents/000/005/215/original/CDP_Cooling_2020_Executive_summary.pdf?1591032754

[33] California regulates these cannisters. Compliance has improved but there are still many issues aside from the basic one that it incentivizes refilling leaking equipment. See February 2020 Workshop Presentation.

[34] CARB Reclaim Technical Meeting April 28, slide presentation.

compliance. Use of these cannisters indicates there is a leak in the system and the owner is not going to have it fixed, therefore it will keep leaking. Incentives for customers and repair shops may be necessary to fix the leaks.

- Require the lowest possible GWP refrigerants for autos. Most new cars use very low GWP refrigerants, but not all. This should be a requirement. There are millions of cars still using R134a with a GWP of 1430. A public report from the state of Minnesota Pollution Control Agency for 2021 reports the percentage refrigerant leaked annually by automobile model. The leaks range from 0.7 percent to 4.2% annually. For 43 vehicle models of all types the average leakage was 10.16 grams a year. If we apply this average to the 14,201,400 licensed vehicles in California in 2019 we get 144,300 kilograms of refrigerant emitted. At the 20 year GWP of the most common car refrigerant R134A of 3,830 this is equivalent to 552,700 metric tons of CO_2. This amount is emitted each year for the life of the car, or 12 years. A refrigerant called Klea 456A can replace R134a in existing cars and has a GWP of 626. Honeywell just announced its sales but it is not yet available in the US. CARB could provide incentives to make it so. Presumably in the next few years even lower GWP replacements will be available, but we must not depend on the market for them to replace higher GWP HFCs.
- CARB already has a program for end-of-life capture and reclaiming, the Refrigerant Recovery, Reclamation, and Reuse (R4) Program. It needs to be made permanent and funding greatly increased.
- CARB and CalRecycle should be tasked with setting up the necessary training and incentives for technicians who deal with end-of-life machines containing HFCs.
- Two types of incentives are needed. First, manufacturers, dealers, and service technicians (including for autos and heat pumps) need incentives for capturing and reclaiming refrigerants. Second, end of life facilities like auto wrecking yards and landfills need incentives to keep them from taking the easy course and venting.
- A final element is a new program, like the CFC (Ozone Depleting Substance) protocol that pays for the destruction of CFCs, to destroy HCFCs and high GWP HFCs that have been banned by either the EPA or CARB. Obviously, this also use incentives to destroy unusable high GWP refrigerants.

An element that cuts across all three strategies is the need for trained service technicians for all aspects of refrigerant use. There is currently a shortage of trained refrigeration technicians, and in the future the training will need to include specifics of natural refrigerants. Natural refrigerants are safe if used as designed and well-serviced, but current technicians to not necessarily have training on CO2, ammonia, and hydrocarbons. Because of the urgency of the need to convert all technologies using HFCs to alternatives, the state will need to step in to ensure that technical schools, community colleges, and manufacturers create the training opportunities that are needed.

Another cross-cutting element is that California should adopt universally the 20-year GWP for SLCPs. This is far more realistic than the 100 year figure, since SLCPs don't stay in the atmosphere that long; it is more relevant for our attempt to eliminate HFCs in the next ten years. Using it makes cost-benefit calculations much more realistic.

CARB has highly proficient staff dealing with HFCs. They just need a mandate to end HFC emissions by 2030 and funds to pay the necessary incentives.

c. Reduction of 80 percent of agricultural methane by 2030

- Agricultural methane makes up 60 percent of California's emissions: 19 percent enteric fermentation, 25 percent dairy manure management, and 10 percent non-dairy livestock (primarily enteric). The draft Plan indicates that we are only at about half of the SB 1383 goal of a 40 percent reduction from 2013 levels (which are relatively high compared to historical levels). Only three approaches are suggested by the draft Plan:
  - Increase the number of anerobic digesters
  - Increase several different alternative manure manage practices
  - Implement unspecified enteric fermentation strategies

  The Environmental Justice Advisory Committee takes a bolder approach calling for:

  - Emissions reductions from energy consumed by California's agricultural sector. There should be no energy created from agricultural waste that creates additional greenhouse gasses or toxic emissions, such as with dairy digesters and bioenergy plants.
  - Transition large-scale, resource-intensive, and polluting factory farms to agroecological models, including a statewide phase out of agricultural burning.
  - Include an ambitious pesticide reduction target to 1) reduce the use of synthetic pesticides by 50% by 2030 and 2) reduce the use of hazardous pesticides by 75% by 2030, starting with organophosphates, fumigants, paraquat and neonicotinoids.

  Agriculture is going to have to change for us to meet our goals. The IPCC AR6 documents that worldwide 22 percent of greenhouse gas emissions are from agriculture or other land use.[35] In the US, 11 percent of emissions were attributable to agriculture in 2020.[36] In California agriculture makes up the fifth largest source of emissions (8% of all emissions), with 70 percent of agricultural emissions due to methane.[37] Agricultural methane emissions are 67 millions of metric tons, with 33 MMT due to enteric fermentation and 30 MMT due to manure management.[38] California agriculture emits about 32 million metric tons of carbon dioxide equivalent annually and various governmental programs claim reductions of 2.5 million metric tons of carbon dioxide annually.[39] In other countries agricultural emissions reductions are starting to be part of planned nationally determined contributions, as in Uruguay.[40]

  It may be advantageous to put a price agricultural methane as New Zealand is. New Zealand has negotiated an approach with farmers which will include agricultural methane in the carbon pricing system they use. In California, this would mean adding agricultural emissions to Cap and Trade.[41] Because there are so many potential ways of reducing farm methane, this may be a better approach than regulation. We would like to see CARB consider it.

  CARB should regulate agricultural methane. SB 1383 was based on a compromise with agricultural interests that required no regulation until 2024 and then only if it could be shown incentives were not adequate to the task. Note that the task in this context is a

[35] https://www.ipcc.ch/report/ar6/wg3/downloads/report/IPCC_AR6_WGIII_SPM.pdf
[36] https://www.ers.usda.gov/topics/natural-resources-environment/climate-change/
[37] https://lao.ca.gov/Publications/Report/4483
[38] https://ww2.arb.ca.gov/ghg-slcp-inventory
[39] https://lao.ca.gov/Publications/Report/4483
[40] https://www.fao.org/fileadmin/user_upload/enteric-methane/docs/Uruguay.pdf
[41] https://www.bbc.com/news/business-61741352

40 percent reduction from 2013 levels. We need an 80% reduction from current levels by 2030. There is no way to achieve a change of this magnitude without direct regulation, even though there will continue to be a role for incentives. Here are aspects of methane regulation we believe are necessary.

- Implement a system for farm-level methane measurement, as described in Final Analysis of Progress toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target (March 2022). Despite citing the study of farm level methane measurement, a CARB staff member said CARB had no plans to implement it. Methane cannot be regulated without farm level measurement.[42]

- Regulate hot spots and super emitters. Aerial and satellite monitoring of methane hot spots is now feasible and has been used in California to a limited extent. "Recent research suggests >50 percent of methane emissions may come from <10 percent of sources, and these 'large localized sources' may be a large contributor to the regional methane "hot spots"."[43] Actually about half of these point sources are landfills, while about 25 percent are from oil and gas installations and 25 percent from dairies.[44] Just as we regulate industrial point sources, we need to regulate agricultural point sources.

- Regulate enteric fermentation emissions. There are three basic ways of reducing enteric emissions from eructation and flatulence.

    1. Require food additives that reduce flatulence. While food additives with substantial capacity to reduce methane exist (3-NOP and Asparagopsis taxiformis) they are regulated as drugs and not yet approved by the FDA. However, Agolin reduces enteric emissions about 10% and is commercially available. There are multiple other additives that are safe and available, although their capacity to reduce emissions is relatively low. Food composition can also be regulated to reduce methane.

    2. Use mechanical products. A company named ZELP expects to have on the market a methane capturing "mask" for cattle. "A catalyst oxidizes the gas and releases it into the atmosphere as carbon dioxide and water vapor. The company estimates the device can reduce methane emissions from cow belches by more than 50%."[45]

    3. Reduce herd size. In the long-run, cattle and dairy cow herd sizes will have to be reduced substantially. We are at the beginning of this process with the introduction of numerous vegetable-based alternatives for meat and dairy products. CARB needs to determine incentives and regulation to reduce herd sizes progressively.

- Regulate dairy anerobic digesters. Because dairy digesters are developed with several independent sources of public money (cap and trade offsets, low carbon fuel program, Dairy Digester Research and Development Program) there is no oversight program. Regulations are needed to:

    1. Ensure that they do not pollute with diesel engines, excessive truck traffic, or sound. The dairy digester incentives program has a way of judging acceptability to

[42] Marklein, Alison R., Deanne Meyer, Marc L. Fischer, Seongeun Jeong, Talha Rafiq, Michelle Carr, and Francesca M. Hopkins. "Facility-scale inventory of dairy methane emissions in California: implications for mitigation." *Earth System Science Data* 13, no. 3 (2021): 1151-1166.
[43] Methane Hotspots Research (AB 1496) | California Air Resources Board https://ww2.arb.ca.gov/our-work/programs/methane/ab1496-research
[44] https://environment-review.yale.edu/super-emitters-california-few-facilities-outsize-methane-emissions
[45] https://www.bloomberg.com/news/articles/2022-04-27/methane-mask-for-cows-tire-plastic-trap-win-climate-design-award

neighbors, but this is only at the beginning of the grant period and is based on a statement from the applicant. Environmental justice advocates object to digesters as polluting. They don't need to be. So regulations should ensure they are not and that they cause no hazards to neighbors and employees.

2. Ensure they do not leak. Digesters produce biogas which is usually upgraded to biomethane and given credits for low carbon intensity since it replaces the release of methane from manure lagoons. However, even small leaks can nullify the advantage of "renewable natural gas." Digesters need to be regulated for leaks.

- Regulate the entire chain of manure management. There are many opportunities for methane, ammonia and nitrous oxide abatement throughout the manure management chain. So far this has not been regulated and a relatively small number of farmers have received incentives for "alternative manure management" procedures through the Alternative Manure Management Program. However, research has identified numerous approaches to greenhouse gas abatement in feeding, housing, storage, treatment, and field application.[46] This quotation provides an idea of the range of emissions associated with these stages at different farms and farms of different sizes:

  > Depending on the practice and farm size, GHG emissions per ton of manure range from 2200 to 12,000 g CO2-eq for collection, 200 to 2400 g CO2-eq for transportation, 16,000 to 84,000 g CO2-eq for storage, and 16,400 to 33,500 g CO2-eq for land-application.[47]

  There is obviously a large potential for reducing greenhouse gases if regulation and incentives move farmers to the low emission ends of this spectrum.

Carb should contract for relevant research. Two research-based pilot projects have the potential to make regulating enteric and manure management emissions more effective and acceptable to farmers.

- Enteric Methane Abatement Pilot[48]

  1) The California Air Resources Board and California Department of Food and Agriculture shall establish a pilot program to identify and implement methods to reduce methane from enteric fermentation.

  2) The pilot shall:

     a. Test both commercially available feed additives such as Agolin[49] and feed additives expected to be approved by the FDA before 2030, such as 3-NOP

[46] Mohankumar Sajeev, Erangu Purath, Wilfried Winiwarter, and Barbara Amon. "Greenhouse gas and ammonia emissions from different stages of liquid manure management chains: abatement options and emission interactions." *Journal of Environmental Quality* 47, no. 1 (2018): 30-41.

[47] Horacio A. Aguirre-Villegas, Rebecca A. Larson,
Evaluating greenhouse gas emissions from dairy manure management practices using survey data and lifecycle tools, Journal of Cleaner Production, Volume 143, 2017, Pages 169-179, ISSN 0959-6526,
https://doi.org/10.1016/j.jclepro.2016.12.133.(https://www.sciencedirect.com/science/article/pii/S0959652616321953)

[48] This proposal is drawn from comments submitted to CARB on the 2022 Scoping Plan by these organizations: Clean Air Task Force (CATF), the Institute for Governance & Sustainable Development (IGSD), the Climate Reality California State Coalition, and the Environmental Investigation Agency (EIA).

[49] Agolin is available on the market now and could be incorporated into pilot research immediately. Overall research shows it to reduce enteric methane by about 10%. However, the longest trial was five months. [Personal correspondence with an Agolin representative.]

b. Test interventions (and control conditions) for cattle health and safety and enteric emissions reduction on conventional dairies over the full life-cycle of the animal or for a minimum of two years

c. Test mechanisms and policies for adoption that will not lead to adverse effects on air and water quality and will safeguard consumer acceptance.

- Methane Reduction through Manure Acidification Pilot[50]

1) The California Air Resources Board and California Department of Food and Agriculture shall establish a pilot program to test, at scale, acidification of manure to abate methane.

2) The pilot shall be conducted with the contracted assistance in design and evaluation of university researchers who have conducted acidification experiments.

3) The pilot shall be of sufficient size as to be able to judge the effectiveness of different methods of administering the acidification intervention.

4) The pilot shall assess:

a. Different levels and frequency of acidification for effectiveness in abating methane, nitrous oxide, and ammonia including treating only the inoculum (manure left in tanks)

b. Different acidifiers (including the commercially available SOP and "self-acidification.")

c. Safety of the acidifiers and processes used and protection of water quality and soil health in both liquid manure lagoons and in concrete holding tanks.

d. The cost benefit of the acidifiers and processes used, employing the 20-year global warming potential (GWP) of methane and the social cost of carbon used by the federal government.

[50] Based on this research: Bastami, Mohd Saufi B., Davey L. Jones, and David R. Chadwick. "Reduction of methane emission during slurry storage by the addition of effective microorganisms and excessive carbon source from brewing sugar." *Journal of environmental quality* 45, no. 6 (2016): 2016-2022; and Sokolov, Vera, Andrew VanderZaag, Jermaneh Habtewold, Kari Dunfield, Claudia Wagner-Riddle, Jason J. Venkiteswaran, and Robert Gordon. "Greenhouse gas mitigation through dairy manure acidification." *Journal of environmental quality* 48, no. 5 (2019): 1435-1443. Prado, Joana, João Chieppe, Anabela Raymundo, and David Fangueiro. "Bio-acidification and enhanced crusting as an alternative to sulphuric acid addition to slurry to mitigate ammonia and greenhouse gases emissions during short term storage." *Journal of Cleaner Production* 263 (2020): 121443; Sorenson, op cit. ; Petersen, S. O., O. Højberg, M. Poulsen, C. Schwab, and J. Eriksen. "Methanogenic community changes, and emissions of methane and other gases, during storage of acidified and untreated pig slurry." *Journal of applied microbiology* 117, no. 1 (2014): 160-172. Sokolov, Vera, Andrew VanderZaag, Jemaneh Habtewold, Kari Dunfield, James T. Tambong, Claudia Wagner-Riddle, Jason J. Venkiteswaran, and Robert Gordon. "Acidification of Residual Manure in Liquid Dairy Manure Storages and Its Effect on Greenhouse Gas Emissions." *Frontiers in Sustainable Food Systems* (2020): 179. Peterson, Carlyn B., Hamed M. El Mashad, Yongjing Zhao, Yuee Pan, and Frank M. Mitloehner. "Effects of SOP lagoon additive on gaseous emissions from stored liquid dairy manure." *Sustainability* 12, no. 4 (2020): 1393. The roughly 20% reduction in methane was also found in a European test. Borgonovo, Federica, Cecilia Conti, Daniela Lovarelli, Valentina Ferrante, and Marcella Guarino. "Improving the sustainability of dairy slurry by a commercial additive treatment." *Sustainability* 11, no. 18 (2019): 4998.