12 December 2017

Richard Corey, Executive Officer
California Environmental Protection Agency
Air Resources Board
1001 I Street
Sacramento, CA 95814

COMMUNITIES FOR A BETTER ENVIRONMENT

Re: **Comment on Final Environmental Analysis for the Strategy for Achieving California's 2030 Greenhouse Gas Target (released 30 November 2017)**

Dear Executive Officer Corey,

By this letter Communities for a Better Environment (CBE) transmits an expert report that provides specific evidence for the following findings as comment on the proposed Scoping Plan Environmental Analysis released by your agency on 30 November 2017:

- De-prioritization and delay of sustained reduction in emissions from the oil sector during the critical period through 2030, when cumulative emissions would approach the climate protection limit defined by state emission targets while the time left to meet that limit shortens, is a clearly foreseeable result of the proposed action.
- This delay during this critical period would greatly increase the annual emission cuts needed to meet the climate protection limit, the difficulty and disruptive impacts of doing so, especially in low-income communities of color near oil facilities, and thus the probability of failure to meet the state's mid-century climate protection goal.
- There is a reasonable potential that implementing the proposed action would result in significant socioeconomic impacts linked to the cumulative emissions it would allow, significant climate impacts linked to those emissions, or both.
- Incremental and sustained annual emission cuts from the extraction, refining, and use of petroleum refined in California that begin promptly could lessen or avoid all of these significant potential impacts of the proposed action. This least-impact path to climate stabilization would be less difficult to implement than the greater annual cuts needed to meet the cumulative limit after further delay but would be foreclosed by further delay.
- The Environmental Analysis did not identify and disclose these significant potential impacts of implementing the proposed action, or this less difficult least-impact path to climate stabilization that implementing the proposed action could foreclose. The Environmental Analysis is deficient in these crucial respects.

Respectfully,

Shana Lazerow
Legal Director

Enclosures (6) CBE Exhibit A, Excerpted from Expert Report of G. Karras
Expert Report of G. Karras including four attachments thereto

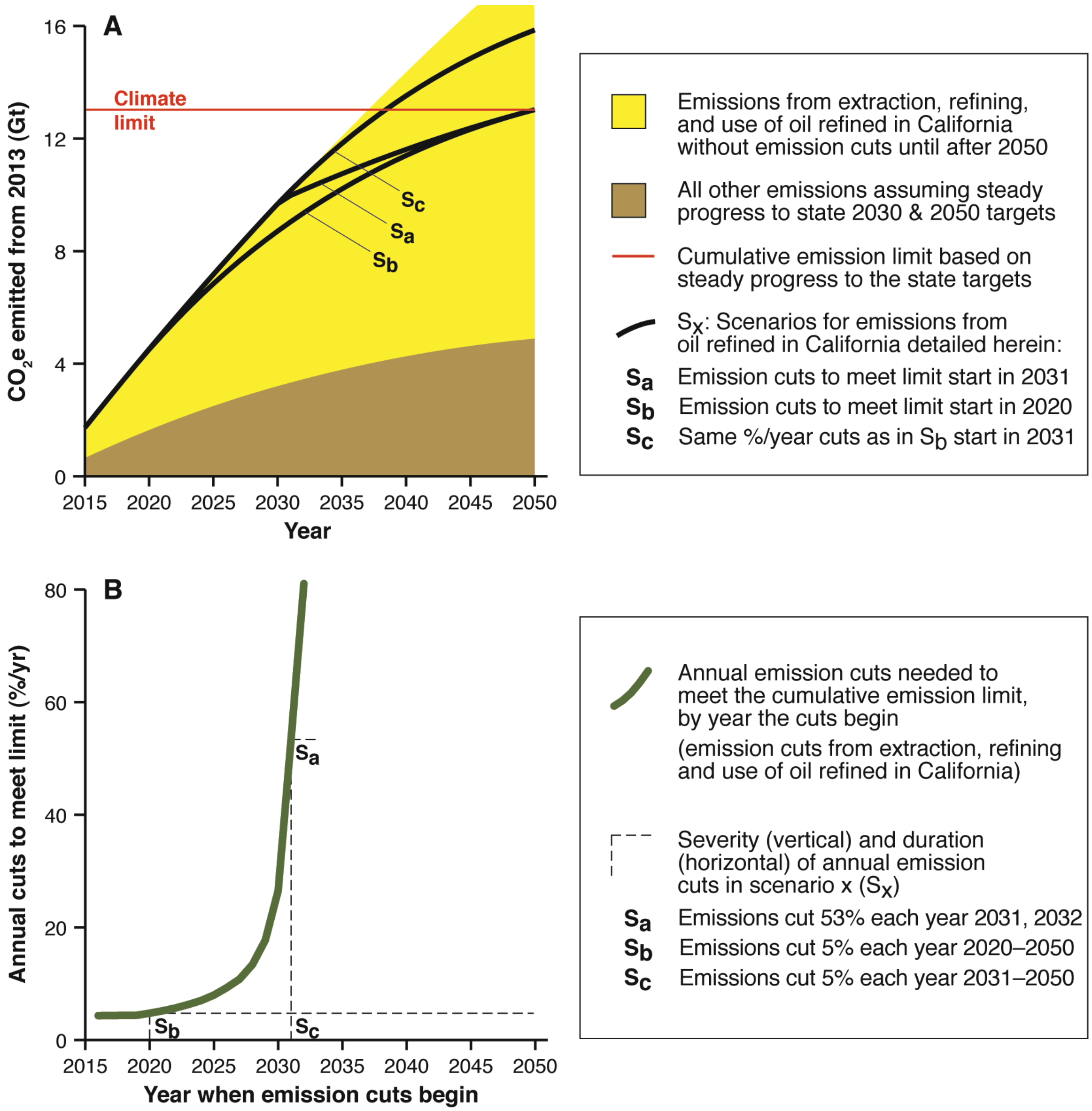

EXHIBIT A. Statewide Greenhouse Gas Emissions from 2015–2050 in Various Emission Scenarios for the Petroleum Fuel Chain (Extraction, Refining, and Use of Oil Refined in California), Assuming that All Other Emissions Meet the State's Climate Targets.

Chart A: Comparison of cumulative emissions with the cumulative emission limit for climate protection that is defined by incremental annual progress to the state's 2030 and 2050 targets. **Chart B:** Effect of delay on annual emission cuts needed to meet the cumulative emission limit.

As cumulative emissions approach the climate protection limit (Chart A) and the time left to meet the limit shortens (A, B), the annual percentage cuts in emissions needed to meet the limit increase nearly exponentially (Chart B).

Gt: Gigaton, 1 billion metric tons. **CO_2e:** Carbon dioxide equivalent, 100-year GWP. **Scenarios** are outlined in the chart legends. All scenarios also assume that annual emissions from oil will not increase before emission cuts begin and will not be cut more than 80% (to account for the potential need for petroleum jet fuel through 2050), and that all non-petroleum emissions will be cut steadily to the 2030 and 2050 targets. Data are from the CARB, CEC, and US EIA.[11-19] *See* the text and attachments KR2–KR4 for data and details of analysis methods and results.

Excerpted from Communities for a Better Environment's December 12, 2017 Expert Report of G. Karras on the November 30, 2017 Final Environmental Analysis for California's 2017 Scoping Plan.

Expert Report of Greg Karras
Communities for a Better Environment (CBE)
12 December 2017

Regarding the
Final Environmental Analysis for the Strategy for Achieving California's 2030 Greenhouse Gas Target; California Air Resources Board: Sacramento, CA. November 30, 2017.
Appendix F to the Final Proposed 2017 Scoping Plan Update.

Contents

I, Greg Karras, declare and say:

1. I reside in unincorporated Marin County and am employed as a Senior Scientist for Communities for a Better Environment (CBE). My duties for CBE include technical research, analysis, and review of information regarding industrial health and safety investigation, pollution prevention engineering, pollutant releases into the environment, and potential effects of environmental pollutant accumulation and exposure.

Qualifications

2. My qualifications for this opinion include extensive experience, knowledge, and expertise gained from more than 30 years of industrial and environmental health and safety investigation in the energy manufacturing sector, including petroleum refining, and in particular, refineries in the State of California.

3. Among other assignments, I served as an expert for CBE and other non-profit groups in efforts to prevent pollution from oil refineries, to assess environmental health and safety impacts at refineries, to investigate alternatives to fossil fuel energy, and to improve environmental monitoring of dioxins and mercury. I served as an expert for CBE and the City and County of San Francisco and local groups in efforts to replace electric power plant technology with reliable, least-impact alternatives.

4. I have served as an expert for CBE and other groups participating in environmental impact reviews of petroleum projects, including, among others, the "Chevron Richmond Refinery Modernization Project," the "Contra Costa Pipeline Project," the "Phillips 66 Propane Recovery Project" and the "Shell Greenhouse Gas Reduction Project" in the County of Contra Costa, the "Valero Crude by Rail Project" in Benicia, the "Phillips 66 Rail Spur Extension and Crude Unloading Project" in Arroyo Grande, and the "Keystone Pipeline Project" Phase I. My work as an expert for CBE and other non-profit groups in a 2007–2008 review of the proposed Chevron Richmond refinery "Hydrogen Renewal Project" was cited by the Appeals Court in support of CBE's subsequent successful advocacy regarding that proposed project (*See* *CBE v. City of Richmond* 184 Cal_Ap.4th).

5. During 2014 I served as an expert for the Natural Resources Defense Council in research on the effects of changes in oil feedstock quality on refinery air emission rates, specifically, on estimating toxic and particulate emissions from U.S. refinery cracking and coking of low quality, bitumen-derived "tar sands" oils.

6. As part of CBE's collaboration with the refinery workers union United Steelworkers (USW), community-based organizations, the Labor Occupational Health Program at UC Berkeley, and environmental groups, I served as an expert on environmental health and safety concerns shared by refinery workers and residents regionally. In this role I served as CBE's representative in the Refinery Action Collaborative of Northern California.

7. I serve as an expert for CBE and other groups in the development of emission control and reduction rules to be considered for adoption by the Bay Area Air Quality Management District.

8. I served as one of CBE's experts supporting informal state-level climate and energy planning discussions with California State agencies and the Office of Governor Edmund G. Brown. In this capacity I participated in meetings organized and attended by Governor Brown's senior advisors on 12 July 2013 in Oakland, California and on 13 April 2015 and 4 December 2016 in Sacramento, California.

9. I authored a technical paper on the first publicly verified pollution prevention audit of a U.S. oil refinery in 1989. I co-authored the first comprehensive analysis of regional oil refinery selenium discharge trends in 1994. From 1992–1994 I authored a series of technical analyses and reports that supported the successful achievement of cost-effective pollution prevention measures at 110 industrial facilities in Santa Clara County. I authored the first comprehensive, peer-reviewed dioxin pollution prevention inventory for the San Francisco Bay, which was published by the American Chemical Society and Oxford University Press in 2001. I co-authored an alternative energy blueprint, published in 2001, that served as a basis for the Electricity Resource Plan adopted by the City and County of San Francisco in 2002. In 2005 and 2007 I co-authored two technical reports that documented air quality impacts from flaring by San Francisco Bay Area refineries, and identified feasible measures to prevent these impacts.

10. My more recent publications include the first peer reviewed estimate of combustion emissions from refining lower quality oil to be based upon data from U.S. refineries in actual operation, which was published by the American Chemical Society in the journal *Environmental Science & Technology* in 2010. I authored a follow up to this study that focused on California refineries, which was peer reviewed and published by the Union of Concerned Scientists in 2011. I authored and presented invited testimony regarding *inherently safer systems* requirements at the U.S. Chemical Safety Board's 19 April 2013 public hearing on the 2012 Chevron Richmond refinery fire. I authored a January 2015 research report on toxic and aerosol emissions from U.S. refinery cracking and coking of bitumen-derived "tar sands" oils. I co-authored a July 2017 CBE technical report on refinery emissions observed under the State's cap-and-trade program from 2013–2015.

11. My curriculum vitae and list of publications are appended hereto as Attachment KR1.

Scope of Review

12. The Scoping Plan does not demonstrate "how direct emissions reductions from the largest sources are prioritized as directed by AB 197" (Environmental Justice Advisory Committee).[1] Instead, it proposes to extend current "market based" and "demand-side" policies to address petroleum fuel chain emissions—emissions from extraction, refining, and refined products combustion.[2] Oil refiners and extractors would receive up to 90 % of their cap-and-trade emission allowances free of charge through 2030. Meanwhile, cap-and-trade exempts emissions from extracting oil imported by refiners and from burning their exported fuels, in-state demand reduction does not prevent refiners from exporting those refined products, and the Low Carbon Fuel Standard exempts all of the emissions from extracting, refining, and burning the exported fuels. These policies have not cut refinery emissions of carbon dioxide equivalent (CO_2e),[3] and refiners here import more feedstock and export more product as statewide crude production and petroleum fuels demand decline.[4-8] Potential climate impacts will be more strongly driven by cumulative CO_2e emissions through mid-century than by annual CO_2e emissions in any one year.[9,10] But the Environmental Analysis (EA)[2] limits its analysis by focusing on annual emissions in 2030 instead of on cumulative emissions through 2050.

13. In light of the clearly foreseeable potential for the proposed action to delay cuts in emissions associated with oil refined in California through 2030, the importance of cumulative emissions through 2050, and the consequent potential for effects of delay, I was asked for my professional opinion on the adequacy of the EA as to these matters. My opinions on these matters and the basis for these opinions are stated in this report.

Annual Emissions Baseline

14. Emissions of CO_2e from the extraction, refining, and refined products combustion associated with oil refined in California, and all other activities statewide, were estimated for the three-year period from 2013–2015. An annotated, referenced tabulation of this estimate is appended hereto as Attachment KR2.[11] The estimate used California Air Resources Board (CARB) emissions data for refining and associated hydrogen plants,[12] extraction,[12] refined products combustion,[13] and all other activities statewide.[13] Emission

intensities for extraction from CARB data[12] and crude oil inputs to the refineries from California Energy Commission (CEC) data[4] were applied to imported oil volumes refined here[4] to complete the extraction emissions estimate. Similarly, CARB's gasoline, diesel-distillate, kerosene including jet fuel, LPG and propane, and pet coke products emission[13] and combustion[14] data were used with CEC[8] and Energy Information Administration[15-16] data to estimate emissions from burning refined product exports. CARB emissions[13,17] and fuel combustion[14] data were used to estimate emissions from all other activities, including the generation of imported electricity. Annual emissions estimated by this method averaged ≈ 0.576 Gt^{-y} (Gt: Gigaton, 1 billion metric tons) from 2013–2015, with petroleum fuel chain emissions accounting for ≈ 62 % (0.360 Gt^{-y}) of this total.[11]

Cumulative Emission Estimates

15. It was necessary to calculate cumulative emissions because as stated, this is the appropriate metric for estimating climate impacts of emission scenarios through 2050[9,10] and the EA did not complete that analysis. Cumulative emissions from 2013–2050 were calculated by adding the annual emissions reported from 2013–2015 (¶ 14) and those in each following year, accounting for the change in annual emissions expected that year. Specifically, the following basic math (Equation 1) was used:

$$CE_{Y1-Yx} = \sum AE_{Y1} \ldots AE_{Y(x-1)} \cdot z \qquad \text{(Eq. 1)}$$

Where,

CE is cumulative emission;
AE is annual emission, expressed in Gt^{-y} (Gt: Gigaton, 1 billion metric tons);
Y1 is 2013 and Yx is a specific year from 2014–2050;
z is the change in AE from the previous year (x–1), expressed as a ratio;
∑ is the sum of AE from year 1 through year x (Y1 … Yx); and
results for CE are expressed in Gt (billions of metric tons).

This basic math simply quantified the fact that cumulative emissions increase with time (as x increases) and are limited by reducing annual emissions over time (as z decreases). For example, with average emissions estimated from 2013–2015 (0.576 Gt^{-y}; ¶ 14), z is exactly 1 in these years, and CE_{Y1-Y3} is calculated as 0.576 Gt^{-y} for 2013 (AE_{Y1} = 0.576) plus $AE_{Y1} \cdot 1$ for 2014 (AE_{Y2} = 0.576) plus $AE_{Y2} \cdot 1$ for 2015 (AE_{Y3} = 0.576), or 1.728 Gt of cumulative emission from 2013–2015.

16. Equation 1 (¶ 15) was used with the reported 2013–2015 emissions baseline (¶ 14), the cumulative emission limit defined by the incremental annual emission cuts that state climate targets anticipate to 2020, 2030, and 2050, and emission scenarios implied by the proposed action, to estimate cumulative emissions (CE) and annual emission cuts (z).

Cumulative Emission Limit

17. State targets for incremental annual emission cuts to 2020 (1990 rate), 2030 (–40%), and 2050 (–80%) seek to limit cumulative emissions, and emissions are now close to the 2020 target. The 2030 and 2050 targets were applied to the average annual emission rate from 2013–2015 (¶ 14) to calculate the effect of the targeted incremental emission cuts from 2015 on cumulative emissions during 2013–2050. Details of this calculation for petroleum fuel chain emissions associated with oil refined in California and emissions associated with all other activities in the state are appended hereto as Attachment KR3.[18] The calculation indicates that achieving the incremental annual emission cuts to the state's 2030 and 2050 targets would limit the total cumulative emission of CO_2e from 2013–2050 to $\approx$ 13.0 Gt.[18]

Emission Scenarios Assessed

18. Equation 1 (¶ 15) and emissions from 2013–2015 (¶ 14) were used to estimate cumulative emissions from 2013–2050 in 19 scenarios for reductions in annual emissions associated with oil refined in California. Three scenarios were given more detailed analysis: Scenario A (S_a) assumed that the minimum sustained annual emission reduction necessary to meet the cumulative emission limit will begin in 2031. Scenario B (S_b) assumed that the minimum sustained annual emission reduction necessary to meet the cumulative emission limit will begin in 2020. Scenario C (S_c) assumed that the same sustained annual emission reduction as that in Scenario S_b will begin in 2031.

19. The scenarios were compared based on several conservative assumptions that were applied to all of them:

- All other (non-petroleum) emissions make steady progress to the state's targets.

- Petroleum fuel chain emissions will not be reduced more than the state's annual emissions target for 2050 (–80%). Allowing ≥ 20 % of current annual emissions accounted for the possibility that safe substitutes for petroleum jet fuel (≈ 16 % of current refinery production)[11] might remain illusive through mid-century.
- No increase in petroleum fuel chain emissions will occur from 2015–2050. This is a conservative assumption for delayed action scenarios, given planned expansions for low quality, higher-emitting grades of oil, such as the Tesoro (Wilmington-and-Carson) and Phillips 66 (Rodeo) projects that are in dispute as of December 2017.

Applying these conservative assumptions to all scenarios allowed them to be compared for effects of the clearly foreseeable potential (¶¶ 12–13) that the proposed action could de-prioritize and delay cuts in emissions associated with oil refined in California.

Emission Scenarios Comparison

20. Results from this analysis (¶¶ 12–19) are tabulated in Attachment KR4[19] and illustrated in Exhibit A below. Note the relationship over time between cumulative emissions (Chart A) and annual emission cuts needed for climate protection (Chart B). As emissions approach the cumulative climate limit, and the time left to meet the limit shortens, the annual emission cuts needed to meet the limit rise nearly exponentially.

21. Starting sustained petroleum fuel chain emission cuts in 2020 (S_b) meets the climate limit by cutting annual emissions only ≈ 5% per year. In contrast, delay to 2031 (S_a) can meet the limit only by cutting annual emissions more than ten times as much (≈ 53%/yr) and cutting them by a total of ≈ 78% over just two years.[19] The substantial jobs and tax base disruptions associated with this precipitous (≈ 78%) cut would be disparately severe in communities hosting oil infrastructure. Low-income communities of color already facing disparately severe CO_2e co-pollutant health risk[20-22] and pollution-related blight due to the proximity of oil infrastructure would bear the brunt of these potential impacts. These impacts would be directly related to cumulative emissions resulting from delay, and by 2031, averting them fully would require holding annual emission cuts to the same (S_b; ≈ 5%/year) pace or less, but that would allow cumulative emissions to exceed the climate limit. Delaying petroleum emission cuts of ≈ 5%/year until 2031 (S_c) would exceed the climate limit by ≈ 2.8 Gt, or ≈ 22%.[19] Delaying these emission cuts until after 2050 would exceed the climate limit by ≈ 5.5 Gt, or ≈ 43%.[19]

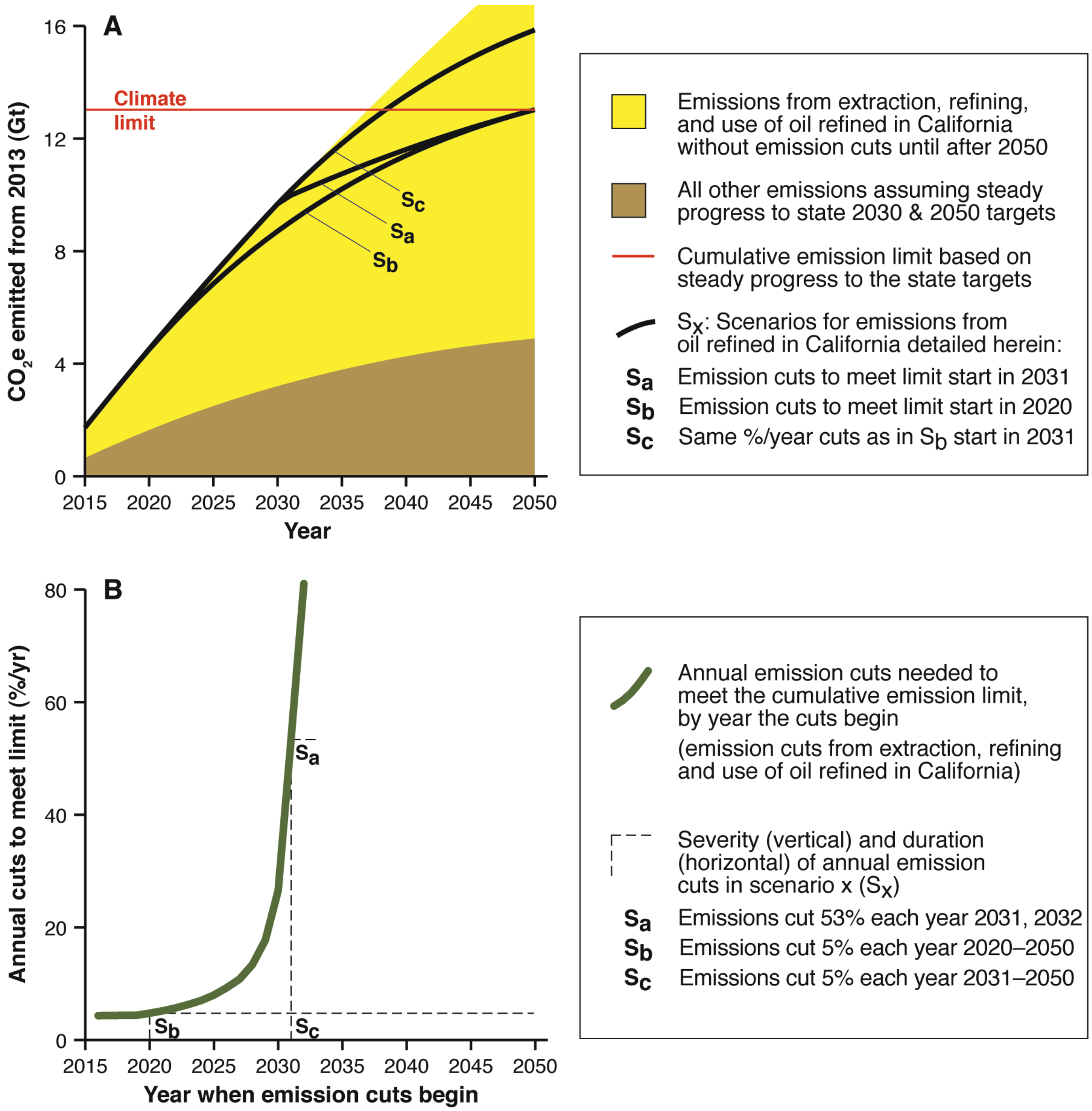

EXHIBIT A. Statewide Greenhouse Gas Emissions from 2015–2050 in Various Emission Scenarios for the Petroleum Fuel Chain (Extraction, Refining, and Use of Oil Refined in California), Assuming that All Other Emissions Meet the State's Climate Targets.

Chart A: Comparison of cumulative emissions with the cumulative emission limit for climate protection that is defined by incremental annual progress to the state's 2030 and 2050 targets. **Chart B:** Effect of delay on annual emission cuts needed to meet the cumulative emission limit.

As cumulative emissions approach the climate protection limit (Chart A) and the time left to meet the limit shortens (A, B), the annual percentage cuts in emissions needed to meet the limit increase nearly exponentially (Chart B).

Gt: Gigaton, 1 billion metric tons. **CO_2e:** Carbon dioxide equivalent, 100-year GWP. **Scenarios** are outlined in the chart legends. All scenarios also assume that annual emissions from oil will not increase before emission cuts begin and will not be cut more than 80% (to account for the potential need for petroleum jet fuel through 2050), and that all non-petroleum emissions will be cut steadily to the 2030 and 2050 targets. Data are from the CARB, CEC, and US EIA.[11-19] *See* the text and attachments KR2–KR4 for data and details of analysis methods and results.

22. These results show that prompt, incremental, and sustained petroleum emission cuts (e.g., scenario S_b) support the least-impact path to climate stabilization in California.

23. These results also describe climate effects of social inertia caused by the cumulative emission impacts that would result from delayed petroleum emission cuts. Davis et al.[23] rank social inertia along with geophysical and technological inertia among the types of resistance to change affecting the climate system. Impacts of the cumulative emissions and unprecedented annual cuts to the climate limit that more delay could force—whether framed as health costs,[24] environmental[20-22] or social[25] injustice, stranded assets,[26,27] local tax base losses, transitory assistance needs[28] or jobs dislocation—would tend to increase climate effects of social inertia. Although it cannot be known today exactly what course the state's people would take in 2031 should petroleum cuts be delayed until then, these results provide specific evidence that the potential for delay to result in exceeding state climate protection targets through 2050 is clearly foreseeable.

System Boundary Context

24. The analysis treats emissions from major emitting activities consistently by including out-of-state emissions that necessarily result from oil sector (≈0.129 Gt^{-y}; 2013–2015)[12] as well as electricity sector (≈0.039 Gt^{-y} from 2013–2015)[13] activities in the state (¶ 14). This consistent system boundary is further supported by analysis of the need to account for cross-border effects of oil refining and other fossil fuel chain activities,[29] California's dominance among West Coast refining states,[15] and the fact that getting and using the oil refined here emits regardless of where that extraction and end-use fuel combustion occur. For context, however, excluding these out-of-state emissions from the baseline and applying the cumulative limit only to in-state emissions, petroleum still dominates total emissions (≈57% v. 62%; compare with ¶ 14), and the impact curve shown in Chart B only shifts by 1 year or less. Thus, a different consistently-applied system boundary assumption might underestimate potential emission impacts linked to in-state activities but would not otherwise change the main results of this analysis significantly.

Findings

25. De-prioritization and delay of sustained reduction in emissions from the oil sector during the critical period through 2030, when cumulative emissions would approach the climate protection limit defined by state emission targets while the time left to meet that limit shortens, is a clearly foreseeable result of the proposed action.

26. This delay during this critical period would greatly increase the annual emission cuts needed to meet the climate protection limit, the difficulty and disruptive impacts of doing so, especially in low-income communities of color near oil facilities, and thus the probability of failure to meet the state's mid-century climate protection goal.

27. Therefore, there is a reasonable potential that implementing the proposed action would result in significant socioeconomic impacts linked to the cumulative emissions it would allow, significant climate impacts linked to those emissions, or both.

28. Incremental and sustained annual emission cuts from the extraction, refining, and use of petroleum refined in California that begin promptly could lessen or avoid all of these significant potential impacts of the proposed action. This least-impact path to climate stabilization would be less difficult to implement than the greater annual cuts needed to meet the cumulative limit after further delay but would be foreclosed by further delay.

29. The Environmental Analysis did not identify and disclose these significant potential impacts of implementing the proposed action, or this less difficult least-impact path to climate stabilization that implementing the proposed action could foreclose. The Environmental Analysis is deficient in these crucial respects.

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30. I have given my opinions on these matters based on my knowledge, experience and expertise and the data, information and analysis discussed in this report.

I declare under penalty of perjury that the foregoing is true of my own knowledge, except as to those matters stated on information and belief, and as to those matters, I believe them to be true.

Executed this 12th day of December 2017 at Richmond, California

Greg Karras

References

(1) *Final EJAC Recommendations—Priority Changes;* AB 32 Environmental Justice Advisory Committee of the California Air Resources Board: Sacramento, CA. November 13, 2017. Appendix A to the Final Proposed 2017 Scoping Plan Update. Available online at: https://www.arb.ca.gov/cc/scopingplan/scopingplan.htm.

(2) *Final Environmental Analysis for the Strategy for Achieving California's 2030 Greenhouse Gas Target;* California Air Resources Board: Sacramento, CA. November 30, 2017. Appendix F to the Final Proposed 2017 Scoping Plan Update. Available online at: https://www.arb.ca.gov/cc/scopingplan/scopingplan.htm.

(3) *Regulation 12, Rule 16: Petroleum Refining Greenhouse Gas Emission Limits, Revised Final Staff Report, June 2017;* Technical report and appendix. **2017.** Bay Area Air Quality Management District: San Francisco, CA.

(4) *Crude Oil Supply Sources to California Refineries;* California Energy Commission: Sacramento, CA. Graph and table reporting sources of annual refinery crude inputs; www.energy.ca.gov/almanac/petroleum_data/statistics/crude_oil_receipts.html.

(5) *PADD 5 Transportation Fuels Markets;* U.S. Energy Information Administration: Washington, D.C. Available at: www.eia.gov/analysis/transportationfuels/padd5.

(6) *Export Monitor;* Brookings Institute: Washington, D.C. Petroleum and coal products exports produced by metro area; note that California refining metro areas produce no coal. **Various years.** *See* www.brookings.edu/research/interactive/2015/export-m.

(7) *Fuel Taxes Statistics & Reports;* California Bureau of Equalization: Sacramento, CA. Taxable gasoline gallons, taxable diesel gallons, and taxable jet fuel gallons 10-year reports. **Various years.** Available at: www.boe.ca.gov/sptaxprog/spftrpts.htm.

(8) *Weekly Fuels Watch Report;* California Energy Commission: Sacramento, CA. Tables reporting weekly quantities of gasoline, distillate/diesel, and jet fuel produced by California refineries in thousands of barrels. (*See* SR7 for LPG, propane, and pet coke.) Available at http://energy.ca.gov/almanac/petroleum_data/fuels_watch/.

(9) Allen, M. R., et al. Warming caused by cumulative carbon emissions towards the trillionth tonne. *Nature* 458: 1163–1166. **2009.** DOI: 10.1038/nature080179.

(10) Meinshausen, M., et al. Greenhouse-gas emission targets for limiting global warming to 2 ºC. *Nature* 458: 1158–1162. **2009.** DOI: 10.1038/nature08017.

(11) *Baseline CO_2e Emissions Data (2013–2015);* annotated table and references. Appended hereto as Attachment KR2.

(12) *Mandatory Greenhouse Gas Reporting Rule Public Data Reports;* California Air Resources Board: Sacramento, CA. *See* emissions reported from petroleum refineries and hydrogen production plants serving refineries, including third-party plants. Available at www.arb.ca.gov/cc/reporting/ghg-rep/reported-data/ghg-reports.htm.

(13) *Greenhouse Gas Inventory by IPCC Category (Tenth Edition: 2000–2015, Last Updated on 6/6/2017);* California Air Resources Board: Sacramento, CA. Available at www.arb.ca.gov/cc/inventory/data/data.htm.

(14) *Fuel Activity for California's Greenhouse Gas Inventory by Sector & Activity (Tenth Edition: 2000–2015, Last Updated on 6/6/2017);* California Air Resources Board: Sacramento, CA. www.arb.ca.gov/cc/inventory/data/data.htm.

(15) *Refinery Capacity Data by Individual Refinery;* U.S. Energy Information Administration: Washington, D.C. **Various dates.** Data by process type for each refinery and year. 2017 data from: www.eia.gov/petroleum/data.php; archive data from: www.eia.gov/petroleum/refinerycapacity/archive/.

(16) *Refinery Net Production;* U.S. Energy Information Administration: Washington, D.C. Available at: www.eia.gov/dnav/pet/pet_pnp_refp2_a_epllban_ypy_mbbl_a.htm.

(17) *Disaggregation of Industrial Cogeneration Categories in California's Greenhouse Gas Inventory (Tenth Edition: 2000–2015, Last Updated on 6/6/2017;* California Air Resources Board: Sacramento, CA. www.arb.ca.gov/cc/inventory/data/data.htm.

(18) *Calculation for Cumulative Emission (CE) Limit Based on Actual Annual Emissions (AE) from 2013–2015 (Att. KR2) and Steady Progress from 2015 to California's 2030 (–40%) and 2050 (–80%) Annual Emission Targets;* table. Appended hereto as Attachment KR3.

(19) *Results for Cumulative Emission (CE) and Change in Annual Emission From the Previous Year (z) in Petroleum Fuel Chain Scenarios, Assuming that All Other Emissions Meet the State's Climate Targets;* tables. Appended hereto as Attachment KR4.

(20) Brody, J. G., et al. Linking exposure assessment science with policy objectives for environmental justice and breast cancer advocacy: The northern California Household Exposure Study. *American Journal of Public Health* **2009** (99): S600–S609. DOI: 10.2105/AJPH.2008.149088.

(21) Pastor, M. et al. *Minding the Climate Gap: What's at Stake if California's Climate Law Isn't Done Right and Right Away;* **2010.** University of Southern California Program for Environmental and Regional Equity: Los Angeles, CA. Available at: http:///dornsife.usc.edu/search/?q=minding+the+climate+gap.

(22) Clark, L. O. et al. Changes in transportation-related air pollution exposures by race-ethnicity and socioeconomic status: Outdoor nitrogen dioxide in the United States in 2000 and 2010. *Environmental Health Perspectives* **2017.** DOI: 10.1289/EHP959.

(23) Davis, S. J., et al. Future CO_2 emissions and climate change from existing energy infrastructure. *Science* 329: 1330–1333. **2010.** DOI: 10.1126/science.1188566.

(24) Perera, F. P. Multiple threats to child health from fossil fuel combustion: Impacts of air pollution and climate change. *Environmental Health Perspectives* 125: 141–148. **2017.** DOI: 10.1289/EHP299.

(25) Encyclical Letter *Laudato Sí* of the Holy Father Francis on Care for Our Common Home. **2015.** http://w2.vatican.va/content/francesco/en/encyclicals/documents/papa-francesco_20150524_enciclica-laudato-si.html. *See* esp. chapter four, paragraph 139.

(26) McGlade, C., and Ekins, P. The geographical distribution of fossil fuels unused when limiting global warming to 2º C. *Nature* 517: 187–190. **2015.** DOI: 10.1038/nature14016.

(27) Fugere, D., et al. *Unconventional Risks: The growing uncertainty of oil investments;* As You Sow: Oakland, CA. Available at: https://www.asyousow.org/media-center/reports/.

(28) Coady, D., et al. *How Large are Global Energy Subsidies?;* IMF Working Paper WP/15/105. **2015.** International Monetary Fund: Washington, D.C. Available at: http://www.imf.org/en/publications/wp/issues/2016/12/31/how-large-are-global-energy-subsidies-42940.

(29) Davis, S. J., et al. The supply chain of CO_2 emissions. *Proceedings of the National Academy of Sciences* 108(45): 18554–18559. **2011.** DOI: 10.1073/pnas.1107409108.

Attachments List

Attachment KR1. Author's CV and Publications List.

Attachment KR2. Baseline CO_2e Emissions Data (2013–2015). Annotated table and references.

Attachment KR3. Calculation for Cumulative Emission (CE) Limit Based on Actual Annual Emissions (AE) from 2013–2015 (Att. KR2) and Steady Progress from 2015 to California's 2030 (–40%) and 2050 (–80%) Annual Emission Targets. Table.

Attachment KR4. Results for Cumulative Emission (CE), and Change in Annual Emission From the Previous Year (z) in Petroleum Fuel Chain Scenarios, Assuming All Other Emissions Make Steady Progress to California's Climate Targets. Tables.

Greg Karras
Curriculum Vitae
Business contact:
gkatcbe@gmail.com

Work experience

1994 to present	**Position**	Senior Scientist
1984 to 1993		Research Associate
	Employer	Communities for a Better Environment (CBE)
	Description	Lead research in toxic pollution documentation and prevention projects—San Francisco Bay Area focus. Assistance to Executive Director, staff, members and Board in program plans and development. Lead responsibility for implementation, budget and coordination of staff in assigned campaigns and projects (1994–2000). Litigation assistance as expert witness. Shared responsibility to develop science as a tool for community organizing (1997–present).
1982 to 1984	**Position**	Research Associate
	Employer	Calif. Environmental Intern Program/Citizens for a Better Environment
	Description	Research, advocacy, and public education and fund raising supporting leak detection, clean up, and prevention program for underground chemical storage tanks in Los Angeles County.
1976 and 1977	**Position**	Student Assistant
	Employer	California Air Resources Board
	Description	Air pollution surveillance field sampling, laboratory analysis, and reporting of results for air quality predictions and alerts in South Coast Air Basin. Summers.

Other relevant experience

Member, American Association for the Advancement of Science.

Member, American Chemical Society.

Member, Refinery Action Collaborative.

Co-chair, San Francisco Alternative Energy Plan Load Forecasting and Power Flow Analysis and DSM–DG working groups. 2002–2004.

Member, Monitoring and TMDL Public Advisory Group to the California Water Resources Control Board. 2000.

Chair, Health Committee, CARAT Team established by the Coalition of Black Trade Unionists, Northern California Chapter. 1998–2000.

Co-organizer with staff, S.F. Bay Water Board and Zero Dioxin Alliance, national science symposia on dioxins. 1997.

Board Member, Silicon Valley Pollution Prevention Center (alternate). ca 1994–1996.

Member, Study Design Committee, Contaminant Levels in Fish Tissue from San Francisco Bay Pilot Study. 1992–1993.

Board Member, Aquatic Habitat Institute (now known as The San Francisco Estuary Institute). ca 1988–1990.

Education

Bachelor of Arts in Biology, 1979
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Attachment KR2. Baseline CO_2e Emissions Data (2013–2015)

	Measurement	Data Source	Units	Value
California Refining				
Capacity	Atm. Crude Distillation	EIA[a]	m^3/d	319,817
CO_2e emitted	Mass emissions	ARB[b]	Mt/y	35.1
Extraction of feed				
Activity rate	Total crude feed rate	CEC[c]	m^3/d	273,146
In-state rate	Crude from California	CEC[c]	m^3/d	101,054
CO_2e emitted				
In-state rate	Mass emissions	ARB[b]	Mt/y	22.7
Total (all feed)	Mass emissions	ARB[b], CEC[c]	Mt/y	61.3
Refined products				
In-state usage:				
	Gasoline	ARB[d]	m^3/d	139,610
	Distillate / diesel	ARB[d]	m^3/d	41,569
	Jet fuel & kerosene	ARB[d]	m^3/d	3,930
	LPG & propane	ARB[d]	m^3/d	6,279
	Petroleum coke	ARB[d]	m^3/d	688
	Other refined products	ARB[d]	m^3/d	1,568
In-state emissions:				
	Gasoline	ARB[d]	Mt/y	121.2
	Distillate / diesel	ARB[d]	Mt/y	41.2
	Jet fuel & kerosene	ARB[d]	Mt/y	3.7
	LPG & propane	ARB[d]	Mt/y	3.5
	Petroleum coke	ARB[d]	Mt/y	0.8
	Other refined products	ARB[d]	Mt/y	2.2
California refinery production				
	Gasoline	CEC[e]	m^3/d	162,228
	Distillate / diesel	CEC[e]	m^3/d	57,169
	Jet fuel & kerosene	CEC[e]	m^3/d	45,105
	LPG & propane	Est[f]	m^3/d	6,210
	Petroleum coke	Est[f]	m^3/d	14,993
California refined product emissions				
In-and-out-of-state products use				
	Gasoline	Calculated	Mt/y	140.8
	Distillate / diesel	from	Mt/y	56.7
	Jet fuel & kerosene	data	Mt/y	42.8
	LPG & propane	above	Mt/y	3.5
	Petroleum coke		Mt/y	17.5
	Other refined products		Mt/y	2.2
		Products use subttl:	Mt/y	263.5
Refinery fuel chain emissions (Calif. refineries 2013–15)			Mt/y	360.0
All other statewide emissions (2013–2015)		ARB[d]	Mt/y	216.3
Statewide total including refinery fuel chain			Mt/y	576.3

(continued on pages KR2-2 and KR2-3)

m^3/d: *cubic meters/day*

Mt/y: *Megatons; million metric tons, per year*

(a) Data for calendar day crude capacity by plant as of January 2017 from the U.S. Energy Information Administration (EIA). (*See* reference SR1.) Includes 3,339 m^3/day of gas oil hydrotreating capacity for one small plant (Alon Bakersfield) that did not report crude capacity from 2011–2017. (Id.)

(b) Data from California Air Resources Board (ARB) Mandatory GHG Reporting Public Data Reports. (SR2.) Includes emissions from separately-owned hydrogen plants serving refineries: the Air Liquide El Segundo and Rodeo plants and the Air Products Carson, Martinez, and Wilmington plants; ARB ID nos. 101701, 101749, 101248, 101017, and 100127.

(c) Data from California Energy Commission (CEC); *Crude Oil Supply Sources to California Refineries.* (SR3.)

(d) Data from California Air Resources Board (ARB) *Greenhouse Gas Inventory by IPCC Category* (SR4), *Disaggregation of Industrial Cogeneration Categories in California's Greenhouse Gas Inventory* (SR5), and *Fuel Activity for California's Greenhouse Gas Inventory by Sector & Activity* (SR6). The ExxonMobil (now PBF) Torrance facility data are based on 2013–2014 in this table and main text Table 2. The 2015 emissions from this facility were anomalous due to an explosion that led to an exceptional FCC outage during most of 2015 and much of 2016.

(e) Data from California Energy Commission (CEC); *Weekly Fuels Watch Report.* (SR7.)

(f) Estimated product leaving the refinery gate, excluding refinery usage. For liquefied petroleum gas (LPG) and propane this value was estimated based on EIA data for PADD 5 net production of propane and butane (SR8) and the portion of PADD 5 conversion capacity accounted for by refineries in California (SR1). For petroleum coke (pet coke) this value was estimated based on EIA data for PADD 5 net production (SR8), the portion of PADD 5 coking capacity for pet coke accounted for by refineries in California (SR1), and pet coke combustion for cogeneration in California (SR5, SR6). Emissions from pet coke combustion by industrial cogeneration in California were conservatively assumed to be refining or extraction-related and were excluded from this estimate value to avoid the potential for double counting of refinery fuel chain emissions. For LPG and propane, total California industrial cogeneration emissions were too small from 2013–2015 (<0.001 Mt/y; SR5) to affect the estimate.

Total fuel chain emission calculation estimates conservatively assumed that emission rates for extraction of oil refined in California, and combustion of California-refined fuels, which occurred in other states and nations, were (and will remain through 2050) equivalent to those reported for these activities in California. These estimates also conservatively excluded any emissions from feedstock import and refined product export transportation associated with combustion of transport fuels which were not produced in California.

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Attachment KR3. Calculation for Cumulative Emission (CE) Limit Based on Actual Annual Emissions (AE) from 2013–2015 (Att. KR2) and Steady Progress from 2015 to California's 2030 (–40%) and 2050 (–80%) Annual Emission Targets.

Gt: Gigaton; 1 billion metric tons.

	Petroleum Fuel Chain			All Other Emissions			Total Emissions		
Year	AE (Gt/y)	CE (Gt)	AE % v. 2015	AE (Gt/y)	CE (Gt)	AE % v. 2015	AE (Gt/y)	CE (Gt)	AE % v. 2015
2013	0.360	0.360	100.0%	0.216	0.216	100.0%	0.576	0.576	100.0%
2014	0.360	0.720	100.0%	0.216	0.433	100.0%	0.576	1.153	100.0%
2015	0.360	1.080	100.0%	0.216	0.649	100.0%	0.576	1.729	100.0%
2016	0.350	1.430	97.3%	0.211	0.860	97.3%	0.561	2.290	97.3%
2017	0.341	1.771	94.7%	0.205	1.064	94.7%	0.546	2.835	94.7%
2018	0.331	2.102	92.0%	0.199	1.263	92.0%	0.530	3.366	92.0%
2019	0.322	2.424	89.3%	0.193	1.457	89.3%	0.515	3.880	89.3%
2020	0.312	2.736	86.7%	0.187	1.644	86.7%	0.499	4.380	86.7%
2021	0.302	3.038	84.0%	0.182	1.826	84.0%	0.484	4.864	84.0%
2022	0.293	3.331	81.3%	0.176	2.002	81.3%	0.469	5.333	81.3%
2023	0.283	3.614	78.7%	0.170	2.172	78.7%	0.453	5.786	78.7%
2024	0.274	3.887	76.0%	0.164	2.336	76.0%	0.438	6.224	76.0%
2025	0.264	4.151	73.3%	0.159	2.495	73.3%	0.423	6.647	73.3%
2026	0.254	4.406	70.7%	0.153	2.648	70.7%	0.407	7.054	70.7%
2027	0.245	4.651	68.0%	0.147	2.795	68.0%	0.392	7.446	68.0%
2028	0.235	4.886	65.3%	0.141	2.936	65.3%	0.377	7.822	65.3%
2029	0.226	5.111	62.7%	0.136	3.072	62.7%	0.361	8.183	62.7%
2030	0.216	5.327	60.0%	0.130	3.202	60.0%	0.346	8.529	60.0%
2031	0.209	5.536	58.0%	0.125	3.327	58.0%	0.334	8.863	58.0%
2032	0.202	5.738	56.0%	0.121	3.448	56.0%	0.323	9.186	56.0%
2033	0.194	5.932	54.0%	0.117	3.565	54.0%	0.311	9.497	54.0%
2034	0.187	6.119	52.0%	0.112	3.678	52.0%	0.300	9.797	52.0%
2035	0.180	6.299	50.0%	0.108	3.786	50.0%	0.288	10.085	50.0%
2036	0.173	6.472	48.0%	0.104	3.890	48.0%	0.277	10.362	48.0%
2037	0.166	6.637	46.0%	0.100	3.989	46.0%	0.265	10.627	46.0%
2038	0.158	6.796	44.0%	0.095	4.085	44.0%	0.254	10.880	44.0%
2039	0.151	6.947	42.0%	0.091	4.175	42.0%	0.242	11.122	42.0%
2040	0.144	7.091	40.0%	0.087	4.262	40.0%	0.231	11.353	40.0%
2041	0.137	7.228	38.0%	0.082	4.344	38.0%	0.219	11.572	38.0%
2042	0.130	7.357	36.0%	0.078	4.422	36.0%	0.207	11.779	36.0%
2043	0.122	7.480	34.0%	0.074	4.496	34.0%	0.196	11.975	34.0%
2044	0.115	7.595	32.0%	0.069	4.565	32.0%	0.184	12.160	32.0%
2045	0.108	7.703	30.0%	0.065	4.630	30.0%	0.173	12.333	30.0%
2046	0.101	7.804	28.0%	0.061	4.690	28.0%	0.161	12.494	28.0%
2047	0.094	7.897	26.0%	0.056	4.747	26.0%	0.150	12.644	26.0%
2048	0.086	7.984	24.0%	0.052	4.798	24.0%	0.138	12.782	24.0%
2049	0.079	8.063	22.0%	0.048	4.846	22.0%	0.127	12.909	22.0%
2050	0.072	8.135	20.0%	0.043	4.889	20.0%	0.115	13.024	20.0%

Attachment KR4. Results for Cumulative Emission (CE) and Change in Annual Emission From the Previous Year (z) in Petroleum Fuel Chain Scenarios, Assuming All Other Emissions Make Steady Progress to California's Climate Targets.

Table KR4–1. Cumulative Emission (CE), in billions of metric tons (Gt).

Year	All Other (Gt)	Scenario S_a Oil (Gt)	Scenario S_a Total (Gt)	Scenario S_b Oil (Gt)	Scenario S_b Total (Gt)	Scenario S_c Oil (Gt)	Scenario S_c Total (Gt)	Delay >2050 Oil (Gt)	Delay >2050 Total (Gt)
2013	0.216	0.360	0.576	0.360	0.576	0.360	0.576	0.360	0.576
2014	0.433	0.720	1.153	0.720	1.153	0.720	1.153	0.720	1.153
2015	0.649	1.080	1.729	1.080	1.729	1.080	1.729	1.080	1.729
2016	0.860	1.440	2.299	1.440	2.299	1.440	2.299	1.440	2.299
2017	1.064	1.800	2.864	1.800	2.864	1.800	2.864	1.800	2.864
2018	1.263	2.160	3.423	2.160	3.423	2.160	3.423	2.160	3.423
2019	1.457	2.520	3.976	2.520	3.976	2.520	3.976	2.520	3.976
2020	1.644	2.880	4.524	2.862	4.507	2.880	4.524	2.880	4.524
2021	1.826	3.240	5.065	3.189	5.015	3.240	5.065	3.240	5.065
2022	2.002	3.600	5.601	3.500	5.502	3.600	5.601	3.600	5.601
2023	2.172	3.959	6.132	3.796	5.968	3.959	6.132	3.959	6.132
2024	2.336	4.319	6.656	4.078	6.415	4.319	6.656	4.319	6.656
2025	2.495	4.679	7.174	4.347	6.842	4.679	7.174	4.679	7.174
2026	2.648	5.039	7.687	4.603	7.251	5.039	7.687	5.039	7.687
2027	2.795	5.399	8.194	4.846	7.642	5.399	8.194	5.399	8.194
2028	2.936	5.759	8.696	5.079	8.015	5.759	8.696	5.759	8.696
2029	3.072	6.119	9.191	5.300	8.372	6.119	9.191	6.119	9.191
2030	3.202	6.479	9.681	5.510	8.712	6.479	9.681	6.479	9.681
2031	3.327	6.647	9.974	5.711	9.038	6.822	10.149	6.839	10.166
2032	3.448	6.725	10.174	5.902	9.350	7.148	10.597	7.199	10.647
2033	3.565	6.804	10.369	6.084	9.649	7.459	11.025	7.559	11.124
2034	3.678	6.882	10.560	6.257	9.935	7.756	11.433	7.919	11.597
2035	3.786	6.960	10.746	6.422	10.208	8.038	11.824	8.279	12.065
2036	3.890	7.039	10.928	6.579	10.469	8.306	12.196	8.639	12.529
2037	3.989	7.117	11.106	6.729	10.718	8.562	12.552	8.999	12.988
2038	4.085	7.195	11.280	6.871	10.956	8.806	12.890	9.359	13.443
2039	4.175	7.273	11.449	7.007	11.182	9.038	13.213	9.719	13.894
2040	4.262	7.352	11.614	7.136	11.398	9.259	13.521	10.079	14.341
2041	4.344	7.430	11.774	7.259	11.603	9.470	13.814	10.439	14.783
2042	4.422	7.508	11.930	7.377	11.799	9.670	14.092	10.799	15.221
2043	4.496	7.587	12.082	7.488	11.984	9.861	14.357	11.158	15.654
2044	4.565	7.665	12.230	7.595	12.160	10.043	14.608	11.518	16.083
2045	4.630	7.743	12.373	7.696	12.326	10.216	14.846	11.878	16.508
2046	4.690	7.822	12.512	7.793	12.483	10.381	15.072	12.238	16.929
2047	4.747	7.900	12.646	7.885	12.631	10.538	15.285	12.598	17.345
2048	4.798	7.978	12.777	7.972	12.771	10.688	15.487	12.958	17.757
2049	4.846	8.057	12.903	8.055	12.901	10.831	15.677	13.318	18.164
2050	4.889	8.135	13.024	8.135	13.024	10.966	15.856	13.678	18.567

(continued on page KR4-2)

Attachment KR4. Results for Cumulative Emission (CE) and Change in Annual Emission From the Previous Year (z) in Petroleum Fuel Chain Scenarios, Assuming All Other Emissions Make Steady Progress to California's Climate Targets.

Table KR4–2. Timing and Extent of Change in Annual Emissions From the Previous Year (z) For All Scenarios Assessed.

Starting Year	z (ratio)	Percentage reduction	Ending Year	Duration of sustained emission cuts (to 2050)
Scenarios that meet the cumulative emissions limit				
2016	0.9567	4.33	2050	35 years
2017	0.9565	4.35	2050	34 years
2018	0.9563	4.37	2050	33 years
2019	0.9561	4.39	2050	32 years
2020	0.9524	4.76	2050	31 years[a]
2021	0.9482	5.18	2050	30 years
2022	0.9432	5.68	2048	27 years
2023	0.9371	6.30	2046	24 years
2024	0.9299	7.01	2045	22 years
2025	0.9202	7.98	2043	19 years
2026	0.9071	9.30	2041	16 years
2027	0.8919	10.82	2040	14 years
2028	0.8660	13.40	2038	11 years
2029	0.8226	17.74	2036	8 years
2030	0.7347	26.54	2034	5 years
2031	0.4664	53.36	2032	2 years[b]
2032	0.1895	81.06	2032	1 year
Scenarios that exceed the cumulative emissions limit				
2031	0.9524	4.76	2050	21 years[c]
> 2050	1.0000	0.00	NA	NA

a. Scenario B; <u>*see*</u> Table KR4–1 for cumulative emission details.
b. Scenario A; <u>*see*</u> Table KR4–1 for cumulative emission details.
c. Scenario C; <u>*see*</u> Table KR4–1 for cumulative emission details.
<u>*See*</u> main text for explanation of methods and equation solved for "z"

Table KR4–3. Scenario S_a Change in Annual Emissions 2030–2032.

Year	Petroleum emissions	
	(Gt^{-y})	(% cut)*
2030	0.35995	0.00%
2031	0.16789	-53.36%
2032	0.07831	-78.24%

* Percentage emission reduction from 2030.