Carbon Negative 2030 Pathways Model Scenario Explained

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The burning of fossil fuels along with habitat and soil destruction has pushed the global climate into "unprecedented" territory, per the latest UN science assessment.[1] "It is Code Red for humanity. The evidence is irrefutable: greenhouse gas emissions are choking our planet and placing billions of people in danger. We must act decisively now to avert a climate catastrophe," Antonio Guterres, UN Secretary General, wrote in response to the report.[2]

Much of the most recent climate science shows that the goal of net zero emissions by 2050, set by the United Nations Intergovernmental Panel on Climate Change (IPCC), is far too slow a timeline to limit warming to 1.5C. Impacts not expected for several decades are already being observed today. Because the IPCC operates by consensus, its results are inherently conservative. Some studies suggest we could surpass 1.5C of warming as soon as 2027 to 2030 globally.[3] [4] The past seven years were the hottest on record,[5] with sea levels set to be at their highest yet.[6] Extreme events are growing in intensity and regularity across the globe and in California.[7]

In 2019, The Climate Center launched the Climate-Safe California campaign[8] to achieve net-negative emissions by 2030, fifteen years earlier than current state policy. To support this objective, in 2020, we began development of an Excel-based "Pathways Model" which includes indices in five major economic sectors that can be adjusted for different levels of reductions as well as negative emissions via nature-based carbon sequestration.

Our modeling exercise shows how California could reduce emissions across the five sectors by 77% between 2020 and 2030. (We assume 2020 emissions are roughly the same as in 2017. State climate targets use 1990 emissions, which were 431 million metric tons of carbon dioxide equivalent (MMT CO_2e), as their baseline year.)[9] This equates to 323 MMT CO_2e. We couple these reductions with CO_2 removal of 103 MMT CO_2e to zero out the remaining 23% of emissions, thereby demonstrating a 2030 net-negative scenario (Figure 1).[10]

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[1] Dennis, B., & Kaplan, S. (2021, August 10). *Humans have pushed the climate into 'unprecedented' territory, landmark U.N. report finds*. The Washington Post. Retrieved from https://www.washingtonpost.com/climate-environment/2021/08/09/ipcc-climate-report-global-warming-greenhouse-gas-effect/

[2] Guterres, A. (2021, August 9). *IPCC report: 'Code red' for human driven global heating, warns UN chief*. UN News. Retrieved from https://news.un.org/en/story/2021/08/1097362

[3] Hébert, R., Lovejoy, S., & Tremblay, B. (2021). *An observation-based scaling model for climate sensitivity estimates and global projections to 2100*. Climate Dynamics, 56, 1105-1129. doi:10.1007/s00382-020-05521-x

[4] Xu, Y., Ramanathan, V., & Victor, D. (2018, December). *Global warming will happen faster than we think*. Nature. Retrieved from https://www.nature.com/articles/d41586-018-07586-5

[5] European Commission. (2022, January 10). *Copernicus: Globally, the seven hottest years on record were the last seven; carbon dioxide and methane concentrations continue to rise*. Retrieved from Copernicus; Climate Change Service: https://climate.copernicus.eu/copernicus-globally-seven-hottest-years-record-were-last-seven

[6] WMO. (2021, October 31). *Past 7 years set to be warmest on record, sea level at new high*. UN News. Retrieved from https://news.un.org/en/story/2021/10/1104472

[7] Buis, A. (2021, November 8). *Extreme Makeover: Human Activities Are Making Some Extreme Events More Frequent or Intense*. Retrieved from Ask NASA Climate: https://climate.nasa.gov/ask-nasa-climate/3125/extreme-makeover-human-activities-are-making-some-extreme-events-more-frequent-or-intense/

[8] www.climatesafeca.org

[9] As its baseline year, our model uses Air Resources Board emissions inventory data for 2017. This is the last year for which data was available when the model was created. We assume emissions changes are small between 2017 and 2020, and use 2017 figures for the "2020 Emissions" bar in Figure 1, in part to chart a 10-year path to net-negative emissions for the 2020s decade only.

[10] To better understand the assumptions, data sources, structure, goals, and logic of the model, please visit The Climate Center's website. This page includes a link to download the model and an explainer on how to use it.

These results were published as part of a report released in March 2021 entitled, "Accelerating the timeline for climate action in California," authored by 8 prominent climate scientists and experts.[11]

The report makes the case for why such dramatic emissions cuts and sequestration rates are the right goals for California. Our model scenario shows only the required level of cuts by sector and does not aim to address whether they are politically feasible. Ambitious targets are essential to send market signals, catalyze innovation, and kickstart the type of policy, planning, and implementation needed to avert the worst impacts of the climate crisis.

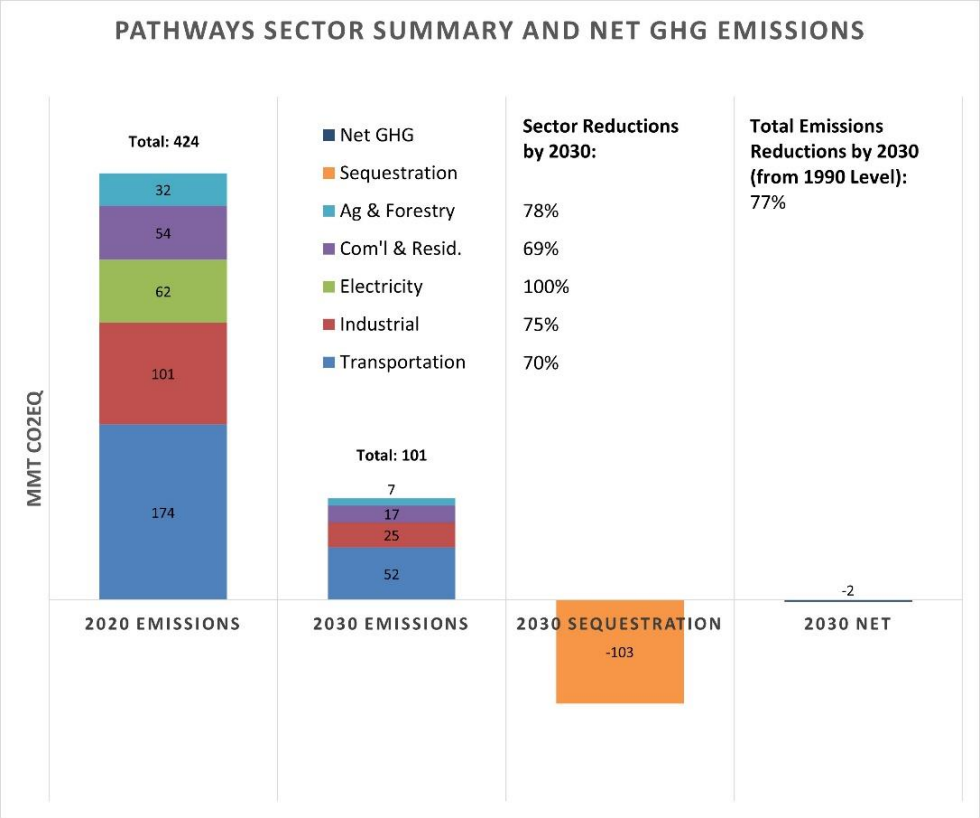

Figure 1. Scenario for net-negative emissions in 2030 in The Climate Center's model. From Kammen, et al., 2021.

The present brief explores in more detail the sector-by-sector model assumptions and results that demonstrate pathways to cutting measured emissions in the state 77% by 2030. Note that this brief does not examine the 103 MMT CO_2e of sequestration that, when paired with 77% GHG cuts, can achieve net negative emissions by 2030 in California. That is the focus of a separate report that documents in detail how working lands can sequester additional carbon at that rate by 2030. The sequestration report will be published by The Climate Center in early 2022 and is available upon request until then.

Agriculture and Forestry (78%)

Greenhouse gas (GHG) emissions from the Agriculture and Forestry sector totaled 32.42 MMT in 2017, the last year for which data was available when the model was created. Of that total, 11.62 MMT came from manure management. Our model assumes an 80% reduction in this amount by 2030 through improved manure management practices that capture methane. There are also 20.79 MMT of harder-to-abate emissions from

[11] Kammen, D.; Matlock, T.; Pastor, M.; Pellow, D.; Ramanathan, V.; Steyer, T.; Stokes, L.; Ventura, F. (2021). *Accelerating the timeline for climate action in California*. ArXiv. Retrieved from https://arxiv.org/abs/2103.07801

Agriculture and Forestry sources like livestock enteric fermentation, energy use, soil management, rice cultivation, and others. We assume these emissions will be reduced by roughly 76% in order to contribute sufficient cuts to achieve a net-negative target by 2030. In total, emissions in our model drop from 32.42 MMT to 7.3 MMT by 2030.

Commercial and Residential Buildings (69%)

GHG emissions from the Commercial and Residential Building sector total almost 54 MMT in the model's baseline. Of that total, 35.3 MMT come from natural gas and 18.3 MMT come from non-natural gas sources, including refrigerants, propane, and petroleum distillates. Our model assumes non-natural gas emissions drop to 8 MMT. It also assumes electric appliances replace natural gas for heating applications in 85% of buildings in California. Other potential corresponding emissions changes, like emissions from increased electricity demand, new emissions from heat pump leakage, and reduced emissions from natural gas leakage, are not included. Overall, our model shows emissions dropping from 54 MMT to 17 MMT by 2030.

Electricity (100%)

Our model scenario assumes that electricity emissions are eliminated by 2030 from a starting point of 62 MMT. This exceeds the SB100 target of 60% carbon-free electricity by 2030. This is accomplished via accelerated renewable energy deployment and procurement, along with achieving 150% of the energy efficiency target established by SB350 (a California Energy Commission (CEC) report suggests that the technical limit to electricity energy efficiency savings is more than double the economic potential and four times the 2030 market potential).[12] It also assumes reaching 150% of the solar photovoltaic adoption in the highest case in CEC's 2019 Integrated Energy Policy Report.[13] Surpassing the IEPR scenario is possible given that California's technical potential for rooftop solar is high (129GW, which would meet almost three-quarters of California's energy needs). It should be noted that our electricity sector projection does not compound into other sectors (e.g. 2030 buildings emissions are calculated using the 2017 grid emissions intensity, not the zero emissions grid modeled for 2030).

Industry (75%)

Industry emitted 101 MMT CO_2e in 2017, our model's baseline year. Within this sector, 45.4 MMT come from industry processes that are suitable for energy efficiency improvements. We assume energy efficiency reaches 85% of this potential, shrinking this sub-sector to 6.8 MMT. Other industrial processes are harder to abate and fall into the categories of gasoline refining, non-gasoline refining (e.g. products like jet fuel or diesel), and other industrial emission (e.g. landfill- and oil and gas processing-related emissions). These remaining emissions shrink from 56 MMT to 18 MMT in our model via research, development, demonstration, and deployment of emerging technologies and processes including green hydrogen, electrification of low- to medium-grade heating, and others. In total, Industry emissions drop from 101 MMT to 25 MMT.

Transportation (70%)

Two model indices influence transportation emissions: vehicle miles traveled (VMT) reduction and avoided emissions from gasoline combustion due to electric vehicle (EV) conversion. Our model assumes a 35% drop in

[12] CEC. (2019). *2019 California Energy Efficiency Action Plan*. California Energy Commission. Retrieved from https://www.energy.ca.gov/filebrowser/download/1900

[13] CEC. (2019). *2019 Integrated Energy Policy Report*. (California Energy Commission) Retrieved from https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2019-integrated-energy-policy-report

VMT and EV conversion that reduces gasoline use by 80%. Both of which reduce emissions via avoided gasoline combustion. This sector's estimate does not consider new emissions from increased EV charging, nor does it include the reduction in electricity emissions intensity through 2030 that would zero out those emissions. These two indices address the 156 MMT of on-road transportation emissions in the state. An additional 19 MMT fall into the category of "other transportation," and include rail, aviation, water-borne, and other unspecified transportation emissions. We assume these emissions drop to 4 MMT. In total, our model scenario drops emissions from 174 MMT CO_2e to 52 MMT CO_2e in 2030.

Conclusion

Recent advances in climate science indicate that global warming is accelerating towards 1.5C quicker than anticipated. Mitigating the climate crisis requires conceptualizing the magnitude of emissions reductions needed in each sector. This clarity is a prerequisite to plan, build political will, and execute a bold and just climate mitigation strategy. The Climate Center's Pathways Model serves that role.

The net-negative 2030 scenario comes with a few key limitations. First, the creation of this model scenario does not account for political and social feasibility. We assume the technical ability to achieving such a target exists, though it would require a wartime-like mobilization of resources and a suite of coordinated policies.

Second, this scenario does not explicitly explore what policy package would be needed to achieve the emissions cuts modeled in each sector. Some policies are implied by the model scenario. For instance, avoiding emissions from gasoline combustion due to EV adoption suggests the need for an accelerated internal combustion engine phase-out date (a recent Executive Order by Governor Newsom sets a non-binding phase-out goal of 2035;[14] complying with this model scenario would require a date in the 2020s).

Finally, this Excel-based model is simple and leaves out complexities that could be captured by higher-powered models. This model is, however, open source and easily manipulated by any user and therefore offers practical benefits in its simplicity. For our purposes, the Pathways Model achieves its aim: generating figures that give advocates, policymakers, and the public a sense of what it might take to enact policies commensurate with our rapidly worsening climate reality and pursue a truly climate-safe California.

[14] Office of Governor Gavin Newsom. (2020). *Executive Order N-79-20.* State of California, Office of the Governor. Retrieved from https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf