DRAFT 2022 SCOPING PLAN UPDATE

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Abbreviations

°F	Fahrenheit
°C	Celsius
AB	Assembly Bill
AQMD	Air Quality Management District
AR5	IPCC Fifth Assessment Report
BAU	business as usual
BECCS	bioenergy with carbon capture and storage
CalEPA	California Environmental Protection Agency
CalSTA	California State Transportation Agency
CARB	California Air Resources Board
CCHVIz	Climate Change and Health Vulnerability Indicators Tool
CDFA	California Department of Food and Agriculture
CDR	carbon dioxide removal
CE	common era
CEQA	California Environmental Quality Act
CES	CalEnviroScreen
CH_4	methane
CMAQ	Community Multiscale Air Quality
CNRA	California Natural Resources Agency
CO_2	carbon dioxide
COPD	chronic obstructive pulmonary disease
CPUC	California Public Utilities Commission
DAC	direct air capture
DAC	disadvantaged community

EA	Environmental Analysis
ED	emergency department
EJ	environmental justice
EJ Advisory Committee	Environmental Justice Advisory Committee
ETS	emissions trading system
EV	electric vehicle
F-gas	fluorinated gas
FCEV	fuel cell electric vehicle
GCF	Governors' Climate and Forests Task Force
GDP	gross domestic product
GHG	greenhouse gas
GSP	gross state product
GW	gigawatt
GWh	gigawatt-hour
GWP	global warming potential
HDV	heavy-duty vehicle
HD ZEV	heavy-duty zero emission vehicle
HFC	hydrofluorocarbon
HPI	Healthy Places Index
ICAP	International Carbon Action Partnership
IPCC	Intergovernmental Panel on Climate Change
IPT	incidence-per-ton
IWG	Interagency Working Group
LCFS	low-carbon fuel standard
LDV	light-duty vehicle
MD	medium-duty

MMT	million metric tons
$MMTCO_2e$	million metric tons of carbon dioxide equivalent
MOU	memorandum of understanding
MRR	Mandatory Reporting of GHG Emissions
$MTCO_2e$	metric tons of carbon dioxide equivalent
MW	megawatt
N_2O	nitrous oxide
NF_3	nitrogen trifluoride
NOx	nitrogen oxides
NWL	Natural and Working Lands
OEHHA	Office of Environmental Health Hazard Assessment
PFC	perfluorocarbon
$PM_{2.5}$	fine particulate
PPP	public-private partnership
RFS	renewable fuel standard
RNG	renewable natural gas
RPS	renewable portfolio standard
SB	Senate Bill
$SC\text{-}CH_4$	social cost of methane
$SC\text{-}CO_2$	social cost of carbon
SC-GHG	social cost of greenhouse gases
$SC\text{-}N_2O$	social cost of nitrous oxide
SEMARNAT	Mexican Secretariat for Environment and Natural Resources
SF_6	sulfur hexafluoride
SGIP	Self-Generation Incentive Program

SLCP	short-lived climate pollutant
SoCAB	South Coast Air Basin
TSD	Technical Support Document
UCLA	University of California, Los Angeles
UNFCCC	United Nations Framework Convention on Climate Change
U.S. EPA	United States Environmental Protection Agency
VMT	vehicle miles traveled
WUI	wildland–urban interface
ZEV	zero emission vehicle

Executive Summary

The 2022 Scoping Plan, once final, will be a major milestone, laying out how the fifth largest economy in the world can get to carbon neutrality by 2045 or earlier. This is the first Scoping Plan that adds carbon neutrality as a science-based guide and touchstone beyond statutorily established emission reduction targets. It identifies a technologically feasible, cost-effective and equity-focused path to achieve carbon neutrality by 2045, or earlier, while also assessing the progress the state is making toward reducing its greenhouse gas (GHG) emissions by at least 40 percent below 1990 levels by 2030, as called for in SB 32 and laid out in the 2017 Scoping Plan.[1] Previous plans focused on specific GHG reduction targets for our industrial, energy, and transportation sectors—to meet 1990 levels by 2020, and then the more aggressive 40 percent below that for the 2030 target. Carbon neutrality takes it one step further by expanding actions to capture and store carbon including through natural and working lands and mechanical technologies, while drastically reducing anthropogenic sources of carbon pollution at the same time.

What this means for California is an ambitious and aggressive approach to squeezing the carbon out of every sector of the economy, setting us on course for a more equitable and sustainable future in the face of the greatest existential threat we face, and ensuring that those who benefit from this transformation include those communities now hardest hit by the ongoing use of fossil fuels. The combustion of these fuels has polluted our air, particularly in low-income communities and communities of color, for far too long, and is the root cause of climate change. This Draft Scoping Plan helps us chart the path to a future where race is no longer a predictor of disproportionate burdens from harmful air pollution and climate impacts.

The major element of this unprecedented transformation is the aggressive reduction of fossil fuels wherever they are currently used in California, building on and accelerating carbon reduction programs that have been in place here for a decade and a half. That means rapidly moving to zero-emission transportation, electrifying the cars, buses, trains, and trucks that now constitute California's single largest source of planet-warming pollution. It also means phasing out the use of fossil gas used for heating our homes and buildings. It means clamping down on chemicals and refrigerants that are thousands of times more powerful at trapping heat than carbon dioxide (CO_2). It means providing our communities with sustainable options for walking, biking, and public transit so that people do not have to rely on a car. It means continuing to build out the solar arrays, wind turbine capacity, and other resources that provide clean, renewable

[1] CARB. 2017. Update to the AB 32 Climate Change Scoping Plan. https://ww2.arb.ca.gov/sites/default/files/classic/cc/scopingplan/scoping_plan_2017.pdf.

energy to displace fossil-fuel fired electrical generation. It also means scaling up new options such as green hydrogen[2] for hard to electrify end uses and renewable gas where needed.

That's on the carbon reduction side. The other side of the equation is a re-envisioning of our forests, shrublands/chaparral, croplands, wetlands, and other lands—what we call Natural and Working Lands—to ensure that they play as robust a role as possible in incorporating and storing more carbon in the trees, plants, soil, and wetlands that cover 90 percent of the state's 105 million acres. And since the goal is to balance carbon output with carbon sequestration, we will need to research, develop, and deploy additional methods of capturing CO_2 that include pulling it from the smokestacks of facilities, or drawing it out of the atmosphere itself and then safely and permanently storing it.

This is a plan that aims to shatter the carbon status quo and take action to achieve a vision of California with a cleaner, more sustainable environment and thriving economy for our children. When final, this ambitious plan will serve as a model for other partners around the world as they consider how to make their transition. As we have so often in the past, California can serve as the successful laboratory of innovation that has produced not only the fifth largest economy on the planet, but ultimately one of the most energy-efficient economies, with a track record of demonstrating the ability to decouple economic growth from carbon pollution. This plan builds upon current and previous environmental justice efforts to integrate environmental justice directly into the plan to ensure that no community is left behind. Specifically, this plan:

- Identifies a path to keep California on track to meet its SB 32 GHG reduction target of at least 40 percent below 1990 emissions by 2030.
- Identifies a technologically feasible, cost-effective path to achieve carbon neutrality by 2045 or earlier.
- Focuses on strategies for reducing California's dependency on petroleum to provide consumers with clean energy options that address climate change, improve air quality, and support economic growth and clean sector jobs.
- Integrates equity and protecting California's most impacted communities as a driving principle throughout the document.
- Incorporates the contribution of natural and working lands to the state's GHG emissions, as well as its role in achieving carbon neutrality.
- Relies on the most up to date science, including the need to deploy all viable tools to address the existential threat that climate change presents, including carbon capture and sequestration as well a direct air capture.

[2] For the purposes of the Draft 2022 Scoping Plan, "green hydrogen" is not limited to only electrolytic hydrogen produced from renewables.

- Evaluates multiple options for achieving our GHG and carbon neutrality targets, as well as the public health benefits and economic impacts associated with each.

The path forward is informed by robust science. The recent *Sixth Assessment Report* (AR6) of the Intergovernmental Panel on Climate Change (IPCC) summarizes the latest scientific consensus on climate change. It finds that atmospheric concentrations of CO_2 have increased by 50 percent since the industrial revolution and continue to increase at a rate of two parts per million each year.[3] By the 2030s, and no later than 2040, the world will exceed 1.5°C warming. While every tenth of a degree matters—every incremental increase in warming brings additional negative impacts—climate-related risks to human health, livelihoods, and biodiversity are projected to increase further under 2°C warming, compared to 1.5°C.[4] In order to remain below 1.5°C with limited or no overshoot of that threshold, global net anthropogenic CO_2 emissions need to reach net zero by 2050.

It has been 16 years since the Global Warming Solutions Act of 2006 was passed and signed into law. In 2017, the second update to the AB 32 Climate Change Scoping Plan[5] (2017 Scoping Plan update) laid out a cost-effective and technologically feasible path to achieve the 2030 GHG reduction target. At the time, many characterized the plan and the AB 32 target as unachievable, citing that it would lead to massive business and job loss, and excessive costs. Those predictions proved to be incorrect as California achieved its AB 32 target four years ahead of schedule all the while growing our economy with the state distinguishing itself as a hub for green technology investment. This Draft 2022 Scoping Plan draws on a decade and a half of proven successes and additional new approaches to provide a balanced and aggressive course of effective actions to achieve carbon neutrality in 2045, if not before, in addition to the 2030 goal.

California's economy is projected to grow vigorously in the coming years and decades. In 2045, under a Reference Scenario, the gross state product would be $5.1 trillion, nearly $2 trillion more than in 2021, and allow growth adding hundreds of thousands of jobs. Under the California Air Resources Board (CARB) staff Proposed Scenario, impacts to this growth would be negligible in both 2035 and 2045, while delivering massive benefits in the form of reduced hospitalizations, asthma cases, and lost work and school days due to cleaner air supported by this plan. This

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[3] IPCC. 2021. *Climate Change 2021: The Physical Science Basis.* Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. In Press. https://www.ipcc.ch/report/ar6/wg1/.

[4] IPCC. 2018. *Global Warming of 1.5°C.* World Meteorological Organization. Geneva, Switzerland. 32 pp. https://www.ipcc.ch/sr15/.

[5] CARB. 2017. *California's 2017 Climate Change Scoping Plan.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/scopingplan/scoping_plan_2017.pdf.

should come as no surprise given the tremendous growth of California's economy since the Great Recession, even as the state has taken drastic measures to lower emissions. As noted, the savings associated with ambitious climate action are extensive, both in terms of avoided climate impacts and health costs. As described in Chapter 1, the health costs of climate and air pollution in the U.S. are well over $800 billion today and will continue to grow in the coming years[6] without robust action. Similarly, the costs of delayed or insufficient climate action could cost the U.S. upwards of $14.5 trillion over the next 50 years.[7] We can either take action now or pay the cost of inaction, both now and later.

We cannot take on this unprecedented challenge alone. Collaboration with the federal government, other U.S. states, and other jurisdictions around the world, will continue to be fundamental for California to succeed in achieving its climate targets, especially as the pace of our efforts increase in the coming years. We believe this collaboration and coordination also creates a race to the top, encouraging and enabling other jurisdictions to also achieve climate and air quality goals, and often providing lessons for national action.

One example of fruitful collaboration is California's longstanding vehicle emissions standards programs, which have repeatedly been freely adopted by other states consistent with the federal Clean Air Act. California's programs frequently pioneer more rigorous standards or new technologies—including the now-standard catalytic converter—and continue to lead the way. From initial standards for cars and trucks decades ago to the world-leading Advanced Clean Trucks program currently helping to electrify heavy-duty vehicles, this partnership continues to offer regulatory options and spread innovative technologies. A major example of future work is the proposed Advanced Clean Cars 2 program, which lays out California's legally binding path to achieving 100 percent ZEV sales in 2035[8]. CARB continues to work closely with many other states that also see zero emission vehicles as critical to their climate and public health goals and expects many states to choose to adopt this regulation as well. This partnership with other states also creates market certainty for automakers, which in turn helps ensure California consumers have access to a variety of ZEVs at multiple price points.

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[6] Alwis, D. D., and V. S. Limaye. No date. *The Costs of Inaction: The Economic Burden of Fossil Fuels and Climate Change on Health in the United States.* NRDC, The Medical Society Consortium on Climate and Health, and WHPCA. https://www.nrdc.org/sites/default/files/costs-inaction-burden-health-report.pdf.

[7] Deloitte. 2022. *The Turning Point: A New Economic Climate in the United States.* https://www2.deloitte.com/content/dam/Deloitte/us/Documents/about-deloitte/us-the-turning-point-a-new-economic-climate-in-the-united-states-january-2022.pdf?id=us:2el:3dp:wsjspon:awa:WSJSBJ:2021:WSJFY22.

[8] Executive Order N-79-20. *https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf*

The Scoping Plan Process

Four scenarios were extensively modeled to develop the Draft 2022 Scoping Plan, with the objective of informing the most viable path to remain on track to achieve our 2030 GHG reduction target and carbon neutrality by 2045 or earlier. All four have their merits and drawbacks and are informed by stakeholder input. The staff-proposed scenario that forms the basis of this Draft 2022 Scoping Plan is the alternative that most closely aligns with existing statute and Executive Orders. It is the proposed alternative because it best achieves the balance of cost-effectiveness, health benefits, and technological feasibility. This said, as the CARB Board and other stakeholders carefully consider the Draft 2022 Scoping Plan, they might find there is value in importing aspects of other alternative scenarios in order to improve upon the staff-proposed alternative. Some of the accelerated options for clean technology or fuels included in the alternative scenarios could potentially also help inform new legislative targets or incentive programs to achieve GHG reductions sooner.

All four scenarios for the industry, energy, and transportation sectors are aggressive and reduce petroleum use from 81 to 99 percent below 2022 levels. The Proposed Scenario reduces petroleum use by 91 percent in 2045 from 2022 levels. On balance, the Proposed Scenario is more feasible than the two 2035 scenarios due to the longer time frame for clean technology and fuel deployment. The additional 10 years for achieving carbon neutrality also allow for technologies to scale and be deployed at lower costs. The Proposed Scenario provides significant health benefits in 2045 compared to the Reference scenario and has the least slowing effect on employment and economic growth of all the scenarios considered.

For the first time, the Draft Scoping Plan includes modeling and quantification of GHG emissions and carbon sequestration in natural and working lands (NWLs). To date, the focus has been on reducing the emissions of GHGs from our transportation, energy, and industrial sectors. The state's 2020 and 2030 GHG reductions targets only include these sources. The Draft 2022 Scoping Plan, through the lens of carbon neutrality, expands the scope to more meaningfully consider how our NWL contribute to our long-term climate goal. For the first time, new and cutting-edge modeling tools allow us to estimate the quantitative ability of our forests and other landscapes to remove and store carbon under different scenarios. These cutting-edge tools were developed through a stakeholder process and in coordination with other agencies for the purpose of this update and will continue to be refined over time and made available to others seeking to do similar work.

Development of this Scoping Plan update also includes careful consideration of, and coordination with, other state agencies, consistent with Governor Gavin Newsom's whole of government approach to tackling climate change. State agency plans and regulations, including

the SB 100 Joint Agency Report,[9] State Implementation Plan, Climate Action Plan for Transportation Infrastructure,[10] AB 74 Studies on Vehicle Emissions and Fuel Demand and Supply,[11,12,13] Short-Lived Climate Pollutant Strategy (SLCP Strategy),[14] CARB's Achieving Carbon Neutrality Report,[15] Climate Smart Lands Strategy,[16] and Natural Working Land Implementation Plan,[17] among others, provided critical inputs and data points for this plan. The Draft 2022 Scoping Plan is the product of work by multiple agencies across the Administration, including dozens of public workshops and years of rigorous analysis and economic modeling by California's leading institutions.

This cooperation on the planning and development side lays the foundation for even closer coordination among and between state agencies to put the plan, once finalized, into effect.

The plan is also the product of tireless efforts of, and recommendations from, the AB 32 Environmental Justice Advisory Committee (EJAC). The EJAC, created by statute, plays a critical role to inform the development of each Scoping Plan and helps ensure environmental justice is integrated throughout the plan. CARB reconvened the EJAC in early 2021 to advise on the development of the 2022 Scoping Plan. In their advisory role, the EJAC has worked together to provide inputs to CARB to inform the development of scenarios and the associated modeling. And in April 2022, the EJAC provided draft preliminary recommendations in advance of the Draft 2022 Scoping Plan to help ensure the draft plan meaningfully addresses environmental justice. About five dozen of the recommendations provided by the Environmental Justice Advisory Committee are referenced in the Draft 2022 Scoping Plan.

Going forward as this plan is revised and ultimately acted on by the Board, ongoing collaboration with the EJAC will be essential to address environmental justice and achieve the ambitious vision outlined in the plan throughout its implementation in the coming years.

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[9] CPUC, CEC, and CARB. 2021. *SB 100 Joint Agency Report.* https://www.energy.ca.gov/sb100.
[10] CalSTA. 2021. Climate Action Plan for Transportation Infrastructure. https://calsta.ca.gov/subject-areas/climate-action-plan.
[11] CalEPA. 2021. Carbon Neutrality Studies. https://calepa.ca.gov/climate/carbon-neutrality-studies/.
[12] Brown, A. L., et. al. 2021. Driving California's Transportation Emissions to Zero. University of California Institute of Transportation Studies. https://escholarship.org/uc/item/3np3p2t0.
[13] Deschenes, O. 2021. Enhancing equity while eliminating emissions in California's supply of transportation fuels. University of California Santa Barbara. https://zenodo.org/record/4707966#.YKPiaKhKi73.
[14] CARB. Short-Lived Climate Pollutants. https://ww2.arb.ca.gov/our-work/programs/slcp.
[15] Energy and Environmental Economics, Inc. 2020. Achieving Carbon Neutrality in California. https://ww2.arb.ca.gov/sites/default/files/2020-10/e3_cn_final_report_oct2020_0.pdf.
[16] CNRA. 2021. Draft Climate Smart Lands Strategy. https://resources.ca.gov/Initiatives/Expanding-Nature-Based-Solutions.
[17] CARB. 2019. Draft California 2030 Natural and Working Lands Climate Change Implementation Plan. https://ww2.arb.ca.gov/resources/documents/nwl-implementation-draft.

Ensure Equity and Affordability

The state has a long history of public health and environmental protection. However racist and discriminatory practices such as redlining have resulted in low-income and communities of color being disproportionately located near and exposed to health hazards and pollution burdens.[18] The Draft 2022 Scoping Plan starts—and ends—with a focus on communities that continue to be burdened by air pollution and will be hardest hit by the impact of climate change and rising temperatures. These communities—primarily low-income and communities of color—are often located adjacent to major roadways and large stationary sources that not only emit GHGs, but also harmful local air pollution. The plan delivers on the promise to transform the way we move, live, and work by moving us away from a dependence on fossil fuels. It includes effective actions to move with all possible speed to clean energy, zero-emission cars and trucks, energy efficient homes, sustainable agriculture, and resilient forests that can effectively store more carbon and help us achieve carbon neutrality. And it prioritizes working with the communities most impacted to ensure that these strategies address the needs of the communities.

An important part of our equity consideration is ensuring the transition to a zero-emission economy is an affordable one and does not further disadvantage low-income communities and communities of color. Some aspects of the transition will have associated costs (e.g., escalating efforts to retrofit existing homes and businesses to support electric appliances and vehicles). The state must ensure that these costs do not disproportionately burden consumers. In addition, the state has an important role to play in providing financial incentives, especially to low-income consumers, to allow for uptake of clean technologies. The Department of Community Services and Development's Low Income Weatherization Program is a prime example of this approach, enabling low-income Californians to be part of the zero emission transition, all while lowering energy bills. The program provides low-income households with solar PV systems and energy efficiency upgrades at no cost to residents.

Energy and Technology Transitions

To support the transformation needed, we must build the clean energy production and distribution infrastructure for a carbon-neutral future. The solution will have to include transitioning existing energy production and transmission infrastructure to produce zero-carbon electricity and hydrogen, and utilizing biogas resulting from wildfire management or landfill and dairy operations, among other substitutes. In almost all sectors, electrification will play an important role. That means that the grid will need to grow at unprecedented rates and ensure

[18] CalEPA. August 16, 2021. Pollution and Prejudice. *https://storymaps.arcgis.com/stories/f167b251809c43778a2f9f040f43d2f5.*

reliability and resiliency through the next two decades and beyond. It also means we need to keep all options on the table, as it will take time to fully grow the electricity grid to be the backbone for a decarbonized economy. We also know that electrification is not possible in all situations. As such, this plan systematically evaluates and identifies feasible clean energy and technology options that will not just bring near-term air quality benefits, but also deliver on longer-term climate goals. This transition will not happen overnight. It will take time and planning to ensure a smooth transition. And while this Draft 2022 Scoping Plan has the longest planning horizon of any Scoping Plan to date, this 25-year horizon is still relatively short in terms of transforming the economy. We must avoid making choices that will lead to stranded assets and incorporate new technologies that emerge over time. Importantly, given the pace at which we must transition away from fossil fuels, we absolutely must identify and address market and implementation barriers to be successful.

As we transition our energy systems, we must also rapidly deploy the clean technologies that rely on clean energy. As called for in Executive Order N-79-20, all new passenger vehicles sold in California will be zero-emission by 2035, and the sales of all other fleets will be as close to zero-emission as possible by 2045. This means the percentage of fossil fuel combustion vehicles will continue to rapidly decrease, becoming a fading vision of the past. Successful implementation of this EO and other zero emission priorities will have to be attractive to consumers. As an example, electric and hydrogen transportation refueling must be as accessible as today's corner gas stations, and active transportation including clean transit options must be cheaper and more convenient than driving.

Cost-Effective Solutions Available Today

Ultimately, to achieve our climate goals, urgent and complete efforts are needed to slash GHG emissions. Fortunately, cost-effective solutions are available to do so in many cases. In short, this plan relies on existing technologies—it does not require major technological breakthroughs that are highly uncertain.

Targeted action to reduce methane emissions can be achieved at low or negative cost, and with significant near-term climate and public health benefits. In many cases, renewable energy and energy storage are cheaper than polluting alternatives,[19] and are already firmly part of our business as usual. For example, modeling related to the most recent integrated resource planning process at the CPUC showed that scenarios associated with the best emissions outcomes had the lowest average rates. As another example, research from Energy Innovation

[19] Neff, B. 2019. *Estimated Cost of New Utility-Scale Generation in California: 2018 Update.* California Energy Commission. May. https://www.energy.ca.gov/publications/2019/estimated-cost-new-utility-scale-generation-california-2018-update.

shows that the U.S. can achieve 100 percent zero carbon power by 2035 without increasing customer costs.[20]

The same is either already true, or soon to be true, for zero emission vehicles as well. Myriad studies show cost parity for light-duty and heavy-duty ZEVs being achieved by mid-decade or shortly thereafter. A carbon neutrality study conducted by the University of California (UC) Institute of Transportation Studies and funded by CalEPA shows that achieving carbon neutrality in the transportation sector will *save* Californians $167 billion through 2045.[21] Similar research out of the Goldman School of Public Policy at UC Berkeley finds that achieving 100 percent light-duty ZEV sales nationwide would save consumers $2.7 trillion through 2050, equivalent to $1,000 per household, per year, for 30 years.[22]

Many of these outcomes are a direct result of California's vision and policy development to advance clean energy and climate solutions, including through the Renewable Portfolio Standard, Advanced Clean Cars regulations, SLCP Reduction Strategy, and others. While we have not yet fully deployed clean energy and climate solutions at the scale needed to reduce costs and adequately address climate change, we have made tremendous progress—even since the last Scoping Plan update. Continued ambition, leadership, and climate policy development from California will help to achieve the scale of emissions reductions needed from technologies and strategies that are already cost-effective or close to it today, and will move additional technologies and strategies to that point in the near future. Achieving those outcomes and reducing costs for the entire array of climate solutions needed to achieve carbon neutrality and then maintain net-negative emissions will prove the true measure of California's success. This will enable California to not just meet our own climate targets, but to ultimately develop the replicable solutions that can scale globally to solve global warming.

Continue with a Portfolio Approach

Over the past decade and a half, the state has undertaken a successful three-pronged approach to reducing GHGs: incentives, regulations, and carbon pricing. The 2017 Scoping Plan update leveraged existing programs such as the Renewable Portfolio Standard, Advanced Clean Cars, Low Carbon Fuel Standard, Short-lived Climate Pollutant Strategy, mobile source measures to

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[20] Phadke, A. et al. 2020. "Illustrative Pathways to 100 Percent Zero Carbon Power by 2035 Without Increasing Customer Costs, Energy Innovation." September. https://energyinnovation.org/wp-content/uploads/2020/09/Pathways-to-100-Zero-Carbon-Power-by-2035-Without-Increasing-Customer-Costs.pdf.

[21] Brown, A. L., D. Sperling, D. Austin, J. R. DeShazo, L. Fulton, T. Lipman, et al. 2021. *Driving California's Transportation Emissions to Zero.* UC Office of the President: University of California Institute of Transportation Studies. http://dx.doi.org/10.7922/G2MC8X9X. Retrieved from https://escholarship.org/uc/item/3np3p2t0.

[22] Goldman School of Public Policy. 2021. *2035: The Report: Transportation.* UC Berkeley. April. https://www.2035report.com/transportation/.

achieve federal air quality targets, and a Cap-and-Trade Program, among others, to lay out a technologically feasible and cost-effective path to achieve the 2030 GHG reduction target. When looking toward the mid-century goal and the deeper GHG reductions needed across the AB 32 GHG Inventory sectors, all of the existing programs must be evaluated and, as necessary, strengthened to support the rapid production and deployment of clean technology and energy, as well as the increased pace and scale of actions on our natural and working lands. The challenge before us requires us to keep all tools on the table. Given the climate mitigation co-benefits, critical actions to deliver near-term air quality benefits, such as those included in the draft State Implementation Plan to achieve the federal air quality standards, are incorporated into this Scoping Plan update,[23] as are new legislative mandates to decarbonize the electricity and cement sectors. And, if additional gaps are identified, new programs and policies must be developed and implemented to ensure all sectors are on track to reduce emissions. Opportunities to leverage these programs to address ongoing air quality disparities must also be considered, along with targeted environmental justice policies such as the AB 617 Community Air Protection Program and the investments made possible through the California Climate Investments Program.

Conclusion

California has never undertaken as comprehensive, far reaching, and transformative an approach to fighting climate change as this plan. Once finalized, it will place every aspect of how we work, play, and travel in California on a more sustainable footing, with a focus on directly benefitting those communities already most burdened by pollution from the use of fossil fuels. This comprehensive approach reflects how climate change is already changing life in California. We have all experienced the impacts of devastating wildfires, and we read daily about the effects that severe drought conditions have on cities and agriculture. Despite much progress, California still has the worst air pollution in the nation, especially in the San Joaquin Valley and the Los Angeles Basin, which is driven by the continued use of fossil fuel powered trucks and cars. Temperatures are rising, with highs shattering records statewide and communities already hit hard by pollution also suffering from extended heat storms.

This Scoping Plan, once finalized, provides a solution; a way forward and a vision of a California where we can and will address those impacts. This plan is fundamentally based on hope. It is a hope grounded in experience and science that we can fundamentally improve the California we leave to our children. The plan is built on the legacy of effective actions and on the conviction that we can effectively marshal the combined capabilities of California—from state, regional,

[23] CARB. 2022. 2022 State Strategy for the State Implementation Plan (2022 State SIP Strategy). *https://ww2.arb.ca.gov/resources/documents/2022-state-strategy-state-implementation-plan-2022-state-sip-strategy*.

tribal, and local government to industry to our research institutions, and most importantly, to the 40 million Californians who will benefit from the actions laid out in the plan. It addresses the challenge of our generation by laying out a pathway and guideposts for action across three decades. But the Scoping Plan is only that: a plan. After it is finalized comes the hard work—and hopeful work—of putting its recommendations into action. And there is no time to waste.

Post-adoption of the Final 2022 Scoping Plan

The finalizing of the Draft 2022 Scoping Plan is expected by year's end. As with previous Scoping Plans, CARB Board approval is the beginning of the next phase of climate action. Specifically, approval of the plan catalyzes a number of efforts, including the development of new regulations as well as amendments to strengthen regulations and programs already in place; not just at CARB but across state agencies. The unprecedented rate of transition will also require identification and removal of market and implementation barriers to the production and deployment of clean technology and energy. All of these actions and more will be needed if we are to achieve 2030 target, as well climate neutrality, by 2045 or earlier.

Chapter 1: Introduction

"The debate is over around climate change. Just come to the state of California. Observe it with your own eyes."

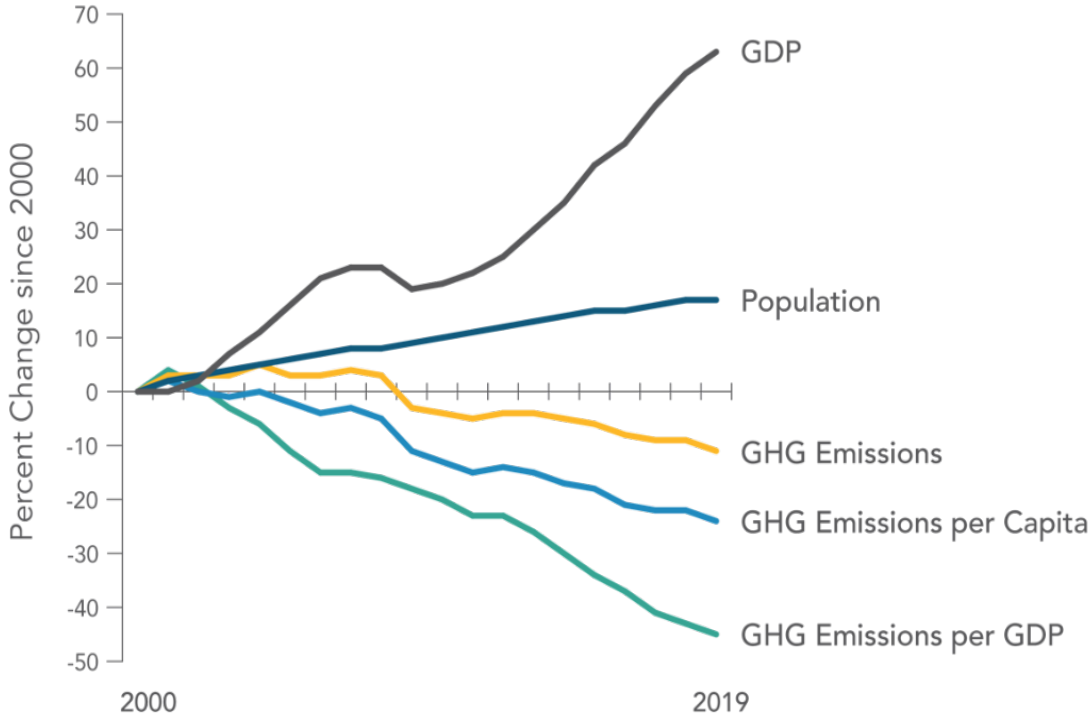
- California Governor Gavin Newsom in September 2020 after surveying the devastation caused by catastrophic wildfires

Just as the evidence of its adverse impacts across the globe is irrefutable, climate change is fundamentally altering California. It is no longer a distant threat that lies somewhere beyond the horizon. It is right here, right now, with growing intensity that is already adversely affecting our communities and our environment. The science that, decades ago, predicted the impacts we are currently experiencing is even stronger today and unambiguously tells us we must act with an elevated commitment and focus to do more and do it sooner to limit irreversible damage. That science is indisputable. Unless we double down on our efforts, we will be faced with more fire, more drought, more temperature extremes and deadly, choking air pollution. The future of our state—our communities, economy, and ecosystems—is inextricably tied to the way we respond in this decade and the partnerships we forge along the way.

The impacts of climate change fall most heavily on vulnerable communities that bear the brunt of extreme heat, drought, wildfires, and other effects. In addition, data show that disadvantaged and low-income communities are also disproportionately impacted by fossil fuel combustion-related air pollution and related health problems. The continued phaseout of fossil fuels will deliver the greatest health benefits to these disadvantaged communities.

As it has responded to these challenges, California has established itself as a global leader in science-based, public health focused climate change mitigation and air quality control. The California Legislature has worked with both Republican and Democratic governors to advance action on public health and environmental protections—and California has made progress on addressing climate change during periods of both Republican and Democratic federal administrations. Since the passage of Assembly Bill 32 (AB 32) (Núñez and Pavley, Chapter 488, Statutes of 2006), California has developed bold, creative, and durable policy solutions to protect our environment and public health, all while growing our economy. In fact, California met the target established in AB 32—a return of greenhouse gas (GHG) emissions to 1990 levels by 2020—in 2016, four years ahead of schedule, even as the state established itself as the sixth largest economy in the world. As Figure 1-1 below shows, California's emissions and economic growth have continued to decouple, and California is now the fifth largest economy in the world.

Figure 1-1: California total and per capita GHG emissions



Recognizing both California's early successes in achieving GHG emissions reductions while growing the economy, as well as the worsening impacts of climate change, our governors and legislators have continued to enact ambitious goals. California's unwavering commitment to address climate change is based on indisputable science and data. This commitment is also informed by our collective efforts to address environmental justice and advance racial equity, so race is no longer a predictor for low-income communities and communities of color to be disproportionately burdened by the impacts of pollution, as shown in the Office of Environmental Health Hazard Assessment's (OEHHA's) recent analysis of race/ethnicity and CalEnviroScreen 4.0 scores.[24]

Many of California's environmental policies have also served as models for similar policies in other U.S. states, and at national and international levels. Moving forward, California will

[24] OEHHA and CalEPA. 2021. Analysis of Race/Ethnicity and CalEnviroScreen 4.0 Scores. https://oehha.ca.gov/media/downloads/calenviroscreen/document/calenviroscreen40raceanalysisf2021.pdf.

continue its pursuit of collaborations and advocacy for action to address climate change at all levels of government. While California is responsible for just one percent of global GHG emissions, we play an important role in exporting both political will and technical solutions to address the climate crisis globally.

Today, we have a chance to re-envision California's future and set the state on a path to be carbon free by 2045 while advancing equity. The Scoping Plan provides a roadmap outlining key policies we can implement to achieve our climate goals while improving the health and welfare of Californians and addressing disparities in health outcomes to create a more equitable future. It will enable us to turn the corner in our efforts to protect and preserve our critical natural and public resources, all while providing unparalleled opportunities for clean, pollution-free economic growth.

Severity of Climate Change Impacts

With increasing severity and frequency of drought, wildfire, extreme heat, and other impacts, Californians just have to look out their windows to know that climate change is real and rapidly getting worse. The impacts we thought we would see in the decades to come are happening now. We must act decisively to both reduce our GHG emissions and build resilience to these impacts for ourselves, future generations and our iconic landscapes.

Wildfires

Of the twenty largest wildfires ever recorded in California, nine of them occurred in 2020 and 2021. 2020 was the worst wildfire season in California's recorded history, with air pollution in our lungs, more than 4.3 million acres burned, over 11,000 structures damaged or destroyed, and over 112 million metric tons of carbon dioxide (CO_2) emitted into the atmosphere.[25] The economic damage of these fires was estimated to be over $10 billion in property damage and over $2 billion in fire suppression costs.[26] But 2020 was not an anomaly. The Camp Fire, which destroyed much of Paradise, California, was the world's costliest natural disaster in 2018, with overall damages of $16.5 billion.[27] It was also the deadliest fire in California history, with 85

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[25] CARB. 2020. Public Comment Draft Greenhouse Gas Emissions of Contemporary Wildfire, Prescribed Fire, and Forest Management Activities. *https://ww3.arb.ca.gov/cc/inventory/pubs/ca_ghg_wildfire_forestmanagement.pdf*.

[26] News18. 2021. San Francisco Bay Area Receives its First Wildfire Warning of 2021, After California Concludes its Driest Year. https://www.news18.com/news/buzz/san-francisco-bay-area-receives-its-first-wildfire-warning-of-2021-after-california-concludes-its-driest-year-3722897.html.

[27] Munich RE. 2019. Extreme Storms, Wildfires and Droughts Cause Heavy Nat Cat Losses In 2018. *https://www.munichre.com/en/company/media-relations/media-information-and-corporate-news/media-information/2019/2019-01-08-extreme-storms-wildfires-and-droughts-cause-heavy-nat-cat-losses-in-2018.html#-1808457171*.

civilian fatalities. However, wildfire damages have not been limited to just human health and the economy. The Castle Fire in 2020 and the KNP Complex and Windy Fires in 2021 led to the loss of an unprecedented number of giant sequoias: an estimated 13 to 19 percent of the large sequoia population in the Sierra Nevada. An iconic species, giant sequoias are the most massive trees on earth, with exceptional longevity outside of climate extremes.[28,29]

The impacts of wildfires to human health cannot be overstated. Wildfire smoke has been linked to negative health impacts, including respiratory infections, cardiac arrests, low birth weight, mental health conditions, and exacerbated asthma and chronic obstructive pulmonary disease.[30] In 2020, with all of California covered by wildfire smoke for over 45 days—and 36 counties for at least 90 days—maximum fine particulate ($PM_{2.5}$) levels persisted in the "hazardous" range of the Air Quality Index for weeks in several areas of the state.[31,32]

Drought

More than 37 million Californians are affected by drought. As of March 2022, 87 percent of California was in severe drought, and 100 percent of the state was in at least moderate drought. The first two months of 2022 were the driest January and February in California history. The harsh drought conditions affecting California are part of a larger megadrought—a drought lasting more than two decades—that has been ongoing in the southwestern region of North America since 2000. The past 22 years have been the region's driest period since at least 800 CE. Although the current drought would exist even without climate change, anthropogenic climate trends have exacerbated drought conditions. Human-caused climate change accounts for 19 percent of drought severity and 42 percent of the soil moisture deficit in this region since 2000.[33]

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[28] Shive, K., C. Brigham, T. Caprio, and P. Hardwick. 2021. 2021 Fire Season Impacts to Giant Sequoias. The Nature Conservancy, Na*tional Park Service.* https://www.nps.gov/articles/000/2021-fire-season-impacts-to-giant-sequoias.htm.

[29] Shive, K. L., A. Wuenschel, L. J. Hardlund, S. Morris, M. D. Meyer, and S. M. Hood. 2022. "Ancient Trees and Modern Wildfires: Declining Resilience to Wildfire in the Highly Fire-adapted Giant Sequoia." *Forest Ecology and Management* Volume 511, 120110. https://doi.org/10.1016/j.foreco.2022.120110.

[30] Reid, C. E., M. Brauer, F. H. Johnston, M. Jerrett, J. R. Balmes, and C. T. Elliott. 2016. "Critical Review of Health Impacts of Wildfire Smoke Exposure." *Environmental Health Perspectives* http://dx.doi.org/10.1289/ehp.1409277.

[31] Vargo J.A. 2020 (updated in 2021 using NOAA HMS). "Time Series of Potential US Wildland Fire Smoke Exposures." *Frontiers in Public Health* https://doi.org/10.3389/fpubh.2020.00126.

[32] CalFire. 2020 *Fire Siege Report.* https://www.fire.ca.gov/media/hsviuuv3/cal-fire-2020-fire-siege.pdf.

[33] Williams, A. P., B. I. Cook, and J. E. Smerdon. 2022. "Rapid Intensification of The Emerging Southwestern North American Megadrought in 2020–2021." *Nature Climate Change* https://doi.org/10.1038/s41558-022-01290-z.

California agriculture is responsible for more than half of all domestic fruit and vegetable production, and in 2021, drought resulted in fallowing nearly 400,000 acres of fields.[34] Direct crop revenue losses were approximately $962 million, and total economic impacts were over $1.7 billion, with over 14,000 full and part-time job losses.[35] During the 2011–2017 drought, California's agricultural industry suffered $5 billion or more in losses.[36]

In addition to its effects on agriculture, drought also has adverse effects on California wildlife. Thousands of Chinook salmon were found washed up on riverbanks in Northern California, due largely to drought and extreme heat, making 2021 one of the worst years on record for winter-run salmon survival. Other impacts of severe drought include water shortages and restrictions. Some projections estimate that the severity of widespread summer drought will nearly triple in California by 2050.

Extreme Heat

2021 was California's hottest summer on record.[37] Death Valley recorded the world's highest reliably measured temperature (130°F) in July 2021, breaking its own record (129°F) from summer 2020.[38] Meanwhile, Fresno also broke its own record, with 64 days over 100°F in 2021.[39] This is part of a trend: the daily maximum average temperature, an indicator of extreme temperature shifts, is expected to rise 4.4°F–5.8°F by 2050 and 5.6°F–8.8°F by 2100.[40] Heat waves that result in public health impacts are also projected to worsen throughout the state. By 2050, these heat-related health events are projected to last two weeks longer in the Central Valley and occur four to ten times more often in the Northern Sierra region.[41]

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[34] Medellín-Azuara, J. 2022. *Economic Impacts of the 2021 Drought on California Agriculture.* University of California Merced. *https://wsm.ucmerced.edu/wp-content/uploads/2022/02/2021-Drought-Impact-Assessment_20210224.pdf.*

[35] Ibid.

[36] NRDC. 2019. Climate Change and Health in California. Issue Brief. *https://www.nrdc.org/sites/default/files/climate-change-health-impacts-california-ib.pdf.*

[37] NOAA. 2022. Climate at a Glance. *https://www.ncdc.noaa.gov/cag/statewide/time-series/4/tavg/3/8/1895-2021?base_prd=true&firstbaseyear=1901&lastbaseyear=2000.*

[38] Masters, J. 2021. Death Valley, California, breaks the all-time world heat record for the second year in a row. Yale Climate Connections. *https://yaleclimateconnections.org/2021/07/death-valley-california-breaks-the-all-time-world-heat-record-for-the-second-year-in-a-row/.*

[39] NOAA. Accessed on 16 March 2022. Climate Data Online Search. https://www.ncdc.noaa.gov/cdo-web/search.

[40] OPR, CEC, and CNRA. 2018. *California's Fourth Climate Change Assessment*. Page 23. *https://www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-013_Statewide_Summary_Report_ADA.pdf.*

[41] OPR, CEC, and CNRA. *California's Fourth Climate Change Assessment - Statewide Summary Report.* *https://www.energy.ca.gov/sites/default/files/2019-11/Statewide_Reports-SUM-CCCA4-2018-013_Statewide_Summary_Report_ADA.pdf.*

Heat ranks among the deadliest of all climate hazards in California, and heat waves in cities are projected to cause two to three times more heat-related deaths by mid-century.[42] Climate vulnerable communities will experience the worst of these effects, as heat risk is associated and correlated with physical, social, political, and economic factors. Aging populations, infants and children, pregnant people, and people with chronic illness are especially sensitive to heat exposure.[43,44] Combining these characteristics and existing health inequities with additional factors such as poverty, linguistic isolation, housing insecurity, and the legacy of racist redlining practices, can put individuals at a disproportionately high risk of heat-related illness and death.[45,46] Rising temperatures will also speed smog-forming chemical reactions, leading to worse asthma, reduced lung function, cardiac arrest, and cognitive decline. African-American, American Indian/Alaskan Native, and Puerto Rican Californians are particularly sensitive to smog because they are between 28.6 and 132.5 percent more likely to be diagnosed with asthma than white Californians.[47]

Wildfires, drought, and extreme heat are some of the most pronounced climate impacts California is experiencing, but they are not the only ones. Sea level rise, rising ocean temperatures, ocean acidification, and inland flooding are also already having devastating impacts on our communities, ecosystems, and economy, and will continue to do so in the years and decades to come.

Imperative To Act

Consequences of Further Warming

The Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report found that the global warming threshold of 1.5°C to avoid the most severe impacts of climate change will not be possible unless we make immediate and large-scale reductions in GHG emissions. It

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[42] Ostro, B., S. Rauch, and S. Green. 2011. "Quantifying the health impacts of future changes in temperature in California."
National Library of Medicine. *https://pubmed.ncbi.nlm.nih.gov/21975126/.*
[43] Basu, R. 2009. "High Ambient Temperature and Mortality: A Review of Epidemiologic Studies from 2001 to 2008." National Library of Medicine. *https://pubmed.ncbi.nlm.nih.gov/19758453/.*
[44] Basu, R., and B. Malig. 2011. "High Ambient Temperature and Mortality in California: Exploring the Roles of Age, Disease, and Mortality Displacement." National Library of Medicine.
https://pubmed.ncbi.nlm.nih.gov/21981982/.
[45] Hoffman, J. S., V. Shandas, and N. Pendleton. 2020. "The Effects of Historical Housing Policies on Resident Exposure to Intra-Urban Heat: A Study of 108 US Urban Areas." MDPI. *https://www.mdpi.com/2225-1154/8/1/12/htm*.
[46] U.S. Climate Resilience Toolkit. No date. Heat and Social Inequity in the United States.
https://toolkit.climate.gov/tool/heat-and-social-inequity-united-states.
[47] NRDC. 2019. Climate Change and Health in California. Issue Brief.
https://www.nrdc.org/sites/default/files/climate-change-health-impacts-california-ib.pdf.

finds that atmospheric concentrations of CO_2 have increased by 50 percent since the industrial revolution, and that they continue to increase at a rate of two parts per million each year.[48] By the 2030s, and no later than 2040, the world will exceed 1.5°C warming.

While every tenth of a degree matters—every incremental increase in warming brings additional negative impacts—climate-related risks to human health, livelihoods, and biodiversity are projected to increase further under 2°C warming, compared to 1.5°C.[49] To remain below 1.5°C with limited or no overshoot of that threshold, global net anthropogenic CO_2 emissions need to be about cut in half by 2030 and reach net-zero by 2050.

If we fail to make rapid changes, we may not be able to limit global warming to 2°C,[50] and the consequences of inaction would be catastrophic. Californians with the fewest resources, who are disproportionately low-income communities and communities of color, would be most vulnerable to the impacts of climate change. Any delays in action or insufficient action are an assault on public health and the environment. While the human costs associated with health impacts can never be fully monetized, a recent report finds that the health costs of climate and air pollution in the U.S. are well over $800 billion today and will continue to grow in the coming years.[51]

The impacts to our economy would be devastating as well. While not specific to California, a 2022 report from Deloitte Economics Institute finds that failing to take sufficient action to reduce emissions could result in economic losses to the U.S. of upwards of $14.5 trillion over the next 50 years.[52] On a hopeful note, however, the report finds that if the country invests now and in the coming years in a net-zero economy, $3 trillion could be added to the economy over the next

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[48] IPCC. 2021. *Climate Change 2021: The Physical Science Basis.* Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

[49] IPCC. 2018. *Special Report: Global Warming of 1.5°C.* World Meteorological Organization. *https://www.ipcc.ch/sr15/*.

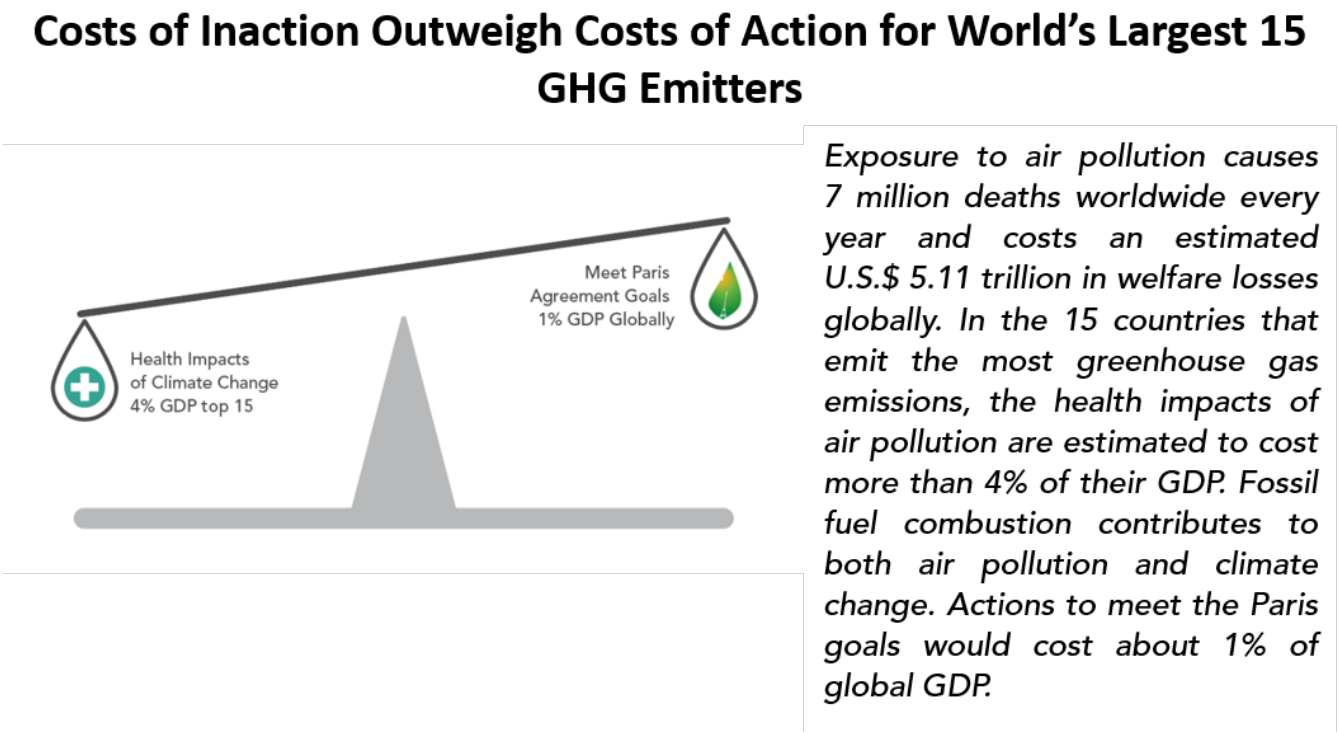
[50] IPCC. 2021. Summary for Policymakers. In: *Climate Change 2021: The Physical Science Basis.* Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. In Press. https://www.ipcc.ch/report/ar6/wg1/downloads/report/IPCC_AR6_WGI_SPM_final.pdf.

[51] Alwis, D. D. and V. S. Limaye. No date. *The Costs of Inaction: The Economic Burden of Fossil Fuels and Climate Change on Health in the United States.* NRDC, The Medical Society Consortium on Climate and Health, and WHPCA. *https://www.nrdc.org/sites/default/files/costs-inaction-burden-health-report.pdf.*

[52] Deloitte. 2022. *The Turning Point: A New Economic Climate in the United States. https://www2.deloitte.com/content/dam/Deloitte/us/Documents/about-deloitte/us-the-turning-point-a-new-economic-climate-in-the-united-states-january-2022.pdf?id=us:2el:3dp:wsjspon:awa:WSJSBJ:2021:WSJFY22.*

50 years. U.S. annual gross domestic product (GDP) would be 2.5 percent higher in 2070 in this fast action scenario than in the delayed action one. The lessons for California from these analyses are clear: invest now or pay the price later. As shown in Figure 1-2, inaction can lead to negative consequences for individuals, communities, the economy, and society as a whole.

Figure 1-2: The real costs of inaction[53]



Scoping Plan Overview

Previous Scoping Plans

The Scoping Plan is a strategy the California Air Resources Board (CARB) develops and updates every five years, as required by AB 32. It lays out the transformations needed across our society and economy to reduce emissions and reach our climate targets. The 2022 Scoping Plan update is the third update to the original plan that was adopted in 2008. The initial Scoping Plan laid out a path to achieve the AB 32 2020 limit of returning to 1990 levels of GHG emissions,

[53] Katowice, P. 2018. *Health benefits far outweigh the costs of meeting climate change goals.* WHO. https://www.who.int/news/item/05-12-2018-health-benefits-far-outweigh-the-costs-of-meeting-climate-change-goals.

a reduction of approximately 15 percent below business as usual.[54] The 2008 plan included a mix of incentives, regulations, and carbon pricing, laying out the portfolio approach to addressing climate change and clearly signaling the need and case for multiple tools for meeting California's GHG targets. The 2013 Scoping Plan update assessed progress toward achieving the 2020 limit and made the case for addressing short-lived climate pollutants (SLCPs).[55] The most recent update, the 2017 Scoping Plan update (2017 Scoping Plan),[56] also assessed the progress toward achieving the 2020 limit and provided a technologically feasible and cost-effective path to achieving the Senate Bill 32 (SB 32, Pavley, Chapter 249, Statutes of 2016) target of reducing GHGs by at least 40 percent below 1990 levels by 2030.

Overview of the 2022 Scoping Plan

In developing the Draft 2022 Scoping Plan, it is paramount that we continue to build on California's success by taking effective actions and doubling down on implementation activities. As such, this Scoping Plan builds on and integrates efforts already underway to reduce the state's GHG, criteria pollutant, and toxic air contaminant emissions by identifying the clean technologies and fuels that should be phased in as the state transitions away from combustion of fossil fuels. By selecting and pursuing a sustainable and clean economy path, the state will continue to successfully execute existing programs, work to eliminate air pollution inequities, demonstrate the coupling of economic growth and environmental progress, and enhance new opportunities for engagement within the state to address and prepare for climate change.

This Draft Scoping Plan for Achieving Carbon Neutrality (Draft 2022 Scoping Plan or 2022 Scoping Plan) is the most comprehensive and far-reaching Scoping Plan developed to date. It identifies a technologically feasible and cost-effective path to achieve carbon neutrality by 2045 while also assessing the progress California is making toward reducing its GHG emissions by at least 40 percent below 1990 levels by 2030, as called for in SB 32 and laid out in the 2017 Scoping Plan.[57] The 2030 target is an important but interim stepping stone along the critical path to the broader goal of deep decarbonization by 2045, as called for by the science. However, modeling for the Draft Scoping Plan shows that this decade must see transformation on a scale never seen before to set us up for success in 2045.

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[54] CARB. 2008. *Climate Change Scoping Plan.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/scopingplan/document/adopted_scoping_plan.pdf.
[55] CARB. 2014. *First Update to the Climate Change Scoping Plan.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf.
[56] CARB. 2017. *California's 2017 Climate Change Scoping Plan.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/scopingplan/scoping_plan_2017.pdf.
[57] CARB. 2017. *California's 2017 Climate Change Scoping Plan.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/scopingplan/scoping_plan_2017.pdf.

The relatively longer path assessed in the 2022 Scoping Plan incorporates, coordinates, and leverages many existing and ongoing efforts to reduce GHGs and air pollution, while identifying new clean technologies and energy. Given the focus on carbon neutrality, this Scoping Plan also includes discussion for the first time of the Natural and Working Lands (NWL) sectors as both sources of emissions and carbon sinks. Chapter 2 of this document includes a description of a suite of specific actions to drastically reduce GHGs across all sectors. Chapter 3 provides the air quality and economic evaluations of the proposed actions. In addition, Chapter 4 provides a broader description of the many actions needed across all sectors to achieve carbon neutrality. Guided by legislative direction, the actions identified in this Scoping Plan reduce overall GHG emissions in California and deliver policy signals that will continue to drive investment and certainty in a low carbon economy. This Scoping Plan builds upon the successful framework established by the Initial Scoping Plan and updates while identifying new, technologically feasible, and cost-effective strategies.

Principles That Inform Our Approach to Addressing the Climate Challenge

California has decades of experience addressing the climate challenge. Through this experience, and based on extensive engagement with stakeholders through our regulatory and program development processes, we've developed a set of principles to inform our approach.

Unprecedented Investments in a Sustainable Future

The scale of transformation needed over this decade to both avoid the worst impacts of climate change and meet our ambitious climate goals is extraordinary. This is why Governor Newsom and the Legislature invested over $15 billion in climate action through the 2021–2022 California Comeback Plan and the Governor has proposed investing over $22 billion through the 2022–2023 California Blueprint (Figure 1-3). Together, these budgets would represent investment of a historic scale. Creating these types of whole-of-society changes needed requires whole-of-government approaches, and that's precisely what the enacted 2021–2022 and proposed 2022–2023 climate budgets advance.

Figure 1-3: Comprehensive California climate change investments

Together, these budgets would result in the following game-changing climate investments:

- $10 billion for zero-emission vehicles (ZEVs), with a particular focus on programs that improve the communities of low-income Californians, such as heavy-duty and port electrification.

- $2 billion for clean energy investments, such as long duration storage and industrial decarbonization.
- Over $9 billion for programs that reduce emissions from the transportation sector, such as active transportation projects and high-speed rail.
- Nearly $1 billion to mainstream climate change in our education system and to train current and future workers to lead the climate revolution.
- Over $1 billion to build sustainable, affordable housing.

These investments are incredibly important in the context of the Draft 2022 Scoping Plan in that they accompany and help support implementation of the many regulations that will continue to be necessary to achieve our 2030 and carbon neutrality targets. In addition, these incentive programs jump-start emission reduction strategies for priority sectors, sources, and technologies, leveraging private-sector investment and building sustainable, growing markets for clean and efficient technologies. Many of California's incentive programs work in concert with federal and other state programs to drive emission reductions. As an example, as we push to end the tailpipe and the harmful emissions associated with it, this Administration continues to invest heavily in incentive programs that allow families, communities and businesses to choose zero-emission vehicles, all while working with the federal government, other states, and jurisdictions around the world to align policies, regulations, and incentives, creating market certainty for the automakers that serve our markets.

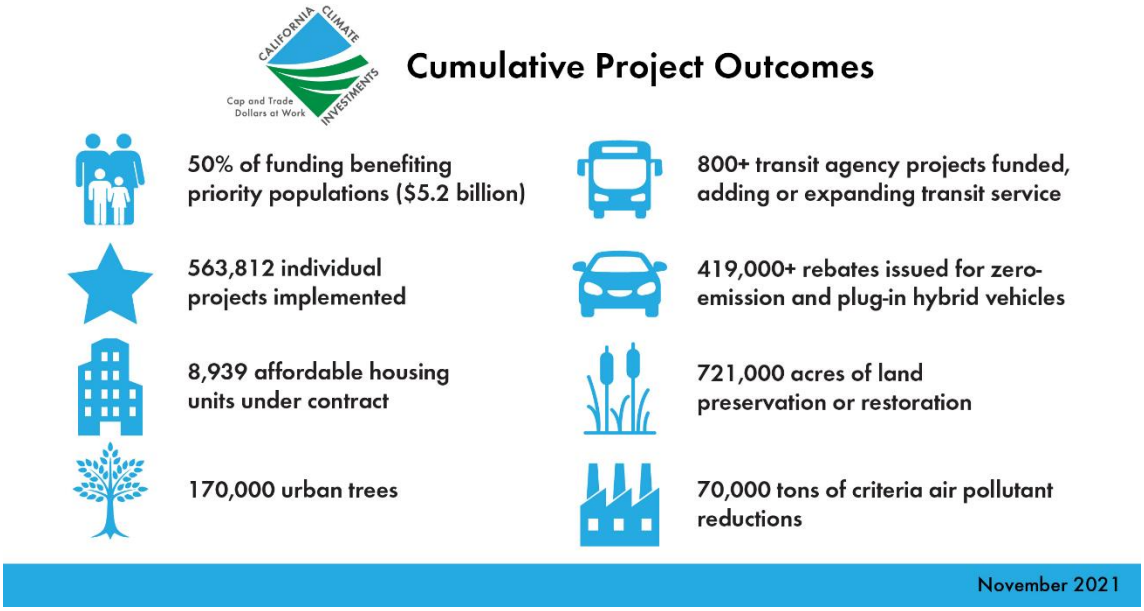
Centering Equity

Just as important as the magnitude of the climate investments California is making is the focus on equity. For California, addressing climate change and advancing our equity and economic opportunity goals cannot be decoupled. State climate and air regulations and plans should and do regularly include components specifically intended to reduce and eliminate air pollution disparities, remove barriers that can prevent frontline communities from accessing benefits, lower costs for low-income Californians, and promote high-quality jobs. CARB's incentive programs, for instance, treat statutory equity targets as a floor which they substantially exceed as they seek to extend access to clean transportation to all. California Climate Investments revenue is also invested with a strong equity focus. We can simultaneously confront the climate crisis and build a more resilient, just, and equitable future for all communities.

California is working to address these gaps through programs like the California Climate Investments, where over 50 percent of the revenues from the Cap-and-Trade Program are invested to provide benefits to disadvantaged and low-income communities (referred to as Priority Populations) (see Figure 1-4). SB 535 (De Leon, Chapter 830, Statutes of 2012) and AB 1550 (Gomez, Chapter 369, Statutes of 2016) direct state and local agencies to make significant investments using auction proceeds to assist California's most vulnerable communities. Under these laws, a minimum of 25 percent of the total investments are required to be located within

and provide benefits to disadvantaged communities and at least 10 percent of the total investments must benefit low-income communities and households. In mid-2022, approximately $5.1 billion of all implemented funds directly benefit California's priority populations, which include disadvantaged and low-income communities and low-income households statewide.

Figure 1-4: California climate investments cumulative outcomes[58,59]



Role of the Environmental Justice Advisory Committee

To inform the development of the Scoping Plan, AB 32 calls for the convening of an Environmental Justice Advisory Committee (EJ Advisory Committee) to advise the California Air Resources Board (Board) in developing the Scoping Plan, and any other pertinent matter in

[58] CARB. 2022. California Climate Investments program implements $10.5 billion in greenhouse gas-reducing programs, expected to reduce 76 million metric tons of emissions. https://ww2.arb.ca.gov/news/california-climate-investments-program-implements-105-billion-greenhouse-gas-reducing-projects.

[59] Per Senate Bill 535 (Chapter 830, Statutes of 2012) and (Chapter 369, Statutes of 2016), *direct investments* to disadvantaged communities and low-income communities and households, which are termed priority populations. *Disadvantaged communities* are currently defined by CalEPA as the top 25 percent of communities experiencing disproportionate amounts of pollution, environmental degradation, and socioeconomic and public health conditions according to the Office of Environmental Health Hazard Assessment's CalEnviroScreen *tool,* plus certain additional communities including federally recognized Tribal Lands. Low-income communities and households are defined by statute as those with incomes either at or below 80 percent of the statewide median or below a threshold designated as low-income by the Department of Housing and Community Development.

implementing AB 32. It requires that the Committee be comprised of representatives from communities in the state with the most significant exposure to air pollution, including, but not limited to, communities with minority populations or low-income populations, or both. On January 25, 2007, the Board appointed the first Environmental Justice Advisory Committee to advise it on the Initial Scoping Plan and other climate change programs.

For the 2022 Draft Scoping Plan update, CARB reconvened its EJ Advisory Committee in May 2021. The committee comprises 18 environmental justice and disadvantaged community representatives, including the EJ Advisory Committee's first tribal representative, who was appointed in February 2022. In October 2021, the EJ Advisory Committee formally created eight workgroups. These workgroups are a space for EJ Advisory Committee members to better understand specific sectors of the Scoping Plan and to assist the EJ Advisory Committee in the development of recommendations on the 2022 Scoping Plan. In December 2021, the EJ Advisory Committee provided scenario input responses to help shape the modeling for the 2022 Scoping Plan. In February 2022, San Joaquin Valley EJ Advisory Committee members hosted their first community workshop, with over 100 attendees. In March 2022, members of the Air Resources Board held a joint public meeting with the EJ Advisory Committee to discuss their draft preliminary recommendations for this Draft Scoping Plan. The full schedule of EJ Advisory Committee Meetings and meeting materials is available on CARB's website.[60] The Draft Scoping Plan includes references where EJ Advisory Committee recommendations are included in the document.

Maximizing Air Quality and Health Benefits

The state has over 50 years of experience successfully cleaning the air in California by addressing criteria pollutants and toxic air contaminants from mobile and stationary sources. CARB has been a leader in measuring, evaluating, and reducing sources of air pollution that impact public health. Its air pollution programs have been adapted for national programs and emulated in other countries. Significant progress has been made in reducing diesel particulate matter (PM), which is a designated toxic air contaminant, and many other hazardous air pollutants. CARB partners with local air districts to address stationary source emissions and adopts and implements state-level regulations to address sources of criteria and toxic air pollution, including mobile sources. CARB also collaborates with national agencies to address air pollution from sources not within its jurisdiction such as aviation and locomotives. In many instances, actions to reduce fossil fuel combustion and achieve federal air quality standards also help to reduce emissions of GHGs. However, air pollution disparities still exist and more must be done to ensure the most vulnerable populations have safe air to breathe. California must

[60] CARB. Environmental Justice Advisory Committee Meetings and Events. *https://ww2.arb.ca.gov/environmental-justice-advisory-committee-meetings-and-events*.

continue to evaluate opportunities to harmonize our climate and air quality programs through innovative policymaking, such as by working with electric utilities to opt-in and generate residential electric vehicle (EV) charging credits under the Low Carbon Fuel Standard, where some of the revenues are invested back into rebate programs that address air quality and climate pollution.[61] And the state's Community Air Protection Program[62] is the first of its kind in the country, with the focus to reduce the exposure in communities most impacted by air pollution.

This Scoping Plan update identifies actions that will deliver near-term air quality benefits to communities with the highest exposures and provide long-term GHG benefits. Many of the actions in the Draft Scoping Plan are key elements of the State Implementation Plan[63] which has a primary focus of reducing harmful air pollution and achieving federal air quality targets. California's approach to leverage air quality and GHG policies together has yielded results. A 2022 report by the Office of Environmental Health and Hazard Assessment (OEHHA)[64] that evaluated GHG and harmful air pollution emissions from the heavy-duty vehicle (HDV) and large stationary source sectors found declines in emissions in both sectors, with the greatest declines in disadvantaged communities. Both sectors are subject to state GHG and air quality policies, in addition to other federal and local rules on harmful air pollution. Because of racist and discriminatory practices such as redlining, both types of sources are disproportionately located adjacent to vulnerable communities, which are predominantly communities of color.[65] The key findings from the OEHHA report are as follows:

- Both HDVs and facilities subject to the Cap-and-Trade Program have reduced emissions of co-pollutants, with HDVs showing a clearer downward trend when compared to stationary sources. These emission reductions have major health benefits, including a reduction in premature pollution-related deaths.
- The greatest beneficiaries of reduced emissions from both HDVs and facilities subject to the Cap-and-Trade Program have been in communities of color and in disadvantaged communities in California, as identified by CalEnviroScreen (CES). This has reduced the

[61] CARB. LCFS Utility Rebate Programs. *https://ww2.arb.ca.gov/resources/documents/lcfs-utility-rebate-programs*.
[62] CARB. Community Air Protection Program. *https://ww2.arb.ca.gov/capp.*
[63] CARB. 2022 State Strategy for the State Implementation Plan. *https://ww2.arb.ca.gov/resources/documents/2022-state-strategy-state-implementation-plan-2022-state-sip-strategy*.
[64] OEHHA. 2022. Impacts of Greenhouse Gas Emission Limits within Disadvantaged Communities: Progress Toward Reducing Inequities. *https://oehha.ca.gov/environmental-justice/report/ab32-benefits*.
[65] CalEPA. 2021. Pollution and Prejudice: Redlining and Environmental Injustice in California. *https://storymaps.arcgis.com/stories/f167b251809c43778a2f9f040f43d2f5*.

emission gap between disadvantaged and wealthier communities, but a wide gap still remains.
- The transition to zero-emission HDVs will expedite further emissions reductions.
- While the progress observed is encouraging, inequities persist, and federal, state, and local climate and air quality programs must do more to reduce emissions of GHGs and co-pollutants to reduce the burden of emissions on disadvantaged communities and communities of color.

It will take all tools at all levels of government, with robust enforcement, to ensure vulnerable communities continue to see improvements in air quality until no disparities exist in air pollution across the state.

Economic Resilience

The state's efforts to tackle the climate crisis will create economic and workforce development opportunities in the clean energy economy in communities across the state. Transitioning of the existing skills and expanded workforce training opportunities in climate-related fields are critical for reducing harmful emissions in California's communities and will support workers transitioning to new, high-quality jobs. The Administration's recent and proposed budgets acknowledge the challenges facing workers in industries most affected by the state's response to climate change—especially those in the fossil fuel industry—and would invest $1 billion in regional partnerships, economic diversification to create new jobs and support a local tax base, workforce transition and development once opportunities are identified, and safety nets to protect and support impacted communities as part of the transition to a carbon neutral economy. The Governor's existing and proposed budget investments create the opportunity to future proof and increase economic resilience in the face of more frequent climate impacts and shifting economic conditions. For these investments and implementation of the Scoping Plan to be successful in supporting the transition to a carbon neutral economy, workers and affected communities must be included in ongoing dialogue to ensure a high-road transition for regional economies.

Partnering Across Government

The Scoping Plan is an actionable plan to identify and align actions to achieve California's climate targets. To realize the outcomes and deliver results in any Scoping Plan, action is critical. For this Draft Scoping Plan, there are also actions that require our federal partners to take action on sources under their jurisdiction (such as rail, aviation, and federally owned/managed lands), while continuing to develop national programs for GHG reductions. We also need our local partners to align on actions related to land-use decisions that support sustainable communities and permitting for clean energy production facilities and infrastructure, diversion of organics from landfills, and others. State agencies also should use the Scoping Plan to review and update programs and policies to support the actions identified in this Scoping Plan update. Importantly,

the Scoping Plan update can serve as a resource as the Legislature considers new legislative direction and funding to support the state's path to carbon neutrality and continue action to address near-term air pollution disparities.

Partnering with the Private Sector

We need to be clear. Government cannot do it alone. The scale of investment needed requires both private-sector investment and partnerships with philanthropies. Public sector dollars, accompanied by strong and steady policy signals, must be a catalyst for deeper and broader investments by the private sector in both reducing emissions and building the resilience of our communities. Governor Newsom is committed to working collaboratively with businesses, including small businesses, to deploy the technologies, capital, and ingenuity that are hallmarks of the private sector.

California structures our climate policies and regulations to create market signals and certainty that spur private sector investment. For example, the Governor's Executive Order on Zero-Emission Vehicles[66] set 2035 as the target year for 100 percent zero-emission vehicle sales, creating a time horizon that allows automakers to scale up zero-emission fleets and sending a clear signal to the companies and utilities that would deploy charging infrastructure. The Executive Order has been followed by development of the Advanced Clean Cars II regulation. CARB has convened auto manufacturers, environmental justice groups, labor organizations, and many other stakeholders to provide input into development of the regulation in a robust and transparent manner; again, with the aim to provide certainty for producers and consumers.

California also pursues public-private partnerships (PPP) as a mechanism to advance our collective climate goals. We know these vehicles can be effective at increasing the impact of public sector dollars and helpful in moving markets in a direction aligned with state policy. A new PPP the Administration is advancing is the Climate Catalyst Revolving Loan Fund, housed at the state's Infrastructure and Economic Development Bank. The fund offers a range of financial instruments—including low-cost credit and credit support—to help bridge the financing gap currently preventing advanced climate-smart technologies, such as clean technologies to utilize biomass produced from wildfire management, from scaling in the marketplace. The fund leverages public sector investments by mobilizing private finance for shovel-ready projects that are stuck in the deployment phase. The fund's initial focus is on projects that reduce wildfire threats through forest biomass management and utilization, and it will soon begin to support climate-smart agriculture projects as well.

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[66] Executive Department. State of California. Executive Order N-79-20. *https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf.*

Supporting Innovation

Reaching our ambitious, deep decarbonization goals will require continued technological innovation. Investment in research, development, and deployment of clean technologies has never been more critical. Sending clear and sustained market and policy signals will encourage large and small companies alike to pursue innovation that can be scaled up and deployed here and beyond our borders. The full suite of AB 32 policies[67] has touched nearly every sector of California's economy and spurred technology innovation in the state, including the growth of technology developers, manufacturers, processors, and assemblers in many areas. Specifically, AB 32 policies and programs support both the supply side and the demand side to build new markets in California. On the supply side, AB 32 policies support businesses to demonstrate and refine technologies, and to help establish critical supply chains. On the demand side, AB 32 policies and programs provide outreach, education, and incentives—as well as disincentives—to motivate everyone from consumers to institutional purchasers to utility planners to adopt new, climate smart technologies. Some direct innovation resulting from the state's climate policies include the following:

- In the past 10 years, a growing market for heavy-duty zero-emission vehicles (HD ZEVs) was established in California, and this market now represents the largest single share of North American supply and demand for HD ZEVs. Vehicle and component manufacturers are making long-term investments to develop and produce HD ZEVs within California.
- Total consumption of renewable diesel in the California Low-Carbon Fuel Standard (LCFS) market has skyrocketed from approximately 1.8 million gallons in 2011 to nearly 589 million gallons in 2020. The LCFS is a key driver of market development for renewable diesel and its coproducts. While the federal renewable fuel standard (RFS) and blenders tax credit also benefit producers, an analysis of their respective contributions to market development, and interviews with industry representatives and independent experts, point to LCFS as a more important factor in market development, at least in recent years.
- In the past five years, a market for small-scale energy storage in California was created where none previously existed. As of 2020, 185 megawatts (MW) of small-scale energy storage projects have been interconnected to the grid. The significant increase in deployment in the last five years is a result of the Self-Generation Incentive Program (SGIP), which significantly reduces the upfront costs to purchase and install small-scale energy storage devices, and of growing customer interest in disaster resiliency in the face

[67] CARB. Climate Change Programs. *https://ww2.arb.ca.gov/our-work/topics/climate-change*.

of increasing risk from wildfire and related utility outages. These systems have already provided disaster resiliency benefits for residential and non-residential customers.

We've seen how quickly market barriers can be overcome in response to strong policy signals, as occurred in the solar panel and electric vehicle battery space. Government stated priorities have a significant role in guiding private and public research, development, and deployment. This Scoping Plan unequivocally puts the marker down on the need for innovation to continue in non-combustion technologies, clean energy, carbon dioxide removal options, and alternatives for SLCPs. The five-year update to the Scoping Plan allows for a periodic evaluation of new tools to add to the state's toolkit.

Engagement with Partners to Develop and Export Policies

California works closely with other states, tribal governments, the federal government, and international jurisdictions to identify the most effective strategies and methods to reduce GHGs, manage GHG control programs, and facilitate the development of integrated and cost-effective regional, national, and international GHG reduction programs. For example, the state's Cap-and-Trade Program has been linked with Québec's since 2014, and CARB staff regularly engage with jurisdictions throughout the world on the design features of our Cap-and-Trade Program through memorandums of understanding (MOUs) and venues such as the International Climate Action Partnership.[68] Low carbon fuel mandates similar to California's LCFS have been adopted by the United States Environmental Protection Agency (U.S. EPA) and by other jurisdictions, including Oregon, Washington, British Columbia, the European Union, and the United Kingdom. Many other jurisdictions from Japan to New Zealand, Australia, and the European Commission also continue to seek information and technical experience on our LCFS. California has and will continue to share information and encourage ambitious emissions reductions with interested jurisdictions, with a focus on China, India, Mexico, Canada, and the European Union. California's early action to reduce super-pollutants such as methane and other SLCPs was reaffirmed by the 2021 Global Methane Pledge signed by the U.S. and over 100 other countries at the 26th Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC).[69]

In addition, under the Clean Air Act, the federal government is authorized to allow California to set more stringent vehicle emissions regulations than federal standards. California's goals and regulations to transition to 100 percent new zero-emission passenger vehicles by 2035, to zero-

[68] International Carbon Action Partnership (ICAP). Homepage. *https://icapcarbonaction.com/en?msclkid=dac30cb7b4f511ec94ccd0f1ae323e98.*
[69] Global Methane Pledge. Homepage. *https://www.globalmethanepledge.org/.*

emission drayage trucks by 2035, and to other trucks and buses where feasible by 2045 are being emulated by partner states across the U.S. and in jurisdictions around the world. These kinds of coordinated policies help signal to vehicle manufacturers a widespread and growing demand for zero-emissions technology, which in turn helps scale production and lower costs for consumers.

With the Mexican Secretariat for Environment and Natural Resources (SEMARNAT), California has engaged in a technical exchange on clean vehicle policies and helped establish Mexico's Emissions Trading System (being piloted in 2022). A 2019 MOU signed between California and Environment and Climate Change Canada enables in-depth collaboration on policies and programs to decarbonize vehicles, engines, and fuels. This partnership has led to tangible emissions reductions, from aligning vehicle emissions targets and policies to collaborating on emissions testing and research critical to enforcing emissions limits for vehicle manufactures. At the national level, China has looked to California for cutting-edge requirements for car diagnostics and policies that promote zero-emissions vehicles. At a local level, Beijing has adopted California's vehicle emissions standards and several other progressive environmental regulations. California will continue and renew such efforts across China.

Between 2021 and 2023, California will also serve as president of the Transport Decarbonisation Alliance, a global network of countries, regions, cities, and companies that come together to share experiences and technical expertise, and to increase the ambition and accelerate the deployment of targeted transportation decarbonization policies across freight, electric vehicle infrastructure, and active mobility. Throughout its presidency, California will focus its leadership on decarbonizing the cross-jurisdiction network of medium- and heavy-duty vehicles, both to ensure cleaner air in freight-adjacent communities and to stem the effects of climate change.

Over the years, California has also asserted the importance of and supported the ongoing efforts of state and local clean air and climate leadership. Through our participation in the Pacific Coast Collaborative alongside British Columbia, Washington, and Oregon,[70] the Under2 Coalition,[71] the U.S. Climate Alliance,[72] the International ZEV Alliance,[73] the Transportation Decarbonisation Alliance, and many more organizations, California has and will continue to build climate partnerships with state and local governments.

California also recognized the need to address the substantial emissions caused by the deforestation and degradation of tropical and other forests and continues its work alongside other subnational governments as part of the Governors' Climate and Forests Task Force

[70] Pacific Coast Collaborative. Homepage. *https://pacificcoastcollaborative.org/*.
[71] Under2 Coalition. Homepage. *https://www.theclimategroup.org/under2-coalition*.
[72] USCA. Homepage. *https://www.usclimatealliance.org/*.
[73] ZEV Alliance. Homepage. Zev Alliance | Accelerating the Adoption of Zero-Emission Vehicles.

(GCF).[74] Founded in 2008, there are currently 39 GCF members, including states and provinces in Brazil, Colombia, Ecuador, Indonesia, Ivory Coast, Mexico, Nigeria, Peru, Spain, and the United States—all of whom are considering or operating programs to reduce emissions from deforestation, land-use, and rural development, and to benefit local and indigenous communities. CARB's California Tropical Forest Standard provides a rigorous methodology to assess jurisdiction-scale programs that reduce deforestation and to incentivize responsible action and investment.[75] The standard provides a strong signal to value the preservation of tropical forests over continued destructive activities such as oil exploration and extraction, and ensures rigorous social and environmental safeguards for indigenous peoples and local communities.

Working Toward Carbon Neutrality

To date, California and many other regions have focused on reducing GHG emissions from the industrial and energy sectors. As defined in statute, the state's 2020 and 2030 targets includes all in-state sources of GHG emissions and those emissions associated with imported power that is consumed in the state. By moving to a framework of carbon neutrality, the scope for accounting is expanded to include all sources and sinks. As such, carbon neutrality is achieved when the flux of GHGs from the sources equal the sinks. Figure 1-5 depicts the sources included in the AB 32 GHG Inventory and the new sources and sinks added in this Scoping Plan under the framework of carbon neutrality. Natural and working lands, given their ability to sequester carbon, play an increasingly important role in this framework. However, modeling for this plan shows that carbon sequestration in our natural and working lands alone will be insufficient to achieve carbon neutrality no later than 2045. Therefore, this plan also considers the role of carbon capture and sequestration and direct air capture of carbon, biological, and mechanical processes included in the IPCC Sixth Assessment Report[76] as necessary tools for climate change mitigation.

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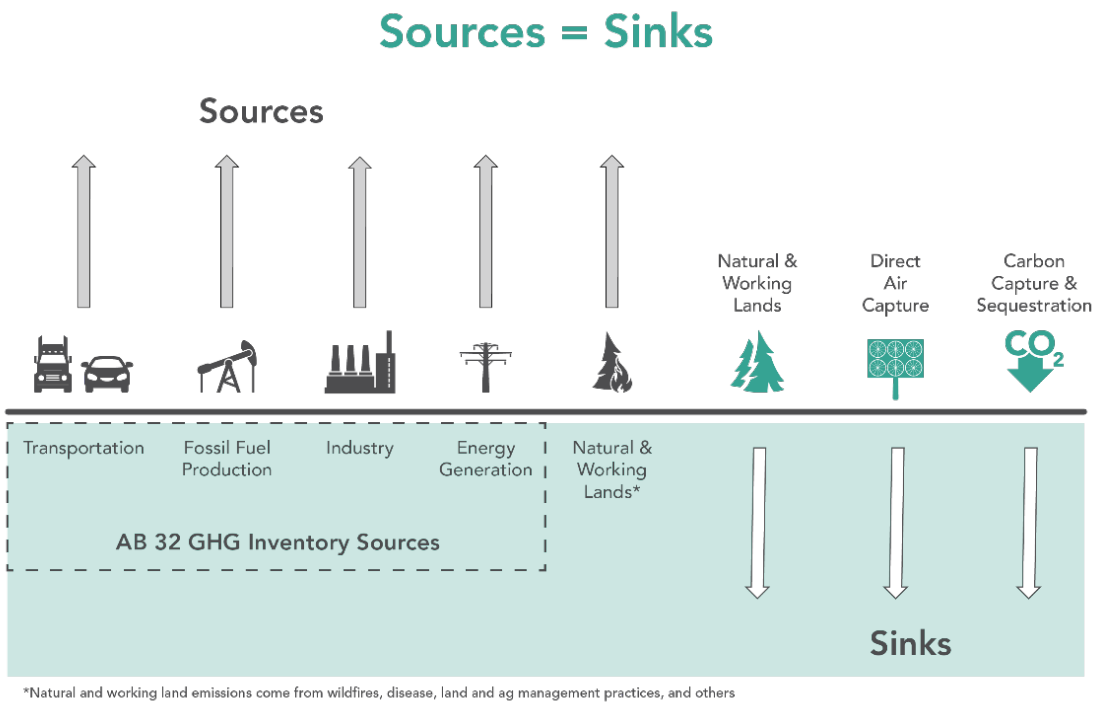
[74] Governors' Climate and Forests Task Force. University of Colorado Boulder: Colorado Law. *https://www.gcftf.org/*.

[75] CARB. California Tropical Forest Standard. *https://ww2.arb.ca.gov/our-work/programs/california-tropical-forest-standard*.

[76] IPCC. 2021. *Climate Change 2021: The Physical Science Basis.* Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J. B. R. Matthews, T. K. Maycock, T. Waterfield, O. Yelekçi, R. Yu, and B. Zhou (eds.)]. Cambridge University Press. In Press.

Figure 1-5: Carbon neutrality: Balancing the net flux of GHG emissions from all sources and sinks



Supporting Healthy and Resilient Lands

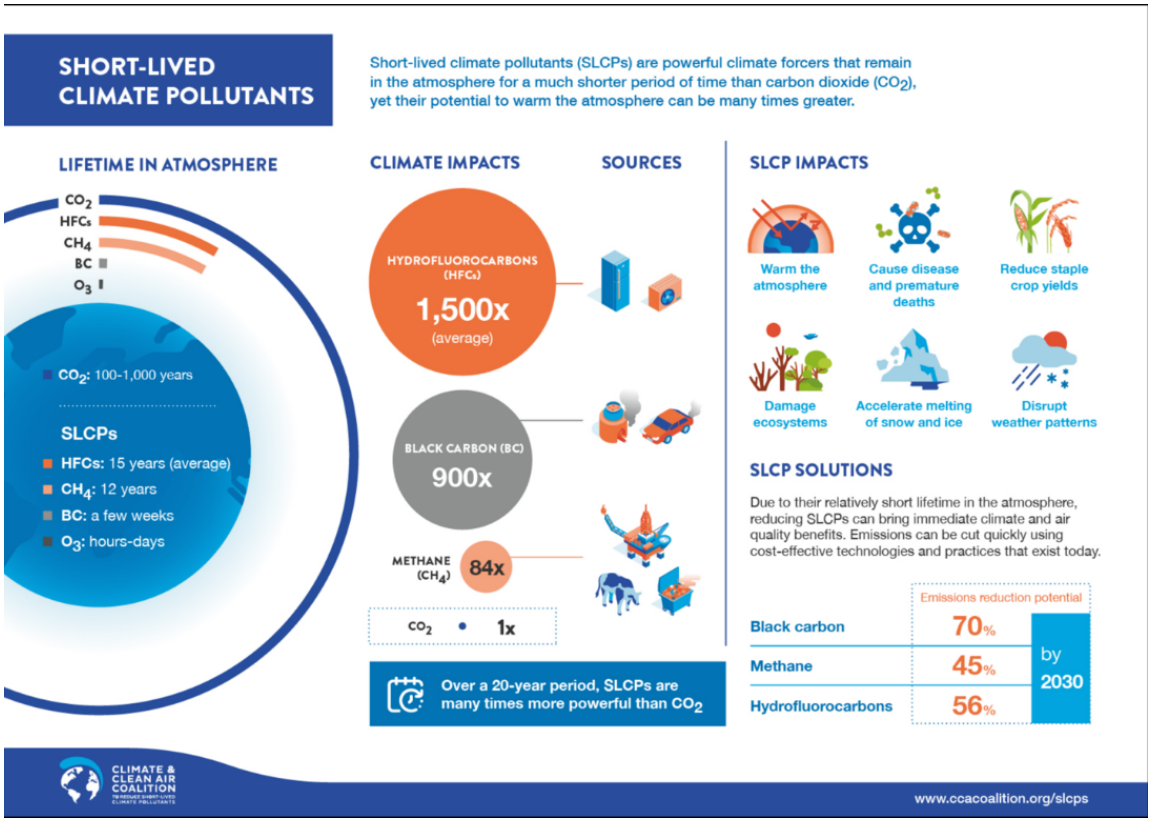
Our natural and working lands are an important piece in California's fight to achieve carbon neutrality and build resilience to the impacts of climate change. Healthy land can sequester and store atmospheric carbon dioxide in forests, soils, and wetlands. Healthy lands can also reduce emissions of powerful short-lived climate pollutants, limit the release of future GHG emissions, protect people and nature from the impacts of climate change, and build our resilience to future climate risks. Unhealthy lands have the opposite effect—they release more GHGs than they store and are more vulnerable to future climate change impacts. Through climate smart land management that focuses on supporting healthy living systems, we can support our carbon neutrality goals, reduce emissions and advance sequestration, and also support healthy and more climate-resilient lands.

Maintaining the Focus on Methane and Short-Lived Climate Pollutants

Given the urgency of climate change, defined by the often-disproportional impacts already being felt by underserved populations across California and the world, and the need to rapidly decarbonize and avoid climate tipping points as identified in the most recent IPCC assessment, efforts to reduce short-lived climate pollutants are especially important. SLCPs include methane

(CH_4), black carbon (soot), and fluorinated gases (F-gases, including hydrofluorocarbons, or HFCs) and are among the most harmful pollutants to both human health and global climate. SLCPs are more potent than CO_2 in terms of their impact on radiative forcing (that is, global warming) and have a much shorter lifetime in the atmosphere than CO_2 does. That means they have an outsized impact on climate change in the near term—they are responsible for up to 45 percent of current climate forcing. It also means that targeted efforts to reduce short-lived climate pollutants emissions can provide outsized climate and health benefits, within weeks to about a decade (see Figure 1-6).

Figure 1-6: Short-lived climate pollutant impacts[77]



[77] Climate and Clean Air Coalition. Short-Lived Climate Pollutants (SLCPs). https://www.ccacoalition.org/en/content/short-lived-climate-pollutants-slcps.

California has been a leader in addressing SLCP emissions. As part of the 2014 Scoping Plan update,[78] CARB committed to developing a dedicated strategy to reduce SLCP emissions. The resulting SLCP Reduction Strategy,[79] adopted by the Board in 2017, implements targets codified in SB 1383 (Lara, Chapter 395, Statutes of 2016) to reduce methane and HFC emissions by 40 percent by 2030 and anthropogenic black carbon emissions by 50 percent. California worked with several other states through the U.S. Climate Alliance to establish a similar goal to reduce SLCP emissions in line with the requirements of the Paris Agreement,[80] identifying the potential to reduce SCLPs by 40–50 percent by 2030 across the U.S. Climate Alliance.[81]

Process for Developing the 2022 Draft Scoping Plan

This Draft 2022 Scoping Plan was developed in coordination with the Governor's Office and state agencies, through engagement with the Legislature, with advice from the Environmental Justice Advisory Committee, tribes, and with open and transparent opportunities for stakeholders and the public to engage in workshops and other meetings. Appendix A (Public Process) includes details of the public workshops and Chapter 5 includes details of the process with the EJ Advisory Committee.

Guidance from the Administration and Legislature

This Draft Scoping Plan update reflects existing and recent direction in the Governor's Executive Orders and Statutes. Table 1-1 provides a summary of major climate legislation and executive orders issued since the adoption of the 2017 Scoping Plan.

[78] CARB. 2014. *First Update to the Climate Change Scoping Plan.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/scopingplan/2013_update/first_update_climate_change_scoping_plan.pdf.
[79] CARB. 2017. *Short-Lived Climate Pollutant Reduction Strategy.* https://ww2.arb.ca.gov/sites/default/files/2020-07/final_SLCP_strategy.pdf.
[80] UNFCCC. 2015. Paris Agreement. https://unfccc.int/sites/default/files/english_paris_agreement.pdf.
[81] USCA. 2018. *From SLCP Challenge to Action: A Roadmap for Reducing Short-Lived Climate Pollutants to Meet the Goals of the Paris Agreement.* http://www.usclimatealliance.org/slcp-challenge-to-action.

Table 1-1: Major climate legislation and executive orders enacted since the 2017 Scoping Plan

Bill/Executive Order	Summary
Senate Bill 27 (SB 27) (Skinner, Chapter 237, Statutes of 2021)	SB 27 requires the California Natural Resources Agency (CNRA), in coordination with other state agencies, to establish the Natural and Working Lands Climate Smart Strategy by July 1, 2023. This bill also requires the Air Resources Board to establish specified CO_2 removal targets for 2030 and beyond as part of its Scoping Plan. Under SB 27, CNRA is to establish and maintain a registry to identify projects in the state that drive climate action on natural and working lands and are seeking funding. Applicants will have to meet criteria related to: • Greenhouse gas reduction or carbon removal. • Monitoring and reporting or carbon removal benefits over time. • Improvements to the state's resilience to climate change. CNRA also must track carbon removal and GHG emission reduction benefits derived from projects funded through the registry. This bill will be reflected directly in the Draft Scoping Plan as sequestration targets in the Natural and Working Lands (NWL) sector found in Chapter 4.
Senate Bill 596 (SB 596) (Becker, Chapter 246, Statutes of 2021)	SB 596 requires the Air Resources Board, by July 1, 2023, to develop a comprehensive strategy for the state's cement sector to achieve net-zero-emissions of GHGs associated with cement used within the state as soon as possible, but no later than December 31, 2045. The bill establishes an interim target of 40 percent below the 2019 average GHG intensity of cement by December 31, 2035. Under SB 596, the Air Resources Board must: • Define a metric for GHG intensity and establish a baseline from which to measure GHG intensity reductions. • Evaluate the feasibility of the 2035 interim target (40 percent reduction in GHG intensity) by July 1, 2028. • Coordinate and consult with other state agencies. • Prioritize actions that leverage state and federal incentives. • Evaluate measures to support market demand and financial incentives to encourage the production and use of cement with low GHG intensity. The Draft Scoping Plan modeling is designed to achieve these outcomes. Chapter 4 includes actions to achieve these outcomes and next steps.
Executive Order N-82-20	Governor Newsom signed Executive Order N-82-20 in October 2020 to combat the climate and biodiversity crises by setting a statewide goal to

	conserve at least 30 percent of California's land and coastal waters by 2030. The Executive Order also instructed the CNRA, in consultation with other state agencies, to develop a Natural and Working Lands Climate Smart Strategy that serves as a framework to advance the state's carbon neutrality goal and build climate resilience. In addition to setting a statewide conservation goal, the Executive Order directed CARB to update the target for natural and working lands in support of carbon neutrality as part of the 2022 Scoping Plan, and to take into consideration the NWL Climate Smart Strategy. Executive Order N-82-20 also calls on the CNRA, in consultation with other state agencies, to establish the California Biodiversity Collaborative (Collaborative). The Collaborative shall be made up of governmental partners, California Native American tribes, experts, business and community leaders, and other stakeholders from across the state. State agencies will consult the Collaborative on efforts to: • Establish a baseline assessment of California's biodiversity that builds upon existing data and can be updated over time. • Analyze and project the impact of climate change and other stressors in California's biodiversity. • Inventory current biodiversity efforts across all sectors and highlight opportunities for additional action to preserve and enhance biodiversity. CNRA is also tasked with advancing efforts to conserve biodiversity through various actions such as streamlining the state's process to approve and facilitate projects related to environmental restoration and land management. The California Department of Food and Agriculture is directed to advance efforts to conserve biodiversity through measures such as reinvigorating populations of pollinator insects, which restore biodiversity and improve agricultural production. The Natural and Working Lands Climate Smart Strategy informs the Draft Scoping Plan.
Executive Order N-79-20	Governor Newsom signed Executive Order N-79-20 in September 2020 to establish targets for the transportation sector to support the state in its goal to achieve carbon neutrality by 2045. The targets established in this Executive Order are: • 100 percent of in-state sales of new passenger cars and trucks will be zero-emission by 2035. • 100 percent of medium- and heavy-duty vehicles will be zero-emission by 2045 for all operations where feasible, and by 2035 for drayage trucks.

	• 100 percent of off-road vehicles and equipment will be zero-emission by 2035 where feasible. The Executive Order also tasked the Air Resources Board to develop and propose regulations that require increasing volumes of zero-electric passenger vehicles, medium- and heavy-duty vehicles, drayage trucks, and off-road vehicles toward their corresponding targets of 100 percent zero-emission by 2035 or 2045, as listed above. The Draft Scoping Plan modeling reflects achieving these targets. Chapter 4 includes actions to achieve these outcomes.
Executive Order N-19-19	Governor Newsom signed Executive Order N-19-19 in September 2019 to call on state government to redouble its efforts to reduce GHG emissions and mitigate the impacts of climate change while building a sustainable, inclusive economy. This Executive Order instructs the Department of Finance to create a Climate Investment Framework that: • Includes a proactive strategy for the state's pension funds that reflects the increased risks to the economy and physical environment due to climate change. • Provides a timeline and criteria to shift investments to companies and industry sectors with greater growth potential based on their focus of reducing carbon emissions and adapting to the impacts of climate change. • Aligns with the fiduciary responsibilities of the California Public Employees' Retirement System, California State Teachers' Retirement System, and the University of California Retirement Program. Executive Order N-19-19 directs the State Transportation Agency to leverage more than $5 billion in annual state transportation spending to help reverse the trend of increased fuel consumption and reduce GHG emissions associated with the transportation sector. It also calls on the Department of General Services to leverage its management and ownership of the state's 19 million square feet in managed buildings, 51,000 vehicles, and other physical assets and goods to minimize state government's carbon footprint. Finally, it tasks the Air Resources Board with accelerating progress toward California's goal of five million ZEV sales by 2030 by: • Developing new criteria for clean vehicle incentive programs to encourage manufacturers to produce clean, affordable cars. • Proposing new strategies to increase demand in the primary and secondary markets for ZEVs.

	• Considering strengthening existing regulations or adopting new ones to achieve the necessary GHG reductions from within the transportation sector. The Draft Scoping Plan modeling reflects efforts to accelerate ZEV deployment. Chapter 4 includes actions to support faster deployment of ZEVs.
Senate Bill 576 (SB 576) (Umberg, Chapter 374, Statutes of 2019)	Sea level rise, combined with storm-driven waves, poses a direct risk to the state's coastal resources, including public and private real property and infrastructure. Rising marine waters threaten sensitive coastal areas, habitats, the survival of threatened and endangered species, beaches, and other recreation areas, and urban waterfronts. SB 576 mandates that the Ocean Protection Council develop and implement a coastal climate adaptation, infrastructure, and readiness program to improve the climate change resiliency of California's coast communities, infrastructure, and habitat. This bill also instructs the State Coastal Conservancy to administer the Climate Ready Program, which addresses the impacts and potential impacts of climate change on resources within the conservancy's jurisdiction.
Assembly Bill 65 (AB 65) (Petrie-Norris, Chapter 347, Statutes of 2019)	This bill requires the State Coastal Conservancy, when it allocates any funding appropriated pursuant to the California Drought, Water, Parks, Climate, Coastal Protection, and Outdoor Access For All Act of 2018, to prioritize projects that use natural infrastructure in coastal communities to help adapt to climate change. The bill requires the conservancy to provide information to the Office of Planning and Research on any projects funded pursuant to the above provision to be considered for inclusion into the clearinghouse for climate adaption information. The bill authorizes the conservancy to provide technical assistance to coastal communities to better assist them with their projects that use natural infrastructure.
Executive Order B-55-18	Governor Brown signed Executive Order B-55-18 in September 2018 to establish a statewide goal to achieve carbon neutrality as soon as possible, and no later than 2045, and to achieve and maintain net negative emissions thereafter. Policies and programs undertaken to achieve this goal shall: • Seek to improve air quality and support the health and economic resiliency of urban and rural communities, particularly low-income and disadvantaged communities. • Be implemented in a manner that supports climate adaptation and biodiversity, including protection of the state's water supply, water quality, and native plants and animals. This Executive Order also calls for the Air Resources Board to: • Develop a framework for implementation and accounting that tracks progress toward this goal.

	• Ensure future Scoping Plans identify and recommend measures to achieve the carbon neutrality goal. The Draft Scoping Plan is designed to achieve carbon neutrality no later than 2045 and the modeling includes technology and fuel transitions to achieve that outcome.
Senate Bill 100 (SB 100) (De León, Chapter 312, Statutes of 2018)	SB 100 mandates that the California Public Utilities Commission, California Energy Commission, and Air Resources Board plan for 100 percent of total retail sales of electricity in California to come from eligible renewable energy resources and zero-carbon resources by December 31, 2045. This bill also updates the state's Renewables Portfolio Standard to include the following interim targets: • 44% of retail sales procured from eligible renewable sources by December 31, 2024. • 52% of retail sales procured from eligible renewable sources by December 31, 2027. • 60% of retail sales procured from eligible renewable sources by December 31, 2030. Under SB 100, the California Public Utilities Commission, California Energy Commission, and Air Resources Board shall use programs under existing laws to achieve 100 percent clean electricity. The statute requires these agencies to issue a joint policy report on SB 100 every four years. The first of these reports was issued in 2021. The Draft Scoping Plan reflects the SB 100 Core Scenario resource mix with a few minor updates.
Assembly Bill 2127 (AB 2127) (Ting, Chapter 365, Statutes of 2018)	This bill requires the California Energy Commission, working with the State Air Resources Board and the California Public Utilities Commission, to prepare and biennially update a statewide assessment of the electric vehicle charging infrastructure needed to support the levels of electric vehicle adoption required for the state to meet its goals of putting at least 5 million zero-emission vehicles on California roads by 2030 and of reducing emissions of GHGs to 40% below 1990 levels by 2030. The bill requires the Energy Commission to regularly seek data and input from stakeholders relating to electric vehicle charging infrastructure. This bill supports the deployment of ZEVs as modeled in the Draft Scoping Plan.
Senate Bill 30 (SB 30) (Lara, Chapter 614, Statutes of 2018)	This bill requires the Insurance Commissioner to convene a working group to identify, assess, and recommend risk transfer market mechanisms that, among other things, promote investment in natural infrastructure to reduce the risks of climate change related to catastrophic events, create incentives

	for investment in natural infrastructure to reduce risks to communities, and provide mitigation incentives for private investment in natural lands to lessen exposure and reduce climate risks to public safety, property, utilities, and infrastructure. The bill requires the policies recommended to address specified questions.
Assembly Bill 2061 (AB 2061) (Frazier, Chapter 580, Statutes of 2018)	Existing state and federal law sets specified limits on the total gross weight imposed on the highway by a vehicle with any group of two or more consecutive axles. Under existing federal law, the maximum gross vehicle weight of that vehicle may not exceed 82,000 pounds. AB 2061 authorizes a near-zero-emission vehicle or a zero-emission vehicle to exceed the weight limits on the power unit by up to 2,000 pounds. This bill supports the deployment of cleaner trucks as modeled in the Draft Scoping Plan.

Consideration of relevant state plans and regulations

Development of this Scoping Plan update also included careful consideration of, and coordination with, other state agency plans and regulations, the SB 100 Joint Agency Report,[82] the 2022 State Strategy for the State Implementation Plan,[83] Climate Action Plan for Transportation Infrastructure,[84] AB 74 Studies on Vehicle Emissions and Fuel Demand and Supply,[85,86,87] Short-Lived Climate Pollutant Strategy (SLCP Strategy),[88] CARB's Achieving

[82] CPUC, CEC, and CARB. 2021. *SB 100 Joint Agency Report.* https://www.energy.ca.gov/sb100.
[83] CARB. January 31, 2022. Draft 2022 State Strategy for the State Implementation Plan. https://ww2.arb.ca.gov/sites/default/files/2022-01/Draft_2022_State_SIP_Strategy.pdf.
[84] CalSTA. 2021. *Climate Action Plan for Transportation Infrastructure.* https://calsta.ca.gov/subject-areas/climate-action-plan.
[85] CalEPA. 2021. Carbon Neutrality Studies. https://calepa.ca.gov/climate/carbon-neutrality-studies/.
[86] Brown, A. L., et. al. 2021. *Driving California's Transportation Emissions to Zero.* University of California Institute of Transportation Studies. https://escholarship.org/uc/item/3np3p2t0.
[87] Deschenes, O. 2021. *Enhancing equity while eliminating emissions in California's supply of transportation fuels.* University of California Santa Barbara. https://zenodo.org/record/4707966#.YKPiaKhKi73.
[88] CARB. Short-Lived Climate Pollutants. https://ww2.arb.ca.gov/our-work/programs/slcp.

Carbon Neutrality Report,[89] Climate Smart Strategy,[90] and draft Natural Working Land Implementation Plan,[91] among others.

Input from partners and stakeholders

CARB also collaborated with other state agencies and solicited comments and feedback from affected stakeholders, including labor and the public. The process to update the Scoping Plan began with kickoff workshops in early June 2021,[92] followed by over a dozen public workshops, including engagement with tribes,[93] and featured a series of Environmental Justice Advisory Committee and environmental justice community meetings.[94] The June 2021 workshop and several others were a joint agency effort, as there are many agencies with direct authority or jurisdiction over different sectors of the economy. Consultation with agencies also included bi-weekly, monthly, and weekly meetings.

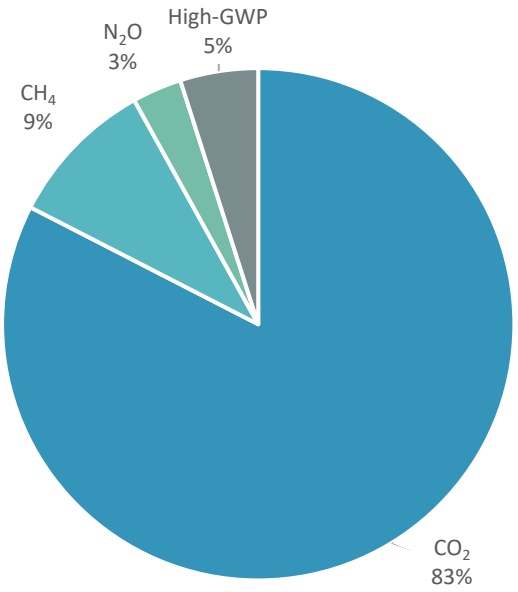
[89] Energy and Environmental Economics, Inc. 2020. *Achieving Carbon Neutrality in California.* *https://ww2.arb.ca.gov/sites/default/files/2020-10/e3_cn_final_report_oct2020_0.pdf*.
[90] CNRA. 2022. Natural and Working Lands Climate Smart Strategy. *https://resources.ca.gov/Initiatives/Expanding-Nature-Based-Solutions*.
[91] CARB. 2019. *Draft California 2030 Natural and Working Lands Climate Change Implementation Plan.* *https://ww2.arb.ca.gov/resources/documents/nwl-implementation-draft*.
[92] Appendix A (Public Process)
[93] CARB. Scoping Plan Meetings & Workshops. https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/scoping-plan-meetings-workshops.
[94] CARB. Environmental Justice Advisory Committee Meetings and Events. https://ww2.arb.ca.gov/environmental-justice-advisory-committee-meetings-and-events.

Emissions Data That Inform the Scoping Plan

Greenhouse Gas Emissions

AB 32 includes which GHGs are to be regulated, reduced, and included in the state's targets and goals. That list includes seven GHGs: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and nitrogen trifluoride (NF_3). Carbon dioxide is the primary GHG emitted in California, accounting for 83 percent of the total GHG emissions in 2019, as shown in Figure 1-7 below. Figure 1-8 illustrates that transportation (primarily on-road travel) is the single largest source of CO_2 emissions in the state. Upstream transportation emissions from the refinery and oil and gas sectors are categorized as CO_2 emissions from industrial sources and constitute about 50 percent of the industrial source emissions. When these emissions sources are attributed to the transportation sector, the emissions from the transportation sector amount to approximately half of statewide GHG emissions. In addition to transportation, electricity production, and industrial and residential sources also are important contributors to CO_2 emissions. Figures 1-7 and 1-8 show state GHG emission contributions by GHG and sector based on the 2019 Greenhouse Gas Emission Inventory. Emissions in Figure 1-8 are depicted by Scoping Plan sector, which includes separate categories for high-global warming potential (GWP) and recycling/waste emissions that are otherwise typically included within other economic sectors.

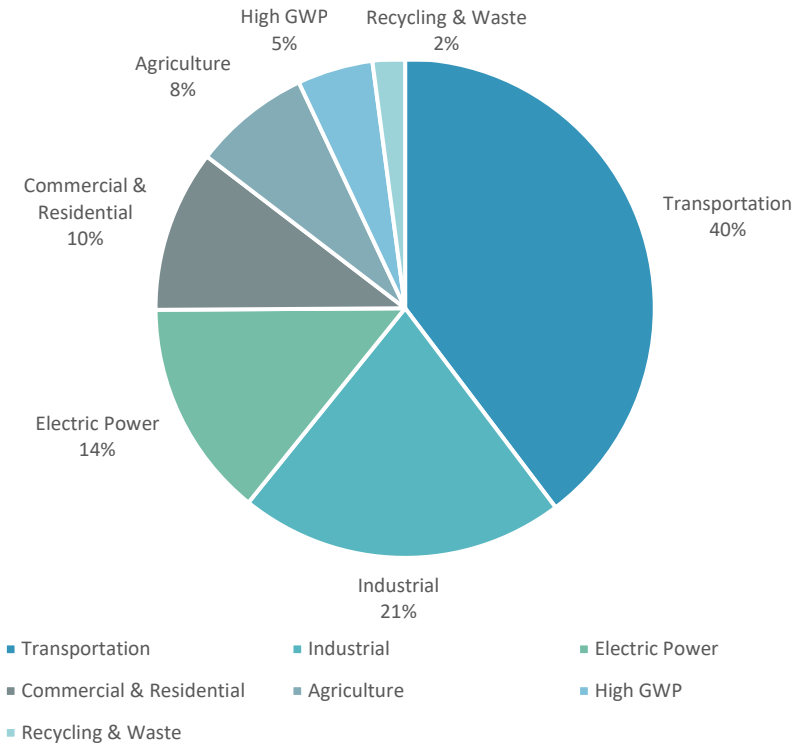
Figure 1-7: 2019 State GHG emission contributions by GHG[95]



2019 Total CA Emissions: 418.2 MMTCO_2e

[95] CARB. 2019. *California Greenhouse Gas Emissions for 2000 to 2019: Trends of Emissions and Other Indicators.* https://ww2.arb.ca.gov/sites/default/files/classic/cc/ca_ghg_inventory_trends_2000-2019.pdf.

Figure 1-8: 2019 State GHG emission contributions by Scoping Plan sector



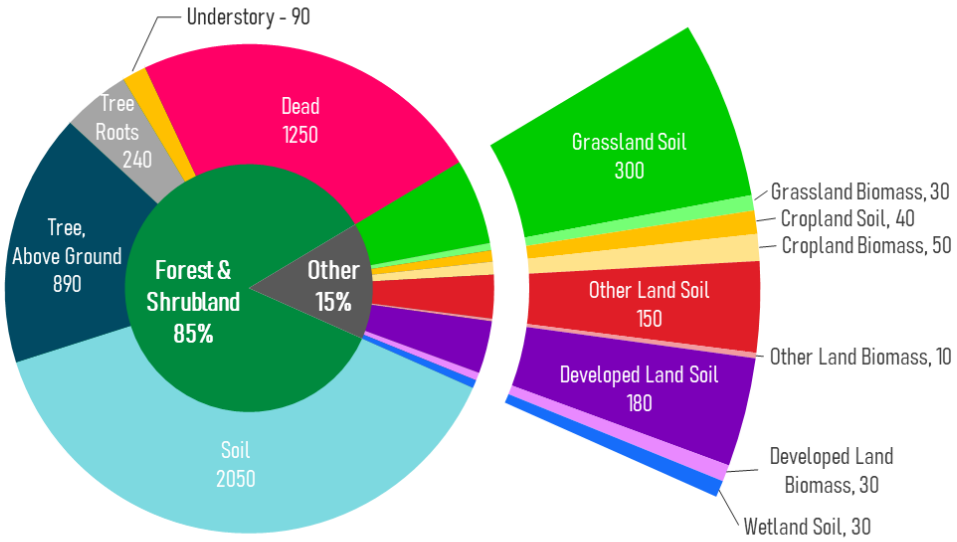
The scope of the AB 32 GHG Inventory encompasses emissions sources within the state's borders, as well as imported electricity consumed in the state. This construct for the inventory is consistent with IPCC practices to allow for comparison of statewide GHG emissions with those at the national level and with other international GHG inventories. Statewide GHG emissions calculations use many data sources, including data from other state and federal agencies. However, the primary source of data comes from reports submitted to CARB through the Regulation for the Mandatory Reporting of GHG Emissions (MRR). The MRR requires facilities and entities with more than 10,000 metric tons of carbon dioxide equivalent ($MTCO_2e$) of combustion and process emissions, all facilities belonging to certain industries, and all electric power entities to submit an annual GHG emissions data report directly to CARB. Furthermore, this regulation requires that reports from entities that emit more than 25,000 $MTCO_2e$ be verified by a CARB-accredited third-party verification body. More information on MRR emissions reports can be found at: Mandatory Greenhouse Gas Emissions Reporting | California Air Resources Board.

All data sources used to develop the GHG Emission Inventory are listed in inventory supporting documentation at: www.arb.ca.gov/cc/inventory/data/data.htm.

Natural and Working Lands

For natural and working lands, the current 2018[96] ecosystem carbon inventory (NWL Inventory) shows that there are approximately 5,340 million metric tons (MMT) of carbon in the carbon pools that CARB has quantified (see Figure 1-9). To put this into context, 5,340 MMT of carbon in land is equivalent to 19,600 MMT of atmospheric CO_2 currently existing as carbon in the biosphere and soil as carbon transitions through the Earth's carbon cycle. Forests and shrublands contain the majority of California's carbon stock because they cover the majority of California's landscape and have the highest carbon density of any land cover type. All other land categories combined comprise over 35 percent of California's total acreage, but only 15 percent of carbon stocks. Roughly half of the 5,340 MMT of carbon resides in soils and half in plant biomass.

Figure 1-9: Carbon stocks in natural and working lands

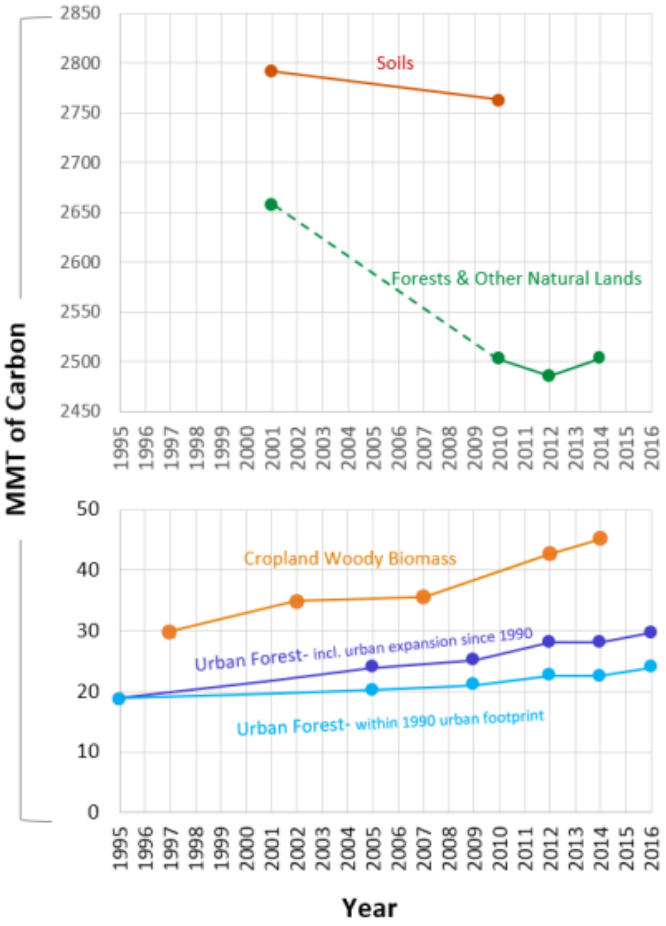


In addition to providing an estimate of the ecosystem carbon that exists on California's landscape, the NWL Inventory also shows how those carbon stocks are changing (see Figure 1-

[96] CARB. 2018. An Inventory of Ecosystem Carbon in California's Natural and Working Lands. https://ww3.arb.ca.gov/cc/inventory/pubs/nwl_inventory.pdf.

10). The inventory attributes stock change to human activity, such as land use change, or to disturbances, such as wildfire. CARB's inventory shows these lands were a source of GHG emissions from 2001 to 2011, releasing more carbon than they stored, and then they returned to be a slight carbon sink from 2012 to 2014. These trends highlight the interannual and interdecadal variability of lands and their ability to be both a source and a sink of carbon.

Figure 1-10: Changes in carbon stock by landscape type



For natural and working lands, the inventory is also based on IPCC methods for tracking ecosystem carbon over time in California's borders, providing for comparability with other national and subnational inventories and carbon accounting. As such, the NWL Inventory is an important tool for tracking both carbon stock changes in California over time and the impacts that interventions such as those identified in this Scoping Plan, actions identified in the Climate Smart Land Strategy, and others have on NWL carbon stocks.

All data sources used to develop the NWL Inventory are listed in the technical support documentation at: https://ww2.arb.ca.gov/nwl-inventory.

Black Carbon

In addition, CARB has developed a statewide emission inventory for black carbon in support of the SLCP Strategy. The inventory is reported in two categories: non-forestry (anthropogenic) sources and forestry sources.[97] The black carbon inventory is calculated using existing $PM_{2.5}$ emission inventories combined with speciation profiles that define the fraction of $PM_{2.5}$ that is black carbon. The black carbon inventory helps support implementation of the SLCP Strategy, but it is not part of California's GHG Inventory that tracks progress toward the state's climate targets under AB 32 or SB 32. The state's major anthropogenic sources of black carbon include off-road transportation, on-road transportation, residential wood burning, fuel combustion, and industrial processes. CARB estimated 2017 black carbon emissions to be approximately 8 $MTCO_2e$.[98]The majority of anthropogenic sources come from transportation—specifically, heavy-duty vehicles. The share of black carbon emissions from transportation is dropping rapidly and is expected to continue to do so between now and 2030 as a result of California's air quality programs. The remaining black carbon emissions will come largely from woodstoves/fireplaces, off-road applications, and industrial/commercial combustion. The forestry category includes non-agricultural prescribed burning and wildfire emissions.

Tracking Life Cycle and Out-of-State Emissions

In recent years there has been increased interest in the embedded carbon in products, also known as *life-cycle emissions.* A life-cycle accounting framework refers to all of the GHG emissions generated from the sourcing, production, and transportation of products to an endpoint. In doing such assessments for a product, emissions may be associated with sourced materials and production activity outside a jurisdiction's borders. While life-cycle emissions can provide a more comprehensive picture of the emissions associated with the goods we consume and ongoing demand, life-cycle inventories are inconsistent with IPCC standards, as they would result in double counting of emissions across jurisdictions. In addition, jurisdictions often lack legal authority to regulate sources outside of their borders. Finally, it is difficult to obtain accurate data for sources and production activities outside of a region's border that would impact the accuracy of such an inventory. For these reasons, the inventory used in the Scoping Plan does not use a life-cycle approach and remains consistent with international accounting standards.

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[97] Senate Bill No. 1383. https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201520160SB1383.
[98] This is a preliminary estimate developed for the 2022 Scoping Plan. Official Black Carbon emissions estimates are provided in the SLCP inventory here: https://ww2.arb.ca.gov/ghg-slcp-inventory.

However, GHG mitigation action may cross geographic borders as part of subnational and international collaboration, or as a natural result of implementation of regional policies. In addition to the state's existing GHG inventory, CARB will develop an accounting framework after the completion of the Scoping Plan that reflects benefits of our policies accruing outside of the state. This accounting framework will be important to better understand the true impact of the state's policies to what is emitted into the atmosphere. For example, the Low Carbon Fuel Standard incentivizes GHG reductions along the entire supply chain for the production and delivery of transportation fuel imported for use in the state. However, our inventory only captures the change in emissions from the tailpipe of when that fuel is used in California and does not capture any GHG reductions that occur in the production process if produced out of state. Natural and working lands forestry actions are another example, where California's policies are inspiring forest management actions in other states that result in increased permanent carbon sequestration. California's NWL inventory does not capture the increased carbon stocks resulting from forestry projects happening outside of California, and the CO_2 removals resulting from these projects are not applied in either CARB's NWL inventory or CARB's GHG Emissions Inventory. For GHG reductions outside of the state to be attributed to our programs, those reductions must be real, quantifiable, verifiable, and permanent.

It will also be important to avoid any double counting (including claims to those reductions by other jurisdictions) and to transparently indicate whether any extra-jurisdictional emissions reductions might be included in another region's inventory. CARB is collaborating with other jurisdictions to ensure GHG accounting rules are consistent with international best practices, as robust accounting rules instill confidence in the reductions claimed and maintain support for joint action across jurisdictions. The policy goals of consistency and transparency are critical as we work together with other jurisdictions on our parallel paths to achieve our GHG targets with real benefits to the atmosphere.

Chapter 2: The Proposed Scenario

This chapter examines the Proposed Scenario, which for the first time includes both the sources in the AB 32 GHG Inventory and Natural and Working Lands (NWL). It begins with a discussion of the alternatives evaluated and the process used to select the Proposed Scenario. Each of the scenarios is designed to achieve reductions in emissions from sources within the state. Four scenarios for the AB 32 GHG Inventory and NWL were considered separately and helped to inform the Proposed Scenario. Each of the alternatives were considered in terms of the important criteria and priorities that the state's comprehensive climate action must deliver, including the need for GHG reductions that are technologically feasible and cost-effective, as well as delivering on health and economic benefits for the state. All the scenarios are set against what is called the Reference Scenario—that is, what the GHG emissions would look like if we did nothing at all beyond the existing policies that are required and already in place to achieve the 2030 target or expected with no new actions in the NWL sector. For the Draft 2022 Scoping Plan, two sets of modeling tools were used to evaluate the AB 32 GHG Inventory and NWL sectors because there is no single model that can assess both AB 32 emissions sources and NWL together. As a result, two different sets of scenarios were developed for each sector type. While the chapter breaks out discussion separately for the two sector types, the Proposed Scenario reflects the combined actions across both sectors by choosing an alternative from each sector type. While the modeling provides point estimates, that does not imply precision. As discussed in the uncertainty section, there are several types of uncertainties that are associated with any outcomes projected by the modeling results. There will be ranges of estimates associated with each point that are not shown in the graphs or results. The Final 2022 Scoping Plan will include a quantified sensitivity analysis.

Scenarios for the AB 32 GHG Inventory Sectors

The Reference Scenario for the AB 32 GHG Inventory sectors shows continuing but modest GHG reductions beyond 2030 that level off toward mid-century. The comprehensive analysis of all four alternatives indicates that the Proposed Scenario is the best choice to achieve California's climate and clean air goals while balancing the legislative direction on prioritizing direct emissions reductions, being technologically feasible, and being cost-effective. It also protects public health, provides a solid foundation for continued economic growth, and drastically reduces the state's dependence on fossil fuel combustion. Each of the alternative scenarios is the product of a process of development informed by public input, the Governor, the Air

Resources Board, legislative direction, and input by the EJ Advisory Committee[99,100] over the course of a year. The scenarios are represented as identified and recommended choices about clean energy and technologies and their rate of deployment, not as immediate policy choices, due to the longer time horizon in this Scoping Plan. With future updates to the Scoping Plan there may be new clean technologies and fuels to add to the list.

The four scenarios evaluated share many similarities. They each embody the following characteristics:

- Drastic reduction in fossil fuel dependence, with some remaining in-state demand for fossil fuels for aviation, marine, and locomotion applications, and for gas for buildings and industry
- Ambitious deployment of efficient non-combustion technologies such as zero emission vehicles and heat pumps
- Rapid growth in the production and distribution of clean energy such as zero carbon electricity and hydrogen
- Progressive phasedown of fossil fuel production and distribution activities as part of the transition to clean energy
- Remaining emissions of fugitive SLCPs such as refrigerants and fugitive methane
- Strong consumer adoption of clean technology and fuel options
- CO_2 removal of remaining emissions to achieve carbon neutrality
- Some reliance on carbon capture and sequestration (CCS)

While the four scenarios have a lot in common, they also have some differences:

- Year in which carbon neutrality is achieved (2035 or 2045)
- Rate of deployment of clean technology and production and distribution of zero carbon energy
- Remaining amount of demand for fossil energy in the year carbon neutrality is achieved
- Constraints on technology and fuels deployed in certain sectors
- Consumer adoption rates of clean technologies and fuels
- Degree of reliance on CO_2 removal
- Degree of reliance on CCS

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[99] EJ Advisory Committee. December 2, 2021. EJAC Responses for the CARB Scenario Inputs. *https://ww2.arb.ca.gov/sites/default/files/2021-12/EJAC%20Final%20Responses%20to%20CARB%20Scenario%20Inputs_12_2_21.pdf*.

[100] CARB. January 25, 2022. Update on PATHWAYS Scenario Modeling Assumptions. *https://ww2.arb.ca.gov/sites/default/files/2022-01/Scenario%20Slides%20for%20Jan25%20EJAC%20Mtg_01242022.pdf*.

The initial scenario concepts were discussed at a public workshop in August 2021. Additional workshops on the modeling scenarios were held in September and October of 2021. The draft modeling scenarios were finalized in mid-December 2021.

The summary below provides an overview of the alternatives designed and considered for the energy and industrial sectors in this update.

Proposed Scenario (modeling scenario Alt 3): carbon neutrality by 2045, deploy a broad portfolio of existing and emerging fossil fuel alternatives and clean technologies, and align with statutes and Executive Orders

Alternative 1: carbon neutrality by 2035, nearly complete phaseout of all combustion, limited reliance on carbon capture and sequestration and engineered carbon removal, restricted applications for biomass derived fuels

Alternative 2: carbon neutrality by 2035 and aggressive deployment of a full suite of technology and energy options, including engineered carbon removal

Alternative 4: carbon neutrality by 2045, deployment of a broad portfolio of existing and emerging fossil fuel alternatives, slower deployment and adoption rates than the Proposed Scenario, and a higher reliance on CO_2 removal

Other considerations for the AB 32 GHG Inventory sectors include the following:

- To what extent does an alternative meet the statewide targets and any sector targets, and also deliver clean air benefits (especially in the near term) to address ongoing healthy air disparities, prioritize reductions for mobile and large stationary sources, and emphasize continued investment in disadvantaged communities?
- Does an alternative support California in building on efforts to collaborate with other jurisdictions and include exportable policies based on robust science?
- Does an alternative provide for flexibility for regulated entities and a cost-effective approach to reduce GHG emissions?
- Does the alternative present a realistic and ambitious path forward consistent with statute and science, and support economic opportunities, particularly in anticipated growth sectors?

Scenarios for the Natural and Working Lands

For the natural and working lands sector, the Reference Scenario shows that NWL will continue to emit GHGs and lose carbon stocks into the future as the combined effects of past unhealthy management practices and climate change impact our lands. Relative to the Reference Scenario, the four NWL scenarios represent different scales of land management on seven landscapes (forests, shrublands/chaparral, grasslands, croplands, developed lands, wetlands,

and sparsely vegetated lands) to support carbon neutrality. The analysis of the four NWL scenarios shows that the Proposed Scenario (modeling scenario Alt 3) is the preferred choice because it prioritizes both GHG and air pollution reductions, ecosystem health and resilience, and implementation and technological feasibility and cost-effectiveness. The Proposed Scenario reduces wildfire risk to the state; increases the health and resilience of California's forests, shrublands, and grasslands; increases soil health; and protects, restores, and enhances California's natural and working lands for future generations. The Proposed Scenario takes into consideration the priority landscapes and nature-based strategies identified in California's Climate Smart Strategy[101] and reflects the state's priorities to manage lands in ways that support the multiple benefits that they provide. The Proposed Scenario, as well as each of the alternative NWL scenarios outlined in this chapter, were informed by input from other agencies, the public, and the EJ Advisory Committee. Additional landscapes and land management activities will be added and evaluated in future Scoping Plan updates.

Each of the NWL scenarios have several similarities, including:

- Prioritizing NWL management actions on forests, shrublands, grasslands, croplands, developed lands, wetlands, and sparsely vegetated lands. These actions can reduce GHG emissions from these lands, protect ecosystems against future climate change, protect communities, and enhance the ecosystem benefits they provide to nature and society.
- Exploring the potential impacts of different levels of NWL management actions that are designed to achieve the objective associated with each scenario.
- Analyzing the carbon impacts of land management actions, climate change, wildfire and water use on California's diverse natural and working lands through 2045.

There are also differences across the four NWL scenarios, including:

- The level of NWL management actions taken on each landscape, such as varying the acres of healthy soils practices for croplands.
- The types of NWL management actions taken on each landscape, such as prescribed burn or thinning for forests, grasslands, and shrublands.

[101] California Natural Resources Agency. 2022. Natural and Working Lands Climate Smart Strategy. *https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Expanding-Nature-Based-Solutions/CNRA-Report-2022---Final_Accessible_Compressed.pdf*.

The draft set of scenarios for NWL were discussed at a workshop on December 2, 2021 and the scenarios were finalized in February 2022.[102]

The summary below provides an overview of the alternatives designed and considered for the NWL sectors in this update.

Proposed Scenario (modeling scenario Alt 3): Land management activities that prioritize restoration and enhancement of ecosystem functions to improve resilience to climate change impacts, including more stable carbon stocks

NWL Alternative 1: Land management activities that prioritize short term carbon stocks in our forests and through increased climate smart agricultural practices on croplands

NWL Alternative 2: Land management activities representative of California's current commitments and plans

NWL Alternative 4: Land management activities that prioritize reducing wildfires in forests, shrublands, and grasslands

Evaluation of Scoping Plan Alternatives

CARB staff solicited feedback from topical experts, affected stakeholders, and the EJ Advisory Committee at public meetings toward assembling input assumptions for four carbon neutrality scenarios for purposes of modeling using PATHWAYS to inform the plan's update process. These revisions were informed by direction in statute, the Governor's Executive Orders, public comments, and the recommendations of the EJ Advisory Committee. The three alternative scenarios were designed to explore the potential speed, magnitude, and impacts of transitioning California's energy demand away from fossil fuels. The modeling assumptions listed below identify the primary fossil fuel alternative that is commercially available and technically feasible for widespread use by 2045 for each sector. CARB assumes that any energy demand that remains after the alternative technology or fuel is applied—such as on-road internal combustion engines, industrial processes, and gas use in existing buildings that have not yet decarbonized—will continue to be met by fossil fuels, resulting in residual GHG emissions.

[102] CARB. February 28, 2022. Natural and Working Lands Alternative Scenarios. *https://ww2.arb.ca.gov/sites/default/files/2022-02/Revised-NWL-2022SP-Scenario-Assumptions-28Feb.pdf*.

Alternative 1: Carbon Neutral by 2035

Alternative 1 includes many of the same action and clean technology and fuels as the other alternatives and Proposed Scenario, but limits the role of some fuels and technologies. It:

- Accelerates the 2030 target from 40 percent below 1990 levels.
- Aims to achieve carbon neutrality by 2035 by eliminating fossil fuel combustion.
- Nearly phases out all combustion, including fossil, biomass-derived, or hydrogen.
- Requires early retirement of vehicles, appliances, and industrial equipment to eliminate combustion, with aggressive deployment and adoption of non-combustion technologies.
- Directly regulates dairies to achieve the SB 1383 methane target.
- Has a high likelihood of leakage for hard to decarbonize sectors such as cement, aviation, etc., unless carbon capture and sequestration and biomass-derived liquid fuels are utilized.
- Requires CO_2 removal to compensate for non-combustion emissions (industrial process emissions) and short-lived climate pollutants; otherwise it does not achieve carbon neutrality.

Alternative 1 reflects many of the priorities shared by the EJ Advisory Committee. No new digesters or landfill dairy capture would be supported; instead, there would need for an overall reduction in herd size over time and more composting. Oil and gas fugitive methane emissions would be nearly eliminated as combustion is phased out. Hard to electrify sectors such as stone, clay, glass, and cement may need to close unless some amount of CCS is allowed with some combustion technology to meet their energy needs. If demand for those goods persists, there is a high likelihood of leakage for those sectors. Alternatives to cement such as hempcrete may not be suitable for all applications, including heavy load-bearing works. To ensure no transportation fossil fuel combustion in 2035, the state may need to establish programs to buy back vehicles before end of life and help ensure low-income households have access to ZEVs and any required charging access. There would be no petroleum supply to support any internal combustion vehicles after 2035. Similar buy-back programs may need to be established for replacing gas appliances before their end of life because of no availability of gas. Oil and gas extraction and refining operations would be phased out by 2035 as demand for these fuels would also be forced to zero in 2035. In addition, all combustion-based generation resources for electricity would no longer be available. Firming capacity would need to be achieved through hydrogen fuel cells.

Summary of the Alternative 1 modeling:

- Most reduction in fossil fuel combustion in 2035 and 2045
- Most reduction in GHG emissions without the use of mechanical carbon dioxide removal (CDR) in 2035 and 2045

- Highest direct costs due to early retirement of nearly all vehicles and gas appliances by 2035 and large number of end-of-life replacements that begin 10 to 20 years later, around 2045
- Highest rate of slowing for economic growth in 2035 and 2045
- Highest Social Cost of Carbon (highest avoided damages) in 2035 and 2045
- Highest health benefit savings in 2045
- Highest rate of slowing for job growth in 2035, and tied with Alternative 2 in 2045
- High degree of uncertainty due to highest pace of clean energy and technology deployment and adoption

Alternative 2: Carbon Neutral by 2035

Alternative 2 takes an "all tools" approach and does not place any limits on feasible fuels and technologies. It does anticipate strong consumer preferences and adoption of clean fuels and technologies. The list below provides a summary of the key characteristics of this alternative. It:

- Accelerates the 2030 target beyond 40 percent below 1990 levels.
- Aims to achieve carbon neutrality by 2035 by relying on rapid scale-up of CO_2 removal.
- Does not phase out all combustion, including fossil, biomass-derived, or hydrogen combustion.
- Allows for retirement of combustion vehicles, appliances, and industrial equipment at end of life.
- Allows for the capture and use of biogas from dairies to achieve the SB 1383 methane target.
- Allows for the use of CCS for hard to electrify sectors.
- Requires CO_2 removal to compensate for non-combustion emissions (e.g., industrial process emissions) and short-lived climate pollutants.

This alternative reflects direction from some stakeholders and members of the Legislature to evaluate what it would take to achieve carbon neutrality by 2035 while deploying all tools available today. Unlike Alternative 1, this alternative does not exclude biomass-derived fuels or CCS. This alternative also allows for legacy combustion technology to reach a natural end of life with no need for early buyback programs, except in the case of medium- and heavy-duty vehicles. For electricity generation, all Renewable Portfolio Standard and SB 100 Zero Carbon sources are allowed. Oil and gas extraction and refining operations are phased down in line with the reduction in demand. To the extent demand persists past 2045, oil and gas extraction and refining would continue, but they are paired with CCS where applicable to avoid shutting down operations while still reducing GHG emissions.

Summary of Alternative 2 modeling:

- Second most reduction in fossil fuel combustion in 2035 and 2045

- Second most reduction in GHG emissions without the use of CDR in 2045
- Second highest direct costs due to significant investment in CDR in 2035
- Second highest rate of slowing for economic growth in 2045
- Second highest Social Cost of Carbon (second highest avoided damages) in 2035 and 2045
- Second highest health benefit savings in 2045, comparable to the Proposed Scenario
- Second highest rate of slowing for job growth in 2035, and tied with Alternative 1 in 2045
- High degree of uncertainty due to the highest pace of mechanical CDR deployment

Alternative 4: Carbon Neutral by 2045

Alternative 4 takes an "all tools" approach and does not place any limits on feasible fuels and technologies. It anticipates a less aggressive adoption of clean fuels and technologies by consumers and slower rates of clean fuels and technology deployment. The list below provides a summary of the key characteristics of this alternative. It:

- Achieves the 2030 target of 40 percent emissions reductions from 1990 levels.
- Aims to achieve carbon neutrality by 2045 by reducing direct emissions while transitioning away from fossil fuels.
- Does not phase out all combustion, including fossil, biomass-derived, or hydrogen combustion.
- Allows for retirement of combustion vehicles, appliances, and industrial equipment at end of life.
- Allows for the capture and use of biogas from dairies to achieve the SB 1383 methane target.
- Allows for the use of CCS for hard to electrify sectors.
- Requires a larger amount of CO_2 removal to compensate for non-combustion emissions (industrial process emissions) and short-lived climate pollutants than the Proposed Scenario does.

This alternative reflects modeling that was conducted for the AB 74 Studies on Vehicle Emissions and Fuel Demand and Supply. Like the Proposed Scenario, this alternative does not exclude biomass-derived fuels or CCS. This alternative also allows for legacy combustion technology to reach a natural end of life with no need for early buyback programs. For electricity generation, all Renewable Portfolio Standard and SB 100 Zero Carbon sources are allowed. Oil and gas extraction and refining operations are phased down in line with the reduction in demand. To the extent demand persists past 2045, oil and gas extraction and refining would continue, but paired with CCS where applicable to avoid leakage and manage GHG emissions. This scenario results in the largest share of fossil fuels remaining in the economy in 2045. Also, this scenario does not achieve the 2050 80 percent reduction in GHGs below 1990 levels as called for in Executive Order S-3-05.

Summary of Alternative 4 modeling:

- Least reduction in fossil fuel combustion in 2045
- Least reduction in GHG emissions without the use of CDR in 2045
- Third highest direct costs in 2034 and 2045, comparable to the Proposed Scenario
- Second highest rate of slowing for economic growth in 2045
- Least Social Cost of Carbon (least avoided damages) in 2035 and 2045
- Less health benefit savings in 2045, comparable to the Proposed Scenario
- Second least rate of slowing for job growth in 2035 and tied with the Proposed Scenario in 2035
- Lesser degree of uncertainty, due to longer time frame for clean energy and technology (including CDR) to be deployed

NWL Scoping Plan Alternatives

For the NWL sectors, staff significantly expanded the scale of the scientific analysis for NWL from previous Scoping Plan efforts. CARB staff utilized modeling tools for this expanded analysis to assess both the carbon and other ecological, public health, and economic outcomes of management actions on forests, shrublands, grasslands, croplands, developed lands, wetlands, and sparsely vegetated lands. CARB staff aligned the scenarios with both the landscape types and actions identified in other efforts called for in the Governor's Executive Order (e.g., California's Climate Smart Strategy and Pathways to 30x30). As part of the 2022 Scoping Plan update, CARB staff modeled as many of the management actions identified in the Natural and Working Lands Climate Smart Strategy as were feasible. The management actions that were included in the model were selected because of the State of California's previous work to quantify these actions' impacts. It was not feasible to model every land management strategy for NWLs, and so it is possible that larger volumes of sequestration (e.g., in soils or in oceans) could result from additional non-modeled activities. California's Natural and Working Lands Climate Smart Strategy includes a more comprehensive listing of priority nature-based solutions and management actions. It is important to note that the absence of a particular management action or its climate benefit in the modeling is not an indication of its importance or potential contributions toward meeting the target or toward supporting the carbon neutrality target for California.

Forests: Management strategies modeled for forests: biological/chemical/herbaceous treatments (e.g., herbicide application), clearcut, various timber harvests (e.g., variable retention, seedtree/shelterwood, selection harvesting), mastication, other mechanical treatments (e.g., piling of dead material, understory thinning), prescribed burning, and thinning. Avoided land conversion to another land use is also included in the modeling. Wildfire is modeled and is responsive to management strategies and climate conditions.

Shrublands and chaparral: Management strategies modeled for shrublands and chaparral: biological/chemical/herbaceous treatments, prescribed burning, mechanical treatment (e.g., mastication, crushing, mowing, piling), and avoided conversion from shrubland to another land use. Wildfire is modeled and is responsive to management strategies and climate conditions.

Grasslands: Management strategies modeled for grasslands: biological, chemical, herbaceous treatments, prescribed burning, and avoided land conversion from grasslands to another land use. Wildfire is modeled and is responsive to management strategies and climate conditions.

Croplands: Management strategies modeled for row crops: cover cropping, no till, reduced till, compost amendment, transition to organic[103] farming, avoided conversion of annual crop agricultural land through easements, establishing riparian forest buffers, alley cropping, establishing windbreaks/shelterbelts, establishing tree and shrubs in croplands, and establishing hedgerows. For perennial crops, windbreaks/shelterbelts, hedgerows, conversion from annual crops to perennial crops, and avoided conversion to other land uses were modeled.

Developed lands: Management strategies modeled for developed lands: Increasing tree canopy cover through planting trees and improved management of existing trees, and removing vegetation surrounding structures in accordance with the CALFIRE Defensible Space PRC 4291.

Wetlands: Management strategies modeled for wetlands: Restoring wetlands through submerging cultivated land in the Sacramento-San Joaquin Delta and avoided land conversion in the Sacramento-San Joaquin Delta.

Sparsely vegetated lands: Management strategies modeled for sparsely vegetated lands: Avoided conversion of sparsely vegetated lands to another land use.

NWL Alternative 1: Land management activities that prioritize short term carbon stocks in our forests and through increased climate smart agricultural practices on croplands.

NWL Alternative 1 takes a “no management” approach for forests, shrublands/chaparral, and grasslands to maximize short term carbon stocks while maintaining current fire suppression levels. Climate smart agriculture practices are maximized to increase carbon on croplands. The list below provides a summary of the alternative’s key characteristics:

- No change in fire suppression

[103] Note: N_2O reductions from decreases in synthetic fertilizer application in organic farming were not modeled.

- Goal is to increase climate smart agricultural practices to the maximum level feasible based on topography, water, and agronomic constraints.
- Significant amount (30 percent by 2045) of croplands change from conventional to organic farming
- Significant increase in statewide urban forest investment to maximize carbon storage in urban forests
- Compliance with CalFire defensible space requirements of PRC 4291 on all parcels up to ownership boundaries
- Maximum number of acres (120,000 acres) of Delta wetlands restoration
- Sparsely vegetated lands are prevented from conversion to another land use.

This alternative reflects stakeholder feedback to reduce management on forests . It maximizes the retention of aboveground carbon stocks on these land types in the short term and allows climate change and disturbance to determine the long-term carbon and wildfire emissions trends. In this alternative, other land types outside of forests, shrublands/chaparral, and grasslands receive extremely aggressive levels of management practices in order to increase carbon stocks immediately, and were established through discussions with other state agencies. For example, the climate smart agriculture practice acreages were determined based on feedback from the California Department of Food and Agriculture (CDFA) and their familiarity with the technical limits of these practices. The large increase in statewide urban forest investment (a 20x increase relative to historic levels) was chosen to illuminate the maximum potential for carbon sequestration in urban forests. The implementation rates in both agriculture and urban forestry are at the upper end of feasibility due to technical, financial, and policy-related constraints that govern management decisions.

NWL Alternative 1 results in the most significant air quality related health impacts from $PM_{2.5}$ wildfire emissions of any scenario. It also has the highest direct costs of any scenario by an order of magnitude because of the large increases in urban forestry expansion and maintenance costs. This scenario also has the largest reduction in personal income as funding is shifted to support urban forestry maintenance.

NWL Alternative 2: Current state commitments and plans will be the basis for the land management activities.

NWL Alternative 2 bases the modeled acreage on current state commitments where they exist. The One Million Acre Strategy, 30x30 Strategy, and other existing regional commitments and plans were referenced for this scenario. The list below provides a summary of the key assumptions of this alternative:

- An increase from the Reference Scenario to 1 million acres treated across forest, shrubland/chaparral, and grasslands focused on fuel reduction treatments, consistent

with the currently announced California/United States Forest Service Shared Stewardship Agreement[104]
- Second highest increases in climate smart agricultural practices
- Second highest increase in statewide urban forest investment
- Compliance with CalFire defensible space requirements of PRC 4291 on all parcels up to ownership boundaries
- Restoration of Delta wetlands in line with existing regional plans
- More reduction in land conversion of sparsely vegetated lands than Alternative 1

This alternative was developed to assess the impact of existing state commitments and plans on future carbon stocks and sequestration rates. For land types that do not currently have these commitments, CARB scaled acreages to complement the range of acreages among all the alternatives while maintaining an aggressive rate of implementation. All practices are increased over the Reference Scenario. This will help provide insight into the range of outcomes that can be expected for NWL and help set a realistically ambitious target.

NWL Alternative 2 results in higher wildfire $PM_{2.5}$ emissions than the Proposed Scenario, and therefore more air quality related health impacts than the Proposed Scenario. This scenario also has the second highest direct costs of any scenario. It also has the second largest reduction in personal income as funding is shifted to support urban forestry maintenance.

NWL Alternative 4: Land management activities that prioritize reducing forest, shrubland, and grassland wildfire fuels.

NWL Alternative 4 prioritizes actions on forests, shrubland/chaparral, and grasslands that reduce wildfire risks. The list below provides a summary of the key assumptions of this alternative:

- Significant increase in acres treated across forests, shrubland/chaparral, grasslands, focused on fuel reduction treatments
- Limited prescribed burning in chaparral
- Modest increase in climate smart agricultural practices
- Modest increase in statewide urban forest investment

[104] State of California and the USDA, Forest Service. August 12, 2020. Agreement for Shared Stewardship of California's Forest and Rangelands Between the State of California and the USDA, Forest Service Pacific Southwest Region. *https://www.gov.ca.gov/wp-content/uploads/2020/08/8.12.20-CA-Shared-Stewardship-MOU.pdf*.

- Compliance with CalFire defensible space requirements of PRC 4291 on all parcels up to the maximum defensible space distance regardless of ownership boundaries
- Restoration of Delta wetlands in line with existing regional plans
- Modest reduction in land conversion of sparsely vegetated lands

This alternative analyzes reducing wildfire risk as the top priority for the state, which results in an approximately 20x increase in forest management and fuels reduction treatments. The acreage of fuels reduction treatments on forests, shrublands/chaparral, and grasslands is based on the low end of the range of the historic estimated annual area burned during the Little Ice Age. This historic annual area burned range was assessed as part of CARB's analysis for the report *California's Historical Wildfire Activity before Modern Wildfire Suppression* developed pursuant to SB 901. This amount of treatment acreage attempts to replicate how much area was historically disturbed by fire, in order to explore how this level of treatment would affect carbon stocks and sequestration. Within wildland urban interface (WUI) areas, creation of defensible space was modeled to the maximum distance required under Public Resources Code (PRC) 4291, regardless of whether this resulted in the removal of vegetation beyond a parcel's ownership boundary. This maximizes the protection afforded to each parcel through defensible space.

In other land types, which are less susceptible to wildfires and their impacts, implementation rates are above Reference Scenario rates but were decreased compared to all other alternatives (except for Delta wetlands, which were set equal to Alternative 2). This was to highlight this alternative's primary focus on wildfire risk reduction.

NWL Alternative 4 has the least amount of wildfire emissions, and therefore has the most health benefits of any scenario. This alternative results in significant shifts in employment in the forestry and logging sector because of the very rapid and significant increase of forest management to 5 million acres annually, starting in 2025. This scenario also results in the second largest reduction in gross state product (GSP) but has the lowest reduction in personal income of any scenario, as employment shifts from state and local government and from construction jobs to forestry and logging.

Comparison of Alternatives with the Proposed Scenario

This section compares the Proposed Scenario to the three alternatives discussed above for both the AB 32 GHG Inventory and NWL sectors. The comparison includes reference to the GHG emissions modeling and economic, jobs, and health analyses discussed in more detail in Chapter 3.

The Proposed Scenario and Alternative 4 have a higher feasibility for implementation compared to Alternative 1 and 2. The annual build out rates for solar in Alternative 1 and Alternative 2 are 10 gigawatts (GW) and 5 GW, respectively. The annual solar build rate to date is 2.7 GW. The

amount of additional renewables needed for producing hydrogen for those alternatives is an additional 47 GW and 44 GW, respectively. In contrast the Proposed Scenario has an annual build out of solar of 7 GW. The amount of CDR needed in 2035 is 48 MMT and 154 MMT, respectively, by 2035. The current rate of direct air capture globally is 0.01 MT/yr. The additional energy needed for electrolysis is 41 GW. The Proposed Scenario assumes 0 MMT in 2035 for CDR. The unprecedented and ambitious build out of renewables by 2035 will be challenging when considering the types of implementation uncertainty discussed in the Scenario Uncertainty section of this chapter. Achieving carbon neutrality also provides a longer time horizon for technologies, such as CCS and direct air capture, to scale and come down in costs. While ambitious, the Proposed Scenario has higher feasibility due to the longer time frame and aggressive, yet slightly slower, pace to build out the clean energy and carbon removal infrastructure.

When comparing the Proposed Scenario to Alternative 4, the Proposed Scenario delivers more air quality benefits, and it has lower direct costs and the least slowing of the economy and job growth. It has the highest social cost of carbon of the two, meaning it reduces the most GHGs to deliver higher avoided costs. And, while the Proposed Scenario delivers the most benefits at lower costs when compared to Alternative 4, it is still worth considering how it compares to Alternative 1 and 2:

- In 2035, Alternative 1 and 2 slow job growth 5x and 3x, respectively, more than the Proposed Scenario.
- In 2035, Alternative 1 and 2 have direct costs of 7x and 6x, respectively, more than the Proposed Scenario.
- In 2035, Alternative 1 and 2 slow economic growth 8x more than the Proposed Scenario in 2035. Alternative 1 and 2 slow economic growth 6x and 5x, respectively, more than the Proposed Scenario in 2045.
- Alternative 1 delivers the most health savings in 2045, but it comes with the highest cost and impacts to the economy and jobs, and least feasibility due to the pace of growth needed for clean energy.
- Alternative 2 delivers the second most health savings in 2045, comparable to the Proposed Scenario, but with the second highest costs and impacts to the economy and jobs. It also has low feasibility, comparable to Alternative 1, due to the pace of infrastructure build out needed for CO_2 removal and clean energy to support direct air capture.

All four alternatives for the AB 32 Inventory are aggressive and reduce petroleum use from 81 to 99 percent below 2022 levels. The Proposed Scenario reduces petroleum use 91 percent in 2045 from 2022 levels. On balance, the Proposed Scenario is more feasible than Alternative 1 and Alternative 2 due to the longer time frame for clean technology and fuel deployment. The section on Implementation Uncertainty includes several examples of feasibility concerns. The

additional 10 years for achieving carbon neutrality also allow for technologies to scale and be deployed at lower costs. The Proposed Scenario provides significant health benefits in 2045 compared to the Reference Scenario and has the least slowing effect on employment and economic growth.

Table 2-1 provides a summary of the key metrics considered in the process to identify an alternative for the AB 32 GHG Inventory sector for the Proposed Scenario.

Table 2-1: AB 32 GHG Inventory sector alternatives key metric ranking[105]

	Alternative 1	Alternative 2	Proposed Scenario	Alternative 4
Reduction in Fossil Fuel Demand in 2045	*	*	*	*
GHG Reductions without CDR in 2045	*	*	*	*
Social Cost of Carbon (avoided damages 2045)	*	*	*	*
Health Benefit Savings in 2045	*	*	*	*
Direct Costs in 2045	*	*	*	*
Slowing of GDP in 2045	*	*	*	*
Slowing of Employment in 2045	* *	* *	*	*
Feasibility/Implementation Risk in 2035	*	*	*	*
Legend	*highest	*mid high	*mid low	*lowest

In terms of Natural and Working Lands, the Proposed Scenario has the highest NWL carbon stocks in 2045 of any of the three scenarios that also provide wildfire risk reduction and public

[105] Please see Chapter 3 for additional detail on key metrics provided in the table.

health benefits, and the second-highest average annual GHG reductions of any scenario over 20 years. The Proposed Scenario also represents a significant increase in climate action on NWLs, by providing an almost 10x increase in forest, grassland and shrubland action; 5x increase in healthy soils practices; 2x increase in organic agriculture; 20 percent increase in urban forestry investment; and significant wetlands restoration and desert land protection relative to historic levels. The Proposed Scenario, relative to the NWL Alternatives, provides the best balance of carbon stock outcomes, GHG emission reductions, increased pace/scale of climate action, costs and economic impacts, implementation feasibility, and co-benefits from land management across the NWL landscapes.

- Only NWL Alternative 1 provides more GHG reductions from lands but comes with a 25x increase in direct costs relative to NWL Alternative 3. And while NWL Alternative 1 is the scenario with higher carbon stocks in 2045, it also results in the highest wildfire emissions of any scenario.
- The Proposed Scenario provides the lowest implementation cost compared to NWL Alternatives 1, 2, and 4.
- The Proposed Scenario has the smallest change in total GSP and employment metrics compared to NWL Alternatives 1, 2, and 4.
- NWL Alternatives 1, 2, and 4 have higher implementation uncertainty because they rely on significant and unprecedented levels of management and investment in urban forestry, croplands, and forests, shrublands, and grasslands.
- The Proposed Scenario has over $3 billion in annual health costs savings from reduced wildfire air pollution, which is the second highest health benefits of any scenario. Only NWL Alternative 4 has higher health cost savings, but it comes with significant implementation uncertainty because it requires rapid and unprecedented increases in management for forests, shrublands, and grasslands.
- The Proposed Scenario and NWL Alternative 4 produce higher levels of biomass relative to NWL Alternatives 1 and 2. The Proposed Scenario is likely to generate the second highest technically recoverable biomass residue for use in product markets or for use with CDR technologies to sequester an estimated 5–10 million metric tons of carbon dioxide equivalent ($MMTCO_2e$) annually. Only NWL Alternative 4 has a higher amount of biomass available in 2045.

Overview of the Proposed Scenario

The Proposed Scenario achieves GHG emission reductions that exceed levels expected based on existing policies represented in the Reference scenario, keeping California on track to achieve the SB 32 GHG reduction target for 2030 and become carbon neutral no later than 2045. Actions that reduce GHG emissions and transition AB32 GHG Inventory sources away from fossil fuel combustion affect each economic sector. Actions that lead to improved carbon stocks affect each landscape.

AB 32 GHG Inventory Sectors

The AB 32 GHG Inventory Sector Reference scenario is the forecasted statewide GHG emissions through mid-century, with existing policies and programs but without any further action to reduce GHGs beyond those needed to achieve the 2030 limit. The Reference scenario was developed based on other projections of business-as-usual conditions. Sources of data and policies included are:

- California Energy Demand Forecast[106]
- The two transportation carbon neutrality studies required by AB 74[107]
- The Mobile Source Strategy[108]
- SB 100 60 percent Renewables Portfolio Standard
- Low Carbon Fuel Standard carbon intensity reduction target of 20 percent

Policies that are under study or design, such as the SB 100 zero-carbon electricity by 2045 or Advanced Clean Trucks regulation, are not included. The Reference scenario reflects current trends and expected performance of policies identified in the 2017 Scoping Plan update—some of which are performing better, such as the renewable portfolio standard (RPS) and LCFS, and others that may not meet expectations, such as vehicle miles traveled (VMT) reductions and methane capture. Figure 2-1 provides the modeling results for a Reference Scenario for the AB 32 GHG Inventory sectors compared to the Proposed Scenario.

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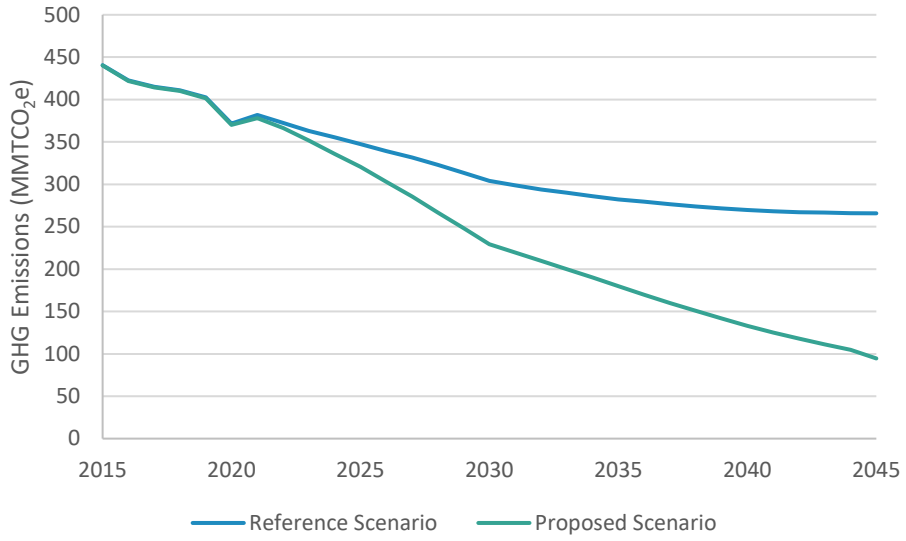
[106] California Energy Commission. 2020. *2019 Integrated Energy Policy Report.* https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2019-integrated-energy-policy-report.
[107] Brown et al. 2021. *Driving California's Transportation Emissions to Zero.* https://escholarship.org/uc/item/3np3p2t0 and Deschenes et al. 2021. *Enhancing equity while eliminating emissions in California's supply of transportation fuels.* https://zenodo.org/record/4707966#.YI72RNrMKUn.
[108] CARB. 2021. 2020 *Mobile Source Strategy.* https://ww2.arb.ca.gov/sites/default/files/2021-12/2020_Mobile_Source_Strategy.pdf.

Figure 2-1: Reference and Proposed Scenario GHG emissions



The Proposed Scenario is summarized in Table 2-2. The table shows the types of technologies and energy needed to drastically reduce GHG emissions from the AB 32 Inventory sectors. It also includes references to relevant statutes and Executive Orders yet is not comprehensive of all existing authorities or any new authorities for actions described. Each action is expected to both reduce GHGs and help improve air quality, primarily by transitioning away from combustion of fossil fuels.

Table 2-2: Actions for the Proposed Scenario: AB 32 GHG Inventory sectors

Sector	Action	Statutes, Executive Orders, Outcome
GHG emissions reductions relative to the SB 32 target	40% below 1990 levels by 2030	SB 32: reduce statewide GHG emissions AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Smart Growth / Vehicle Miles Travelled (VMT)	VMT per capita reduced 12% below 2019 levels by 2030 and 22% below 2019 levels by 2045	SB 375: reduce demand for fossil transportation fuels and GHGs, and improve air quality
Light duty vehicle (LDV) Zero Emission Vehicles (ZEVs)	100% of LDV sales are ZEV by 2035	EO N-79-20: reduce demand for fossil transportation fuels and GHGs, and improve air quality AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Truck ZEVs	AB 74 ITS report: 100% of medium duty (MD)/HDV sales are ZEV by 2040	EO N-79-20: reduce demand for fossil transportation fuels and GHGs, and improve air quality AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Aviation	10% of aviation fuel demand is met by electricity (batteries) or hydrogen (fuel cells) in 2045 Sustainable aviation fuel meets most or the rest of the aviation fuel demand that has not already transitioned to hydrogen or batteries	Reduce demand for petroleum aviation fuel and reduce GHGs AB 197: direct emissions reductions for sources covered by the AB 32 Inventory

Sector	Action	Statutes, Executive Orders, Outcome
Ocean-going Vessels (OGV)	2020 OGV At-Berth regulation fully implemented with most OGVs utilizing shore power by 2027 25% of OGVs utilize hydrogen fuel cell electric technology by 2045	Reduce demand for petroleum fuels and GHGs, and improve air quality B 197: direct emissions reductions for sources covered by the AB 32 Inventory
Port Operations	Executive Order N-79-20: 100% of cargo handling equipment (CHE) is zero-emission by 2037 100% of drayage trucks are zero emission by 2035	Reduce demand for petroleum fuels and GHGs, and improve air quality AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Freight and Passenger Rail	100% of passenger and other locomotive sales are ZEV by 2030 100% of line haul locomotive sales are ZEV by 2035 Line haul and passenger rail rely primarily on hydrogen fuel cell technology, and others primarily utilize electricity	Reduce demand petroleum fuels and GHGs, and improve air quality AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Oil & Gas Extraction	Phase out operations by 2045	Reduce GHGs and improve air quality AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Petroleum Refining	CCS on majority of operations by 2030 Production reduced in line with petroleum demand	Reduce GHGs and improve air quality AB 197: direct emissions reductions

Sector	Action	Statutes, Executive Orders, Outcome
Electricity Generation	Sector GHG target of 38 MMTCO$_2$e in 2030 and 30 MMTCO$_2$e[109] in 2045 Retail sales load coverage[110]	SB 350 and SB 100: reduce GHGs and improve air quality AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
New Residential and Commercial Buildings	All electric appliances beginning 2026 (residential) and 2029 (commercial)	Reduce demand for fossil gas and GHGs, and improve ambient and indoor air quality AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Existing Residential Buildings	80% of appliance sales are electric by 2030 and 100% of appliance sales are electric by 2035 Appliances are replaced at end of life	Reduce demand for fossil gas and GHGs, and improve ambient and indoor air quality AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Existing Commercial Buildings	80% of appliance sales are electric by 2030 and 100% of appliance sales are electric by 2045 Appliances are replaced at end of life	Reduce demand for fossil gas and GHGs, and improve ambient and indoor air quality AB 197: direct emissions reductions for sources covered by the AB 32 Inventory

[109] The 2045 target is based on the Proposed Scenario modeling results and corresponds to meeting 100 percent retail sales with eligible renewable and zero-carbon resources.
[110] SB 100 speaks only to retail sales and state agency procurement of electricity. The *2021 SB 100 Joint Agency Report* interprets this to mean that other loads–wholesale or non-retail sales and losses from storage and transmission and distribution lines are not subject to the law.

Sector	Action	Statutes, Executive Orders, Outcome
Food Products	7.5% energy demand electrified directly and/or indirectly by 2030; 75% by 2045	Reduce demand for fossil gas and GHGs, and improve air quality AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Construction Equipment	25% energy demand electrified by 2030 and 75% by 2045	Reduce demand for fossil energy and GHGs, and improve air quality AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Chemicals and Allied Products; Pulp and Paper	Electrify 0% of boilers by 2030 and 100% of boilers by 2045 Hydrogen for 25% of process heat by 2035 and 100% by 2045 Electrify 100% of other energy demand by 2045	Reduce demand for fossil energy and GHGs, and improve air quality AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Stone, Clay, Glass & Cement	CCS on 40% of operations by 2035 and on all facilities by 2045 Some process emissions reduced through alternative materials	SB 596: reduce demand for fossil energy, process emissions, GHGs, and improve air quality AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Other Industrial Manufacturing	0% energy demand electrified by 2030 and 50% by 2045	Reduce demand for fossil energy and GHGs, and improve air quality AB 197: direct emissions reductions for sources covered by the AB 32 Inventory

Sector	Action	Statutes, Executive Orders, Outcome
Combined Heat and Power	Facilities retire by 2040	Reduce demand for fossil energy and GHGs, and improve air quality AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Agriculture Energy Use	25% energy demand electrified by 2030 and 75% by 2045	Reduce demand for fossil energy and GHGs, and improve air quality AB 197: direct emissions reductions
Low Carbon Fuels for Transportation	Biomass supply used to produce conventional and advanced biofuels, as well as hydrogen	Reduce demand for petroleum fuel and GHGs, and improve air quality AB 197: direct emissions reductions for sources covered by the AB 32 Inventory
Low Carbon Fuels for Buildings and Industry	In 2030s renewable natural gas (RNG) blended in pipeline Renewable hydrogen blended in natural gas pipeline at 7% energy (~20% by volume), ramping up between 2030 and 2040 In 2030s, dedicated hydrogen pipelines constructed to serve certain industrial clusters	Reduce demand for fossil energy and GHGs, and improve air quality AB 197: direct emissions reductions for sources covered by the AB 32 Inventory

Sector	Action	Statutes, Executive Orders, Outcome
Non-combustion Methane Emissions	Increase landfill and dairy digester methane capture Some alternative manure management deployed for smaller dairies Moderate adoption of enteric strategies by 2030 Divert 75% of organic waste from landfills by 2025 Oil and gas fugitive methane emissions reduced 50% by 2030 and further reductions as infrastructure components retire in line with reduced fossil gas demand	SB 1383: reduce short-lived climate pollutants
High Global Warming Potential Emissions	Low GWP refrigerants introduced as building electrification increases mitigating HFC emissions	SB 1383 reduce short-lived climate pollutants

Natural and Working Lands

The Reference Scenario for NWL represents the amount of land management that occurred between 2001 and 2014, and projects the outcomes from maintaining the 2001–2014 levels of land management until 2045. The management and land use practices that occur within the Reference Scenario are derived from empirical data used by staff. For forests, shrublands/chaparral, and grasslands, the Reference Scenario constitutes approximately 250,000 acres of annual statewide treatments. For croplands, the Reference Scenario represents no healthy soil practices because during this period the healthy soil program did not yet exist. For land use change within all land types that consider land use change, historical rates of land conversion from 2001–2014 also are taken from empirical data and modeled into the future for the Reference Scenario.

Table 2.3 summarizes the Proposed Scenario. The table also includes references to relevant statutes and Executive Orders where available.

Table 2-3: Actions for the Proposed Scenario: NWL sectors

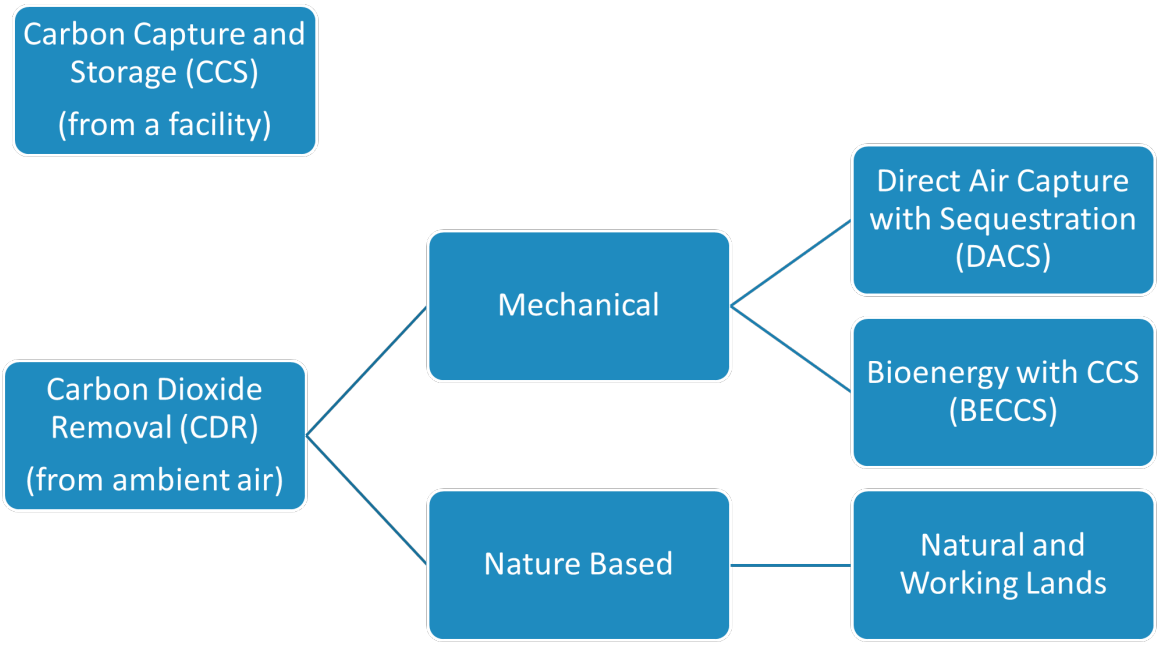
Sector	Action	Statutes, Executive Orders, Outcome
Natural and Working Lands	Conserve 30% of the State's NWLs and coastal waters by 2030. Implement near- and long-term actions to accelerate natural removal of carbon and build climate resilience in our forests, wetlands, urban greenspaces, agricultural soils, and land conservation activities in ways that serve all communities and in particular low-income, disadvantaged, and vulnerable communities.	EO N-82-20 and SB 27: CARB to include an NWL target in the Scoping Plan SB 1386: NWL an important strategy in meeting GHG reduction goals
Forests and Shrublands	2–2.5 million acres treated statewide annually in forests, shrublands/chaparral, and grasslands, comprised of regionally specific management strategies that include prescribed fire, thinning, harvesting, and other management actions. No land conversion of forests, shrublands/chaparral, or grasslands.	Restore health and resilience to overstocked forests and prevent carbon losses from severe wildfire, disease, and pests. Improve air quality and reduce health costs related to wildfire emissions. Improve water quantity and quality and improve rural economies. Provide forest biomass for resource utilization. EO B-52-18: CARB to increase the opportunity for using prescribed fire. AB 1504: CARB to recognize the role forests play in carbon sequestration and climate mitigation.

Sector	Action	Statutes, Executive Orders, Outcome
Grasslands	The 2–2.5 million acres treated includes increased management of grasslands interspersed in forests to reduce fuels surrounding communities using management strategies appropriate for grasslands. No land conversion of forests, shrublands/chaparral, or grasslands.	Reduce wildfire emissions, improve air quality, and reduce health costs.
Croplands	Implement climate smart practices for annual and perennial crops on ~50,000 acres annually. Land easements/ conservation on annual crops at ~6,000 acres annually. Increase organic agriculture to 20% of all cultivated acres by 2045 (~65,000 acres annually).	Reduce short-lived climate pollutants. Increase soil water holding capacity. Increase organic farming and reduce pesticide use. SB 859: Recognized the ability of healthy soils practices to reduce GHG emissions from agricultural lands.
Developed Lands	Urban forestry investment increase of 20% above current levels and utilize tree watering that is 30% less sensitive to drought. Establish defensible space that accounts for property boundaries.	Increase urban tree canopy and shade cover. Reduce heat island effects and support water infrastructure. Reduce fire risk via defensible space.
Wetlands	Restore 60,000 acres of Delta wetlands.	Increase carbon sequestration and reduce short-lived climate pollutants. Helps to reverse land subsidence while improving flood protection and providing critical habitat
Sparsely Vegetated Lands	Land conversion at 50% of the Reference Scenario land conversion rate.	Reduce the rate of land conversion to more GHG-intensive land uses.

Proposed Strategies for Carbon Removal and Sequestration

To achieve carbon neutrality, any remaining emissions must be compensated for using carbon removal and sequestration tools. The following discussion presents more detail on the options available to capture and sequester carbon. Carbon removal and sequestration will be an essential tool to achieve carbon neutrality. The modeling clearly shows, there is no path to carbon neutrality without carbon removal and sequestration. Carbon removal and sequestration can take different forms. Figure 2-2 illustrates the forms of carbon removal and sequestration considered in the Draft 2022 Scoping Plan. There are numerous other carbon removal options under research, development, and pilot deployment. As those mature and new types emerge, those would be considered for future scoping plan updates.

Figure 2-2: Forms of carbon removal and sequestration considered in the Draft 2022 Scoping Plan



The Proposed Role of Carbon Capture and Sequestration

Carbon capture and sequestration (CCS) will be a necessary tool to reduce GHG emissions and mitigate climate change while minimizing leakage. CCS is a process by which large amounts of CO_2 are captured, compressed, transported, and sequestered. CCS projects are paired with a source of emissions as the CCS project captures CO_2 as it leaves a facility's smokestack. CCS projects are often paired with large GHG-emitting facilities such as energy, manufacturing, or fuel production facilities. The sequestration component of CCS includes CO_2 injection into

geologic formations (such as depleted oil and gas reservoirs and saline formations), as well as use in industrial materials (e.g., concrete). CCS is distinct from biological sequestration, which is typically accomplished through NWL management and conservation practices that enhance the storage of carbon or reduce CO_2 emissions with nature-based approaches. CCS is also distinct from mechanical CO_2 removal technologies where CO_2 is removed directly from the atmosphere using mechanical and/or chemical processes.

CARB adopted a CCS Protocol in 2018 as part of amendments to the Low Carbon Fuel Standard.[111] At this time, no CCS projects have been implemented or generated any credits under that protocol. However, CCS projects have been implemented elsewhere since the 1970s, with over two dozen projects operational around the world, and over 100 more at the stages of advanced or early development.[112] CCS projects are in development for addressing emissions from fuel, gas, energy production, and chemical production. As of November 2019, more than half of the global large-scale CCS facilities (representing approximately 22 $MMTCO_2$/yr in capacity[113]) were in the U.S., mostly as a result of sustained government support for the technologies.[114] This support includes the federal 45Q tax credit for CCS[115] and research and deployment grants from federal agencies.[116,117,] California's deep sedimentary rock formations in the Central Valley represent world-class CO_2 storage sites that would meet the highest standards, with storage capacities of at least 17 billion tons of CO_2.[118,119] In the Proposed Scenario modeling, CCS is included in limited sectors, including cement production facilities and

[111] CARB. 2022. Carbon Capture & Sequestration. *https://ww2.arb.ca.gov/our-work/programs/carbon-capture-sequestration*.
[112] Global CCS Institute. 2021. *Global Status of CCS 2021.* *https://www.globalccsinstitute.com/wp-content/uploads/2021/11/Global-Status-of-CCS-2021-Global-CCS-Institute-1121.pdf*.
[113] IHS Markit. August 2021. Carbon Removal Potential: An Overview. *https://ww2.arb.ca.gov/sites/default/files/2021-08/ihsmarkit_presentation_sp_engineeredcarbonremoval_august2021.pdf*.
[114] Beck, Lee. 2019. *Carbon capture and storage in the USA: The role of US innovation leadership in climate-technology commercialization.* *https://academic.oup.com/ce/article/4/1/2/5686277*.
[115] Congressional Research Service. 2021. Carbon Storage Requirements in the 45Q Tax Credit. IF11639. *https://crsreports.congress.gov/product/pdf/IF/IF11639*.
[116] U.S. Department of Energy. 2020. U.S. Department of Energy Announces $131 Million for CCUS Technologies. *https://www.energy.gov/articles/us-department-energy-announces-131-million-ccus-technologies*.
[117] U.S. Department of Energy. 2021. Funding Opportunity Announcement 2515, Carbon Capture R&D for Natural Gas and Industrial Point Sources, and Front-End Engineering Design Studies for Carbon Capture Systems at Industrial Facilities and Natural Gas Plants. *https://www.energy.gov/fecm/articles/funding-opportunity-announcement-2515-carbon-capture-rd-natural-gas-and-industrial*.
[118] For comparison purposes, California's emitted 418.2 million metric-tons of CO_2e in 2019.
[119] Lawrence Livermore National Laboratory. 2020. *Getting to Neutral: Options for Negative Carbon Emissions in California.* Revision 1. *https://www-gs.llnl.gov/content/assets/docs/energy/Getting_to_Neutral.pdf.*

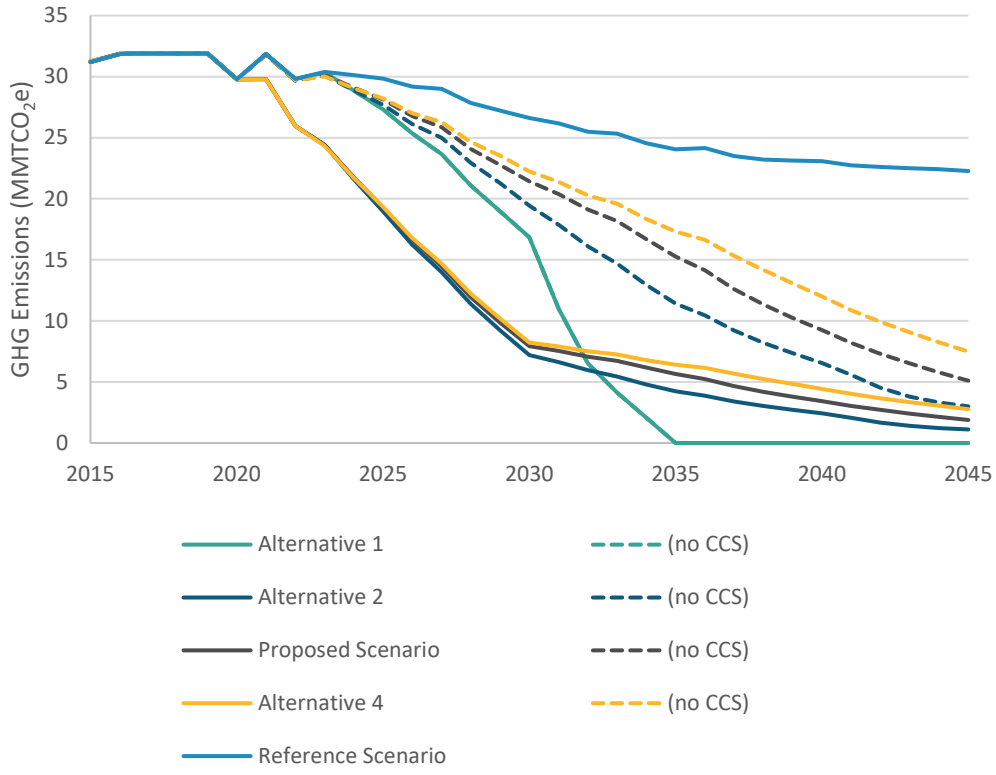
refineries. In addition, CCS can support clean dispatchable power for reliability needs and hydrogen production until such time as there is sufficient renewable power for electrolysis.

Cement plants have emissions associated with combustion and process-related activities. Combustion emissions account for approximately 40 percent of the total emissions at the cement plants. The remaining emissions are related to process-related activities. Due to the high heat content needed to produce cement, there is currently no technically feasible alternative to combustion. SB 596 calls for a 40 percent reduction in GHG intensity in cement emissions from 2019 levels by 2035, and then net zero emissions by 2045. To meet in-state demand, the state relies on cement both produced in state and imported. To minimize emissions leakage and address emissions from cement plants, the Proposed Scenario assumes CCS for cement plants. Additional reductions will need to be pursued and considered as part of implementation of SB 596, which calls for CARB to develop a comprehensive strategy by July 1, 2023, for the state's cement sector to achieve net-zero emissions of GHGs associated with cement used within the state as soon as possible, but no later than December 31, 2045. This effort will begin in the summer of 2022 and include sector specific workshops.

The Proposed Scenario also assumes CCS for petroleum refineries. Even with implementation of EO N79-20, and despite all ambitious efforts in this scenario, there will remain some demand for petroleum fuels for legacy vehicles on road, and in aviation, rail, and marine applications. On the supply side, the modeling assumes all in-state demand is met through some very limited refining activities in California. Figure 2-3 shows the emissions from the refining sector with and without CCS. If CCS is not deployed, the emissions would be directly emitted into the atmosphere, and CO_2 removal by NWL or direct air capture would need to increase to compensate for the sector's emissions. Refineries can have a variety of point sources that emit CO_2, such as steam methane reformers for producing hydrogen, combined heat and power units, and catalytic crackers. Each configuration of a refinery can be unique to its footprint, onsite operations, and the types of crude oils processed. There are newer technologies with smaller footprints[120] that can be deployed in modular configurations to capture CO_2 in space constrained and multiple point source facilities such as refineries. While the modeling included CCS as being available in the first half of this decade, implementation barriers now indicate that is unlikely, and those emissions will be emitted into the atmosphere. For the Final 2022 Scoping Plan, the modeling will reflect updated assumptions for the earliest deployment of CCS for any sector in California. CCS can provide a path to reducing GHG emissions from these facilities to meet petroleum demand while avoiding leakage.

[120] Carbon Clean. Modular Carbon Capture Systems for Industry. https://www.carbonclean.com/modular-systems?hsLang=en.

Figure 2-3: Petroleum refining emissions with and without carbon capture and sequestration



In the modeling for the Proposed Scenario, there is also an increasing transition from combustion of fossil fuels to hydrogen. Hydrogen can be produced through electrolysis with renewable electricity or through steam methane reformation of renewable or fossil gas. If steam methane reformation is paired with CCS, the hydrogen produced could potentially be zero carbon. Additionally, any renewable gas could be sourced from gasification of forest or agricultural waste resulting from forest management and other NWL management practices, which could also lead to net negative carbon outcomes. There is a high degree of uncertainty, however, around the availability of solar to support both electrification of existing sectors and the production of hydrogen through electrolysis. Producing all of the necessary hydrogen with electrolysis would require about 40 GW of additional solar capacity. Steam methane reformation paired with CCS can be considered in the near term to ensure a rapid transition to hydrogen and increase hydrogen availability until such time as electrolysis with renewables can meet the ongoing need. Additional background and next steps for CCS can be found in Chapter 4.

It is important to recognize that the EJ Advisory Committee has raised multiple concerns related to the inclusion of CCS and mechanical CDR in the Draft Scoping Plan. Concerns range from potential negative health and air quality impacts, to safety concerns related to potential leaks, to viability of current technology. Additionally, the EJ Advisory Committee has policy concerns

about the strategy and wants to ensure that engineered carbon removal is not used as a substitute for strategies to achieve emissions reductions onsite or result in delays in phasing away from fossil fuels. Given these and other concerns and the importance of building public awareness, CARB recognizes the need for a multi-stakeholder process including other state, federal, and local agencies; independent experts; and community residents to further understand and address community concerns related to CCS.

In the context of CCS deployment, the Council of Environmental Quality (CEQ) also highlighted the need to further assess and quantify potential impacts on local criteria air pollutants and other emissions resulting from carbon capture retrofits at industrial facilities in response to concerns regarding potential cumulative emissions from single and/or multiple sources.[121] An October 2020 Stanford report[122] discussed how the potential post-combustion capture for CO_2 could also reduce emissions of criteria air pollutant emissions from certain facilities. Exploring these potential outcomes will be important to ensure deployment of CCS does not exacerbate air pollution impacts in communities and maximizes any air pollution benefits.

The Proposed Role of Natural and Working Lands Emissions and Sequestration

California's NWL assessments highlight the importance of increasing the pace and scale of NWL actions to ensure that our ecosystems are better equipped to withstand future climate change so they continue to provide the benefits that nature and society depend upon for survival. As climate change increases the likelihood of extreme wildfires, drought, heat, and other impacts, carbon stocks in California's NWLs will face increased risks and impacts. We know from previous climate change and Scoping Plan work[123] that lands can be a net source of GHG emissions or a net sink, and that the magnitude of carbon stock changes and GHG emissions and sequestration from NWLs are dependent on the effects of climate change and land management. The expanded modeling conducted for this Scoping Plan shows that NWL are projected to be a net source of emissions through 2045 and indicates a probable decrease of carbon stocks into the future. This projection is further corroborated by previous, independent research that has reached the same conclusion, showing a range of varying levels of carbon

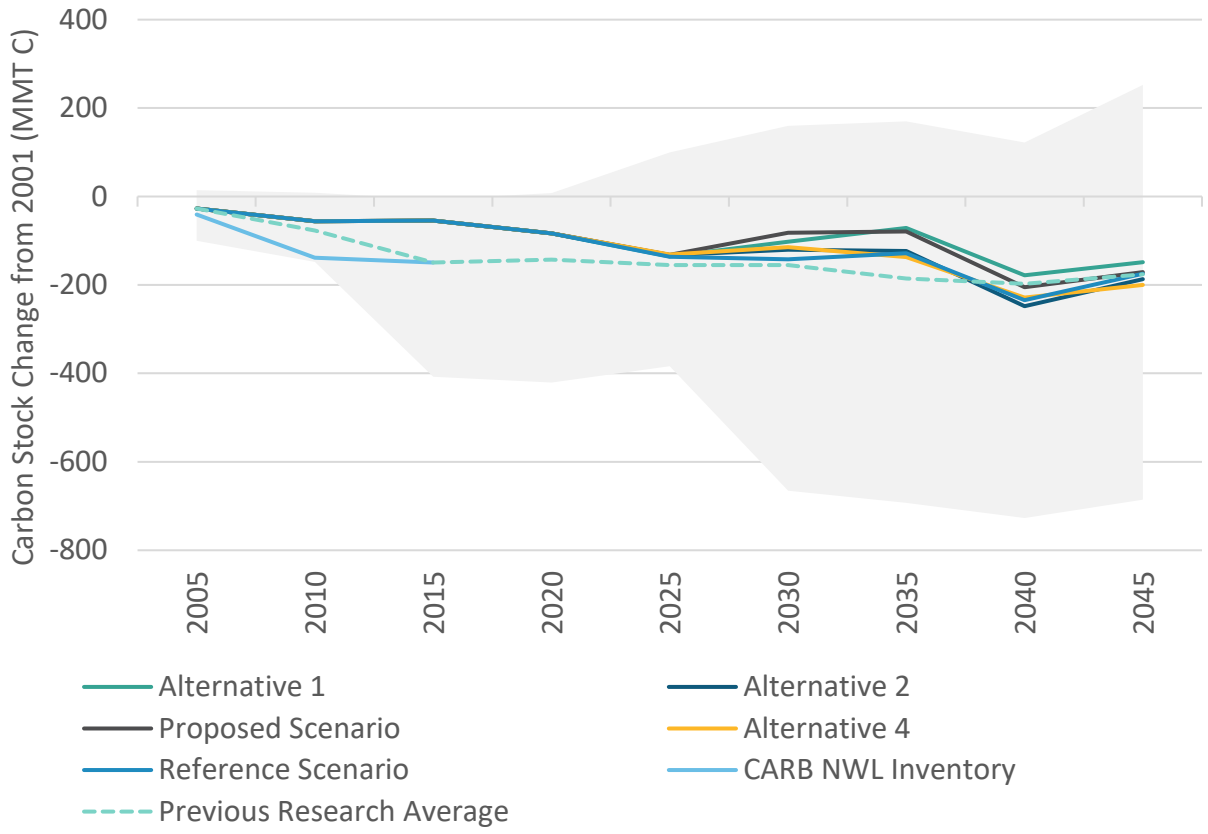
[121] Federal Register, February 2020. Vol 87, No. 32. *2022-03205.pdf (govinfo.gov)*

[122] Stanford, October 2020. *An Action Plan for Carbon Capture and Storage in California: Opportunities, Challenges,* and Solutions. CCS in CA: Full Report Download | Stanford Center for Carbon Storage

[123] CARB. 2019. January 2019. *Draft California 2030 Natural and Working Lands Climate Change Implementation Plan*. *https://ww2.arb.ca.gov/sites/default/files/2020-10/draft-nwl-ip-040419.pdf*.

stock loss. Figure 2-4 shows the modeling results of the four scenarios overlaid with the NWL inventory and findings from independent research.

Figure 2-4: Comparison of NWL modeling scenarios with existing research



The modeling indicates that immediate and aggressive climate action can reduce the environmental impacts that would occur in the absence of this action. The results of the modeling demonstrate that regular NWL management over the next two decades can increase carbon stocks from the Reference Scenario trajectory, reduce GHG emissions from lands, and improve ecosystem and public health. This effort is the most comprehensive scientific effort taken by any government to include NWL within its overall climate strategy. Even so, we know that uncertainty exists about future climate and economic forces and the impacts they may have on our ecosystems, so it is important that the state take decisive and aggressive action to improve and diversify ecosystem structures and management.

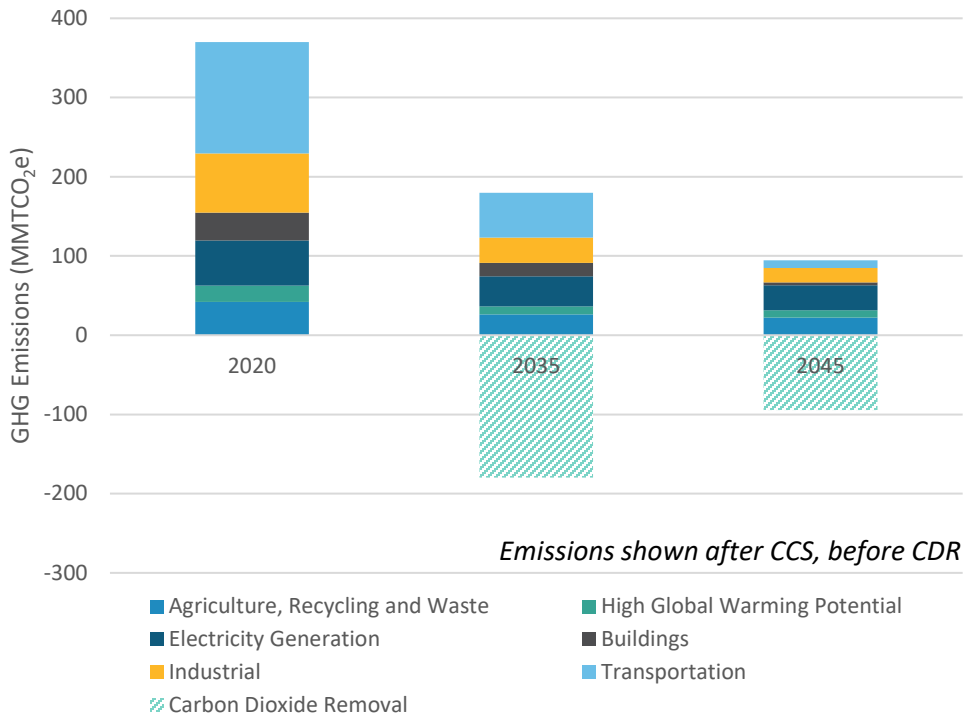
The effects of climate change, including increased drought, wildfire, and extreme heat, play a significant role in determining the future of California's carbon stocks. And while management actions will help to reduce the impact that climate change will have on California, it is clear from

the analysis that NWL sinks and sources are highly variable from year to year, and short time frames do not adequately demonstrate the impact that climate and management are having on ecosystems. For the purposes of climate planning then, it is best to focus on carbon stock changes over longer periods rather than focusing on sequestration or emissions on shorter time frames. The Proposed Scenario is estimated to result in additional NWL emissions of 8 $MMTCO_2e$ annually from 2025–2045. The Reference Scenario is estimated to result in annual emissions of 9 $MMTCO_2e$ over the same time period, and so the Proposed Scenario slows the rate of emissions and provides an approximate 1 $MMTCO_2e$ in additional annual sequestration relative to the Reference Scenario. Because NWLs are projected to be a net emissions source, the annual NWL emissions of approximately 8 $MMTCO_2e$ from the Proposed Scenario will need to be compensated by CDR approaches to ensure California can achieve carbon neutrality by 2045.

The Proposed Role for Carbon Dioxide Removal (Direct Air Capture)

As demonstrated in the modeling, there will still be residual emissions in the AB 32 GHG Inventory sectors in 2045 that must be addressed. Figure 2-5 includes the emissions by sector for the AB 32 GHG Inventory Sectors in 2020, 2035, and 2045 for the Proposed Scenario.

Figure 2-5: Residual emissions in 2020, 2035, and 2045 and potential carbon dioxide removal in 2035, and 2045 for the Proposed Scenario



To achieve carbon neutrality, mechanical CDR will therefore need to be deployed. Because NWL management is not estimated to be a significant carbon removal path in the near term, additional CDR options will be needed. Mechanical CDR refers to a range of technologies that capture and concentrate ambient CO_2. Direct air capture (DAC) is one available option that is under development today and could be widely deployed. Note that, unlike CCS, DAC technologies are not designed to be attached to a specific source or smokestack. The technologies include chemical scrubbing processes that capture CO_2 through absorption or adsorption separation processes. Another carbon removal option that involves rapid mineralization of CO_2 at the Earth's surface is called *mineral carbonation.*[124] As is the case with CCS, mechanical CDR technologies will need government or other incentive support to get over technology and market

[124] The National Academies Press. 2018. Direct Air Capture and Mineral Carbonation Approaches for Carbon Dioxide Removal and Reliable Sequestration: Proceedings of a Workshop–in Brief. *https://nap.nationalacademies.org/catalog/25132/direct-air-capture-and-mineral-carbonation-approaches-for-carbon-dioxide-removal-and-reliable-sequestration#:~:text=National%20Academies%20of%20Sciences%2C%20Engineering%2C%20and%20Medicine%3B%20Division,concentrate%20carbon%20dioxide%20%28CO%202%29%20from%20ambient%20air*.

barriers. In the United States, the U.S. Department of Energy announced financing specifically for DAC in March 2020[125] and March 2021.[126] Additionally, almost $9 billion in CCS support was included in the USD 1 trillion Infrastructure Investment and Jobs Act passed by the Senate in August 2021. This includes funding to establish four DAC hubs. There are a number of proposals to increase the value of the 45Q tax credit, including in the 2022 budget proposal that would provide USD 85 per tonne of CO_2 captured and stored from some industrial applications and USD 120 per tonne for DAC with storage.[127] In 2021, there were approximately 19 DAC facilities globally.[128]

Ultimately, the role for mechanical CDR will depend on the success of reducing emissions directly at the source in the AB 32 GHG Inventory sectors and the ability of the NWL to sequester carbon. However, mechanical CDR also provides an opportunity to not just achieve carbon neutrality, but also remove legacy GHG emissions from the atmosphere. As such, increased deployment of DAC can help achieve net negative emissions. This would further help avoid the most damaging impacts of climate change. Like the assumptions for CCS, the Proposed Scenario includes startup of DAC in the first half of this decade.[129] We believe that is unlikely given the current policy and permitting uncertainties, and we will need more DAC to remove more carbon due to delays in earlier deployment. While the incentives for DAC show support for this technology, the only California program that recognizes this technology is the LCFS program. Permitting must also happen across different levels of government and across multiple state agencies. Energy availability must also be addressed if DAC is to be implemented in remote areas. Additional information and next steps on DAC can be found in Chapter 4.

Proposed SB 27 Carbon Dioxide Removal Targets for 2030

As identified in Chapter 1, SB 27 (Skinner, Chapter 237, Statues of 2021) directed CARB to "establish carbon dioxide removal targets for 2030 and beyond" as part of this Scoping Plan. The legislation also directed CARB to take into consideration the Natural and Working Lands Climate Smart Strategy, science-based data, cost-effectiveness, and technological feasibility in

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[125] U.S. Department of Energy. 2020. Department of Energy to Provide $22 Million for Research on Capturing Carbon Dioxide from Air. https://www.energy.gov/articles/department-energy-provide-22-million-research-capturing-carbon-dioxide-air.

[126] U.S. Department of Energy. 2021. DOE Invests $24 Million to Advance Transformational Air Pollution Capture. https://www.energy.gov/articles/doe-invests-24-million-advance-transformational-air-pollution-capture.

[127] U.S. Department of the Treasury. 2021. General Explanations of the Administration's Fiscal Year 2022 Revenue Proposals. https://home.treasury.gov/system/files/131/General-Explanations-FY2022.pdf#page=60.

[128] IEA. 2022. Direct Air Capture – Analysis. https://www.iea.org/reports/direct-air-capture.

[129] The modeled scenarios assume that residual emissions will be compensated using DAC technologies by including the direct cost in terms of $ per ton CO_2 removed. The energy source for DAC is not modeled, but renewable electricity and/or hydrogen produced from electrolysis are zero-carbon options consistent with the carbon neutrality targets in the Draft Scoping Plan.

setting the targets." For NWL, the modeling indicates that over the full 20-year period California's lands will be a net source of emissions. However, despite being a net source of emissions overall, there are individual actions on lands that can result in net annual removals of CO_2 from the atmosphere and be utilized to provide nature-based CO_2 removals.

The Proposed Scenario modeling indicates that, for the AB 32 GHG Inventory sectors, both the Reference Scenario and the Proposed Scenario would meet or exceed the 2030 SB 32 40 percent GHG reduction target though GHG reduction policies without the need for CDR to compensate for emissions in 2030 to achieve the SB 32 target. CDR will, however, be necessary in increasing amounts over the following decades to achieve carbon neutrality by 2045. SB 27 provides an opportunity to start action on CO_2 earlier than modeled to give more time for actions and technologies to scale and come down in costs over the next 25 years.

Given the likelihood of NWL to be a net source of emissions, and the need for CDR to compensate for residual emissions to achieve carbon neutrality by 2045, California will need increasing deployment of mechanical CDR over the coming decades. In the immediate future, scaling nature-based CDR approaches also can help provide some CO_2 removal quickly while mechanical CDR is scaled up between now and 2045.

For 2030, achieving 1–2 $MMTCO_2e$ in annual CDR in California through a combination of nature-based and mechanical methods would serve as an important milestone to scaling CDR. After 2030, the amount of CDR deployed would need to increase approximately 30 to 40 percent annually, on average, between 2030 and 2045 to help achieve carbon neutrality by 2045.

Achieving 1-2 $MMTCO_2e$ of CDR in California could be accomplished through a combination of approaches, including the following:

- NWL strategies that can provide net CO_2e removals on some of their landscapes, such as urban forestry, afforestation, and increases in soil carbon paired with GHG reductions from soils. For example, the Proposed Scenario estimates that approximately 600,000 $MTCO_2e$ in net sequestration may be possible from increases in urban forestry by 2030.
- Biomass utilization strategies paired with sequestration, like bioenergy with carbon capture and storage (BECCS). The Proposed Scenario estimates that 5–10 $MTCO_2e$ may be available from recoverable biomass, but this will require the permitting, construction, and startup of new infrastructure in California.
- DAC approaches that capture and concentrate ambient CO_2, which will also require the build out of new infrastructure to support it.

This target for CDR provides a near term milestone for California and can serve as an important marker for progress in deploying CDR to support California's carbon neutrality goal. Preliminary estimates indicate that, globally, capacity from already announced projects will range from about 2 million metric tons per year ($MMTCO_2/y$) to 8 $MMTCO_2/y$ from bioenergy paired with CCS, and

from about 2,000 metric tons per year ($MTCO_2/y$) to 1 $MMTCO_2/y$ from DACS by 2027.[130] Achieving 1-2 MMT/y in California is a technologically feasible level that would allow California to take a leadership role on deploying CDR.

Scenario Uncertainty

Modeling

Several types of uncertainty are important to understand in both forecasting future emissions and estimating the benefits of emission reduction actions. In developing the Draft 2022 Scoping Plan, we forecast a reference scenario and estimated the GHG emissions outcome of the AB 32 GHG Inventory sectors using the PATHWAYS[131] model. Inherent in the reference scenario modeling is the expectation that many of the existing programs will continue in their current form, and the expected drivers for GHG emissions such as energy demand, population growth, and economic growth will match our current projections.

However, there is also the expectation that each of the policies included and implemented to achieve the 2030 target in the 2017 Scoping Plan update will deliver their exact outcomes. It is unlikely the future will precisely match our projections, and this will lead to uncertainty in the forecast. For example, we never could have foreseen and forecasted for economic and emissions impacts related to the extended disruptions from the COVID-19 pandemic. Thus, the single "reference" or "forecast" line should be understood to represent one possible future in a range of possible predictions. For the Proposed Scenario, PATHWAYS utilized inputs that reflect technically feasible levels of deployment or adoption of low- or zero-carbon fuels and technologies. Each of the assumptions provided to PATHWAYS has some uncertainty, which is also reflected in the results.

Similarly, for the NWL modeling, we projected a Reference scenario and alternatives using a mix of individual modeling tools[132] that provide estimates of the carbon and other ecological, public health, and economic outcomes from land management. The Reference scenario assumes that level of land management actions that occurred between 2001 and 2014 for forests, shrublands, grasslands, croplands, developed lands, wetlands, and sparsely vegetated lands continues into the future, and the alternatives assess the effect of increasing levels of climate action on NWL between 2025 and 2045. For NWL, it is also unlikely that the future will precisely match the carbon stock outcomes, particularly given the effects climate change will have on our lands and the diversity of land management actions and market forces possible.

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[130] IHS Markit. August 2021. Carbon Removal Potential: An Overview. https://ww2.arb.ca.gov/sites/default/files/2021-08/ihsmarkit_presentation_sp_engineeredcarbonremoval_august2021.pdf.
[131] See Appendix H (AB 32 GHG Inventory Sector Modeling).
[132] See Appendix I (NWL Technical Support Document).

Thus, while the results presented in the Proposed Plan may seem precise due to the need for precision in model inputs, these results are estimates, and they embody uncertainty that is not reflected in the output of a single number in a given year.

Implementation

As this Proposed Plan is meant to chart a path to achieving carbon neutrality, additional work will be required to fully design and implement any policies and actions identified in this plan. During the subsequent development of policies, the Legislature, CARB, and other state agencies will learn more about technologies, costs, and how each industry works as a more comprehensive evaluation is conducted in coordination with stakeholders, including community engagement. Significant areas of uncertainty include permitting wait times[133] and local ordinances that might limit or slow the build out of utility scale renewables.[134,135] In another example, times to reach commercial operations for solar projects after securing an interconnection agreement also have increased in recent years, to 3.5 to 5.5 years.[136]

For NWL, areas of uncertainty include the ability to scale up land management strategies given diverse land ownership throughout the state, workforce needs for fuels reduction treatments, and limited and uncertain financial support to sustain increased and ongoing land management. Further, in NWL, unknowns exist that can dramatically change ecosystems. It is possible that currently unforeseeable catastrophic environmental change could occur. In any case, dramatic environmental change is likely to decrease carbon stocks and increase emissions given the current high levels of carbon stocks. Thus, the actual reductions may be different than what is estimated as part of this plan's modeling.

Given the uncertainty around the modeling assumptions, and performance uncertainty as specific policies are fully designed and implemented, estimates associated with the Proposed Scenario are certain to be different than what is ultimately implemented. One way to mitigate for this risk is to develop policies that can adapt and increase certainty in GHG emissions reductions. Periodic reviews of progress toward achieving the 2030 target and longer term

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[133] California Energy Commission. 2021. *SB 100 Joint Agency Report.* https://www.energy.ca.gov/sb100#anchor_report.

[134] Roth, Sammy. 2019. California's San Bernardino County slams the brakes on big solar projects. Los Angeles Times. https://www.latimes.com/business/la-fi-san-bernardino-solar-renewable-energy-20190228-story.html?fbclid=IwAR2qHGq3bahHme6SFErLsnyFi9UPIfBHIhvnOh3dU3OM7kUTMcEqYfN3pQA.

[135] Chediak, Mark. 2021. California NIMBYs Threaten Biden's Clean Energy Goals. BNN Bloomberg. https://www.bnnbloomberg.ca/california-nimbys-threaten-biden-s-clean-energy-goals-1.1634351?msclkid=668c9ae9c11311ec92e34035ea157ad4.

[136] Rand, Joseph, et al. 2022. Queued Up: Characteristics of Power Plants Seeking Transmission Interconnection As of the End of 2021. Power Point Presentation. Lawrence Berkeley National Laboratory. https://emp.lbl.gov/sites/default/files/queued_up_2021_04-13-2022.pdf.

deeper decarbonization, as well as performance of specific policies, also provide opportunities for the state to consider any changes to ensure we remain on course to achieve the 2030 target and carbon neutrality. The need for this periodic review process was anticipated in AB 32, as it calls for updates to the Scoping Plan at least once every five years. For this Draft Scoping Plan, the metrics provided on the rate of deployment of clean fuels and technologies, along with the annual AB 32 GHG Inventory, provide additional information that can be used to assess progress on sectors and aggregate emissions. This is also true on CARB's NWL carbon inventory.

Targeted Evaluations for the Proposed Scenario: Oil and Gas Extraction and Refining

The path forward must include ending dependence on petroleum to achieve both air quality and climate goals. This will not happen overnight. There are about 28 million combustion engine heavy- and light-duty trucks and passenger vehicles in California. These are almost always replaced at end of life. The ZEV Executive Order calls for 100 percent ZEV car sales beginning in 2035 and a 100 percent ZEV medium- and heavy- duty fleet by 2045, as feasible. The result is an ongoing, albeit shrinking, pool of vehicles that will continue to require petroleum fuels. To avoid leakage, as called for in AB 32, and meet that remaining demand for petroleum fuel, a complete phaseout of oil and gas extraction and refining is not possible by 2045. The Draft 2022 Scoping Plan assumes the following: (1) a phasedown in oil and gas extraction by 2045 and refining in line with the reduction in demand for in-state on-road petroleum fuel demand and (2) GHG emissions from oil and gas extraction could be reduced approximately 85 percent in 2045 from 2020 levels if extraction decreases in line with in-state finished fuel demand. Since the transportation sector is the largest source of GHG emissions and harmful local air pollution, we must continue to research and invest in efforts to deploy zero emissions technologies and clean fuels, and reduce VMT. Ongoing progress and efforts to reduce demand for petroleum fuels and opportunities to phase down oil and gas extraction and refining will be included in the next Scoping Plan update.

Oil and Gas Extraction

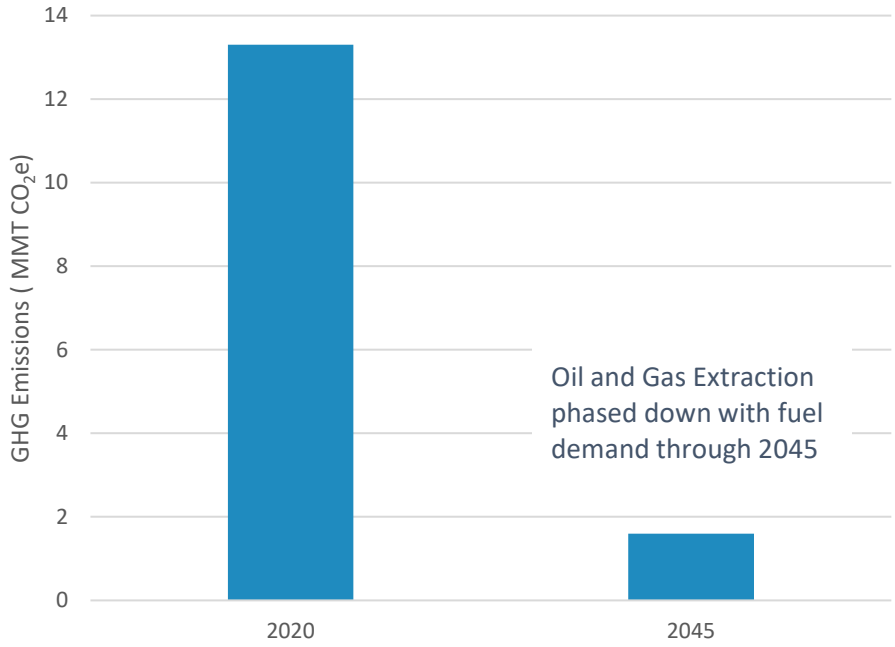
On April 23, 2021,[137] Governor Newsom directed CARB to evaluate the phaseout of oil and gas extraction no later than 2045 as part of the 2022 Scoping Plan update. As noted above, the Proposed Scenario still has some California demand for finished fossil fuels (gasoline, diesel, and jet fuel) in 2045. This demand is primarily for transportation, including for sectors that are directly regulated by the state and some that are subject to federal jurisdiction, such as interstate

[137] Governor Newsom. April 23, 2021. Governor Newsom Takes Action to Phase Out Oil Extraction in California. Press Release. *https://www.gov.ca.gov/2021/04/23/governor-newsom-takes-action-to-phase-out-oil-extraction-in-california/*.

locomotives, marine, and aviation. As discussed more fully below, while significant GHG reductions from oil and gas extraction will be achieved as demand for fossil fuels is reduced due to strategies in this Draft 2022 Scoping Plan, it is not feasible to phase out oil and gas production fully by 2045 given this remaining demand.

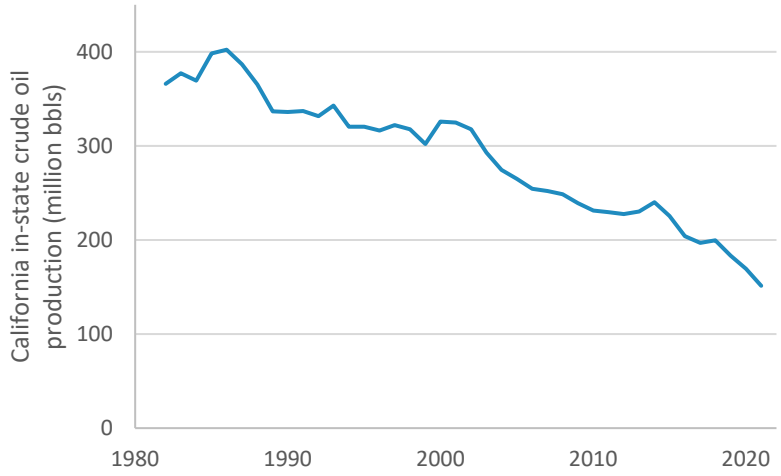
While the modeling includes a phasing out of activity in the oil and gas sector, it is possible to estimate what the GHG emissions would be if the oil and gas extraction were phased down in line with finished fuel demand. This in-state finished fuel demand could be met by in-state oil and gas extraction, even at the reduced levels of extraction in the future due to oil field depletion. In the Proposed Scenario, with successful deployment of zero carbon fuels and non-combustion technology to phase down petroleum demand, the oil and gas extraction GHG emissions could be reduced by approximately 85 percent in 2045 from 2020 levels if extraction decreases in line with in-state finished fuel demand. If in-state extraction were to be fully phased out, the future petroleum demand by in-state refineries would be met through increased crude imports to the state relative to the Proposed Scenario. AB 32 defines leakage as, “a reduction in emissions in greenhouse gases within the state that is offset by an increase in emissions of greenhouse gases outside the state.” AB 32 also requires any actions undertaken to reduce GHGs to “minimize leakage.” Increases in imported crude could result in increased activity outside California to extract and transport crude into California. Therefore, our analysis indicates that a full phaseout of in-state extraction could result in GHG emissions leakage and in-state impacts to crude oil imported into the state. Figure 2-6 compares the 2020 emissions from this sector with the modeled results when the sector is phased down with in-state petroleum demand.

Figure 2-6: Oil and gas extraction sector GHG emissions in 2020 and 2045 when activity is phased down with fuel demand



According to California Energy Commission data used in Figure 2-7, the total oil extracted in California peaked at 402 million barrels in 1986. Since then, California crude production has decreased by an average of 6 million barrels per year, to about 200 million barrels in 2020. This steadily decreasing production of crude in California is expected to continue as the state's oil fields deplete.

Figure 2-7: California in-state crude oil production[138]



A University of California, Santa Barbara, report estimated that under business-as-usual conditions California oil field production would decrease to 97 million barrels in 2045.[139] The business-as-usual model assumed no additional regulations limiting oil extraction in California.

Any crude oil demand by California refineries not met by California crude oil will be met by marine imports of Alaskan and foreign crude.[140] As shown in Figure 2-8, approximately 99 percent of crude imports into California are delivered by marine transportation. The remaining imports occur by rail.[141] There are no pipelines that bring crude oil into California from out of state.[142]

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[138] CEC. No date. Oil Supply Sources to California Refineries. Accessed April 21, 2022. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/oil-supply-sources-california-refineries.

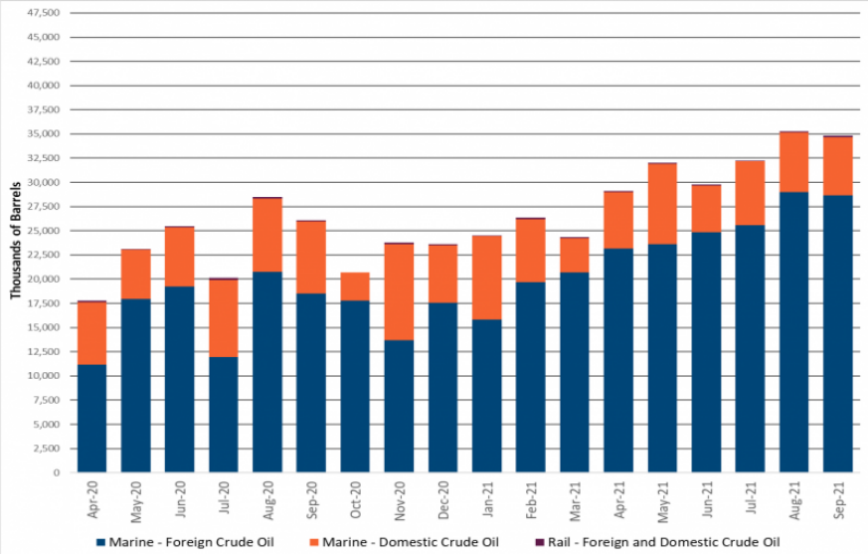
[139] UC Santa Barbara. 2021. Enhancing Equity While Eliminating Emissions in California's Supply of Transportation Fuels.

[140] California Energy Commission. 2020. *Petroleum Watch: How Petroleum Products Move*. March. https://www.energy.ca.gov/sites/default/files/2020-03/March_2020_Petroleum_Watch.pdf; California Energy Commission. 2020. Petroleum Watch: What Types of Crude Oil Do California Refineries Process? February. https://www.energy.ca.gov/sites/default/files/2020-02/2020-02_Petroleum_Watch_ADA_0.pdf.

[141] California Energy Commission. June 2021. Crude Oil Imports by Transportation Type. Accessed March 16, 2022. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/crude-oil-imports-source.

[142] California Energy Commission. 2020. *Petroleum Watch: How Petroleum Products Move*. March. https://www.energy.ca.gov/sites/default/files/2020-03/March_2020_Petroleum_Watch.pdf.

Figure 2-8: Crude oil imports by transportation type[143]



Crude oil delivered by marine tankers is delivered to onshore storage tanks and subsequently to refineries via pipeline. Most crude oil produced in California is delivered to California refineries by pipeline. Using historical trends, any increases in imported crude above historic levels would result in increased deliveries through the marine ports. This increased activity could require more infrastructure to store and move larger volumes of crude to the refineries in state.

California refineries import a variety of crude oils to meet refinery needs. California petroleum refineries are generally designed to process relatively heavy crude relative to other U.S. refineries. In 2018, crude inputs to California refineries had an average American Petroleum Institute (API) gravity of 26.18 and an average sulfur content of 1.64 percent. Processing significantly lighter or heavier crude blends would require significant changes to a refinery.[144] Most crude imported from Alaska and the Middle East is relatively light (API gravity > 30) compared to California crude (API gravity < 20).[145] If California crude production is insufficient to meet the demand at California refineries, then California refineries will need access to a similarly heavy source of crude so that the average API gravity of crude remains within their established operating window. South American crude oil imports into California are the heaviest

[143] California Energy Commission. June 2021. Crude Oil Imports by Transportation Type. Accessed March 16, 2022. https://www.energy.ca.gov/data-reports/energy-almanac/californias-petroleum-market/crude-oil-imports-source.
[144] California Energy Commission. 2020. *Petroleum Watch: What Types of Crude Oil Do California Refineries Process?* February. https://www.energy.ca.gov/sites/default/files/2020-02/2020-02_Petroleum_Watch_ADA_0.pdf.
[145] California Energy Commission. 2020. *Petroleum Watch: What Types of Crude Oil Do California Refineries Process ?* February. https://www.energy.ca.gov/sites/default/files/2020-02/2020-02_Petroleum_Watch_ADA_0.pdf.

relative to other regions, and therefore they may be the most likely to replace decreased California crude oil supply.[146]

In summary, the modeling indicates that demand for petroleum will persist due to legacy fleets that will not be replaced until end of life. The modeling also shows what the GHG emissions reductions would be if oil and gas extraction activities were phased down in line with the reduction of in-state petroleum demand. Trend data shows that oil and gas extraction already has been on the decline and will continue to decline. It is possible to anticipate the likely regions and types of crude that would be imported to meet in-state petroleum demand. Importantly, activity at the ports would increase, and new infrastructure would be needed to store and deliver crude to in-state refineries. And while GHG emissions from this sector would go to zero in our AB 32 GHG Inventory with a full phaseout, emissions related to the production and transport of crude to California may increase elsewhere, resulting in emissions leakage.

As the state continues to reduce demand for petroleum, efforts to protect public health for communities located near oil and gas extraction efforts must also continue. In October 2021, Governor Newsom directed action to prevent new oil drilling near communities and expand health protections.[147,148]

Petroleum Refining

In the Proposed Scenario CARB modeled phasing down refining activity in line with petroleum demand. Meeting petroleum demand means sufficient availability of finished fuel (gasoline, diesel, and jet fuel). Crude is processed at in-state refineries to produce finished fuel. In response to stakeholder requests,[149] this evaluation focuses on the Proposed Scenario, but with an evaluation of a complete phasedown of refinery operations in state.

The Proposed Scenario results in California petroleum refining emissions of 5.1 $MMTCO_2e$ in 2045, a reduction of approximately 83 percent relative to 2020 levels that is in line with the

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[146] California Energy Commission. 2020. *Petroleum Watch: What Types of Crude Oil Do California Refineries Process ?*; February. https://www.energy.ca.gov/sites/default/files/2020-02/2020-02_Petroleum_Watch_ADA_0.pdf.

[147] Office of Governor Gavin Newsom. 2021. California Moves to Prevent New Oil Drilling Near Communities, Expand Health Protections. https://www.gov.ca.gov/2021/10/21/california-moves-to-prevent-new-oil-drilling-near-communities-expand-health-protections-2/?msclkid=6c0da86bc58e11ecb81cf596d4d8a735.

[148] California Department of Conservation Geologic Energy Management Division. October 2021. Draft Rule for Protection of Communities and Workers from Health and Safety Impacts from Oil and Gas Production Operations. Public Health Rulemaking (ca.gov)

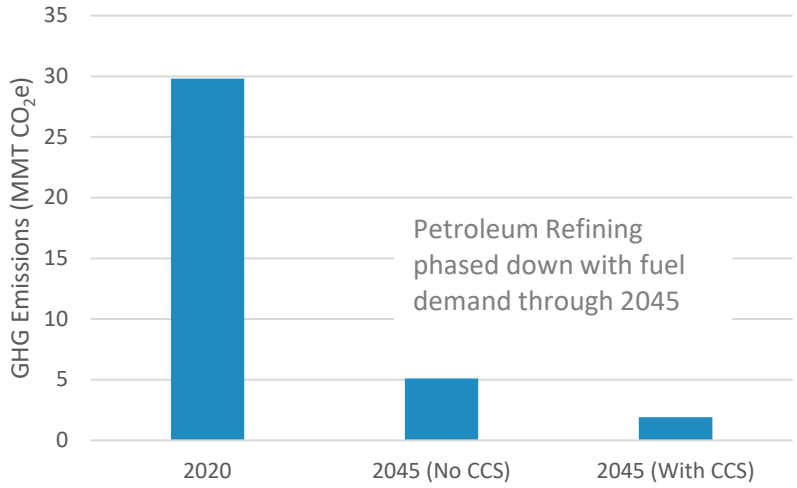
[149] California Environmental Justice Alliance. October 22, 2021. Comment on 2022 Scoping Plan Update - Scenario Inputs Technical Workshop. https://www.arb.ca.gov/lists/com-attach/68-sp22-inputs-ws-WzhdPll5AjACW1Qx.pdf.

decline in in-state finished fuel demand.[150] Emissions from refining can be reduced further through the application of CCS technology, as shown in Figure 2-9. If in-state refining is phased down to zero and the demand for the finished fuels produced by that refining persists, imported finished fuels may be needed to meet the remaining in-state demand.[151] The current data shows unmet demand for liquid petroleum transportation fuels would most likely be met by marine imports. A California Energy Commission report notes, "The only way for California to receive large amounts of crude and refined products is by marine."[152]

There are currently no pipelines capable of bringing refined products to the state, and rail imports of refined products have historically made up less than 1 percent of all imports.[153] Significant increases in marine imports would likely require significant reconfiguring, retrofitting, or replacing of crude pipelines and storage tanks at current marine terminals and possible reconfiguring of existing finished fuel infrastructure to account for changes in volumes and locations of supply points.

[150] This reduction in demand does not assume any need for ongoing operations to support exports to neighboring states.
[151] If demand assumes an ongoing need to support exports to neighboring states, the residual demand would require a five-fold increase in finished fuel imports.
[152] California Energy Commission. 2020. *Petroleum Watch: How Petroleum Products Move*. March. https://www.energy.ca.gov/sites/default/files/2020-03/March_2020_Petroleum_Watch.pdf.
[153] California Energy Commission. 2020. *Petroleum Watch: How Petroleum Products Move*. March. https://www.energy.ca.gov/sites/default/files/2020-03/March_2020_Petroleum_Watch.pdf.

Figure 2-9: Petroleum refining sector GHG emissions in 2020 and 2045 (with and without CCS) when activity is phased down with fuel demand



If California's finished fuel demand is not met by continued refining activity in California, the state would need to import finished fuels to meet the ongoing demand. This would likely result in a two- to five-fold increase in the number of finished fuel ship deliveries to marine terminals. Marine tankers delivering refined products are often much smaller than crude oil tankers, so changes in fuel use and emissions cannot be easily estimated from the change in both the type and the number of ship deliveries.[154]

If refining ceased in California, the rail and marine deliveries currently needed to support both refining processes and the export of waste products, such as petroleum coke, would cease.

In summary, the modeling indicates that demand for petroleum will persist through 2045. The modeling also shows what the GHG emissions reductions would be if refining activities were phased down in line with the reduction in in-state petroleum demand. CCS can further reduce emissions for this sector. Importantly, activity at the ports would increase, and new infrastructure would be needed to store and deliver finished fuel across the state. And while GHG emissions from this sector would go to zero in our AB 32 GHG Inventory with a full phaseout, emissions related to the refining and transport of finished fuel to California may increase elsewhere, resulting in emissions leakage.

[154] Personal communication with CEC staff, March 2022; U.S EIA. 2017. *World Oil Transit Chokepoints*. 3. https://www.eia.gov/beta/international/regions-topics.php?RegionTopicID=WOTC.

Progress Toward Achieving the 2030 Target

Since the adoption of the first Scoping Plan in 2008, carbon pricing in the form of a Cap-and-Trade Program has been part of the portfolio to achieve the state's GHG reduction targets, and it will remain critical as we work toward carbon neutrality. This section provides an update on the program and its role in achieving the 2030 target.

Cap-and-Trade Program Update

The Cap-and-Trade Program first came into effect in 2012, under AB 32, and included declining allowance caps through 2020. In 2017, AB 398[155] was passed by a supermajority in the Legislature and included prescriptive direction on the design of the program from 2021 through 2030. The AB 398 Cap-and-Trade Program came into effect on January 1, 2021, and includes the following changes:

- Doubling of stringency with an annual cap decline of 4 percent per year from 2021–2030
- AB 398 price ceiling
- AB 398 redesigned allowance price containment reserve with two tiers
- AB 398 100 percent leakage assistance factor for industry
- AB 398 lower offset limits: Usage limit cut from 8 percent to 4 percent, and half of offsets must provide direct benefits to California

The reduction in the role of offsets in the program was in recognition of ongoing concerns raised by environmental justice advocates regarding the ability of companies to use offsets for compliance instead of investing in actions on site to reduce GHG emissions that could also potentially reduce criteria or toxic emissions.[156,157] However, data show the relationship between facility emissions of GHGs and co-pollutants is highly variable by sector and pollutant. Changes to the allowance price containment reserve and the addition of the price ceiling were included to ensure protections against price spikes in the program, while the changes to the leakage

[155] California Legislature Information. 2017. Bill Text - AB-398 California Global Warming Solutions Act of 2006: market-based compliance mechanisms: fire prevention fees: sales and use tax manufacturing exemption. *https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180AB398*.

[156] Plummer, Laurel, et al. 2022. Impacts of greenhouse gas emission limits within disadvantaged communities: Progress toward reducing inequities. *OEHHA and CalEPA. https://oehha.ca.gov/media/downloads/environmental-justice/impactsofghgpoliciesreport020322.pdf*.

[157] The OEHHA report also found that companies that use the most offsets often own the facilities that contribute to local $PM_{2.5}$ exposure. However, there was no causal relationship found to indicate that implementation of the Cap-and-Trade Program was contributing to increases in local air pollution. Also see: CARB. FAQ Cap-and-Trade Program. *https://ww2.arb.ca.gov/resources/documents/faq-cap-and-trade-program.*

assistance factors were to ensure the maximum protection against leakage in the program. The original design of the program included an auction floor price that increases by 5 percent plus inflation each year, and that escalation factor is retained in the post-2020 program and also applied to the allowance price containment reserve and price ceiling. These features, combined with the self-ratcheting mechanism for unsold allowances at auctions,[158] help ensure the program is able to handle periods of high and low demand for allowances while continuing to ensure a steadily increasing price signal for regulated entities to invest in GHG reduction technologies.

As a result of achieving the 2020 target four years earlier than mandated by law, there are unused allowances in circulation. CARB estimated the amount to be approximately 310 million allowances after the conclusion of the third compliance period (2019–2020). This bank represents approximately 5 percent of the total number of vintage 2013–2030 allowances issued within the joint market. This bank of allowances can only remain banked if year-over-year the covered emissions are declining by 14 MMT. If the annual decline in actual emissions is less than 14 MMT, regulated entities will need to use the banked allowances to cover their compliance obligations. It is likely that the existing bank of 310 allowances will be needed over the early part of this decade and will be exhausted by the end of the decade. During the same period, prices for allowances will continue to increase at least 5 percent plus inflation year-over-year, sending a steadily increasing price signal to spur investment in onsite reductions for covered entities.

CARB will use the modeling for the Final 2022 Scoping Plan to assess what, if any, changes are warranted to the Cap-and-Trade, or other, programs to ensure we are on track to achieve the 2030 target. Since the original adoption of the Cap-and-Trade regulation, the program has been amended eight times through a robust public process. Moreover, Environmental Protection Secretary Blumenfeld testified at a Senate hearing that CARB will report back to the Legislature by the end of 2023, giving a status of the allowance supply with any suggestions on legislative changes to ensure the number of allowances is appropriate to help the state achieve its 2030 target. Engaging in this process in 2023 will allow for the finalization of the Scoping Plan, inclusions of additional data points for the second year of operation of the AB 398-designed program (which only came into force in January 2021), and an opportunity to hold public workshops.

[158] The self-ratcheting mechanism temporarily removes unsold allowances from the market until either sufficient demand manifests for two consecutive auctions and they are incrementally reintroduced at future auctions, or they are permanently removed from general circulation if demand remains low.

It is also worth noting that the COVID-19 pandemic had significant impacts on economic activity in California and elsewhere.[159] Emissions were significantly lower in 2020 due to the impacts of the global pandemic. There is an expectation that emissions will increase as the economy recovers and behaviors continue to shift from the impacts of the ongoing pandemic. As a result, 2020 should be regarded as an outlier in the emissions trends. This scenario of increasing emissions is similar to what happened in the first compliance period, where the state economy was recovering from the Great Recession, and does not correlate to a problem with the structure of this program or other programs that cover emissions related to the manufacturing or transportation sectors. In any assessment of this and other programs, it is essential to consider external factors such as economic activity and availability of zero carbon energy such as hydropower, among others.

Initial GHG Modeling Estimates for 2021 through 2030

The SB 32 target of at least a 40 percent reduction of GHGs below the 1990 target by 2030 is a milestone toward achieving the deeper reductions needed to meet the state's carbon neutrality goals. It builds upon the directives of AB 32, including reducing GHG emissions to 1990 levels by 2020, which California achieved four years ahead of schedule. The 2017 Scoping Plan update laid out a path to achieving the 2030 target that focused on reducing emissions in the state and was technologically feasible and cost-effective, reflecting statutory direction. Many of the programs to achieve the 2030 target doubled, or increased, in stringency beginning January 1, 2021.

Starting in 2020 and extending into 2022, the COVID-19 pandemic impacts reverberated across the globe in a multitude of ways, including the devastating loss of millions of lives. The pandemic also had a significant impact on GHG emissions by virtue of its impact on global economies and lifestyle changes for Californians, with extended work and school disruptions. Thus, assessing our progress toward meeting our SB 32 target is confounded by the unprecedented nature of the pandemic. Nevertheless, an assessment of progress toward the 2030 target is critical, since achieving the SB 32 target would make the state well positioned to achieve its carbon neutrality goals and bring critical near-term air quality benefits to address historical and ongoing disparities in access to healthy air.

This draft analysis relies on the modeling data generated to support a range of scenarios, including a reference to the modeling projections from the 2017 Scoping Plan update. The Reference Scenario characterizes projected GHG emissions in the event that no additional GHG

[159] CARB. November 4, 2021. Mandatory Greenhouse Gas Reporting - 2020 Emissions Year FAQs. https://www.arb.ca.gov/cc/reporting/ghg-rep/reported-data/2020mrrfaqs.pdf?_ga=2.264251343.1760432228.1650736660-1644197524.1577749754.

reduction policies or measures are implemented from those reflected in the 2017 Scoping Plan the Board approved. For the draft projection of GHG emissions over this decade (i.e., the Reference Scenario) we begin with point estimates of emissions for each year. The second step is to assess the uncertainty around the point projections. The major factors of uncertainty for this decade include the successful rate of deployment of clean technology and fuels identified in the 2017 Scoping Plan, including consumer adoption patterns, economic recovery from the pandemic, and the permitting and build out of necessary new assets and reuse of existing assets to produce and deliver clean energy. This section compares the draft projected emissions over this decade relative to what was included in the 2017 Scoping Plan when it was adopted in late 2018. A more detailed analysis of updated GHG emissions projections over this decade that reflects the quantified uncertainty factors mentioned above will be available in late 2022.

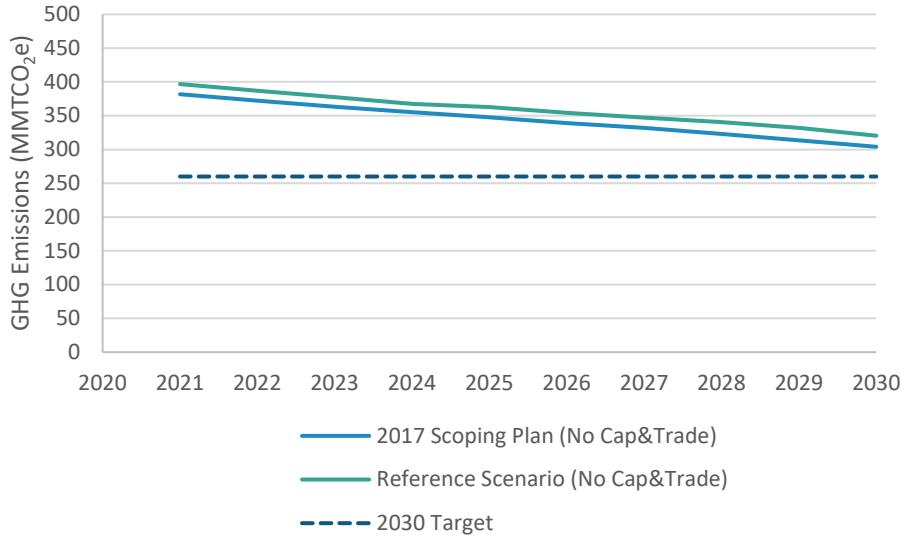
Figure 2-10 shows the 2017 Scoping Plan projections from the PATHWAYS model for the scoping plan scenario adopted by the Board in late 2017, excluding the contribution of the Cap-and-Trade Program, without any consideration of uncertainty factors (i.e., a characterization of the uncertainty that a given GHG reduction measure included in the 2017 Scoping Plan will actually achieve the GHG reductions it is projected to deliver). The Reference Scenario represents what GHG emissions would look like if we did nothing beyond the existing policies that are required and already in place to achieve the 2030 limit. The Reference Scenario is the recent PATHWAYS modeling without any consideration of uncertainty factors and indicates that GHG emissions are *projected to be lower over this decade than originally projected when the 2017 Scoping Plan update was adopted*. Importantly, neither of these trend lines includes any contribution to reductions achieved from the Cap-and-Trade Program, as PATHWAYS is not able to explicitly model a carbon pricing policy. However, as the Reference Scenario projections are lower than the projections from the 2017 Scoping Plan update over this decade, a comparison of the point estimate trends indicates that the role of the Cap-and-Trade Program for meeting our 2030 GHG target may be reduced from what was originally estimated in the 2017 Scoping Plan update.

As discussed below, the Cap-and-Trade Program will likely play a reduced role depending on how uncertainties play out and if new prescriptive policies or legislation is introduced for this decade. In Figure 2-10 the two trajectories are very closely aligned, but it will be important to evaluate the uncertainty over this decade. That is, the greater the actual reductions from non-Cap-and-Trade Program measures are, the less reliant the GHG reduction program will be on the need for Cap-and-Trade to “fill the gap” to meet the state’s 2030 reduction target. For example, we already know that we have a more stringent LCFS implemented than originally contemplated in the 2017 Scoping Plan update, SB 100 also calls for a more ambitious Renewable Portfolio Standard for 2030, and SB 596 requires specific reductions in the cement sector over this decade and beyond. There is also a proposed Advanced Clean Cars Regulation that is more stringent than modeled in the 2017 Scoping Plan. However, we also know we are not on track to achieve the VMT reduction called for in the 2017 Scoping Plan update and that

we will need additional actions over the coming years to reduce short-lived climate pollutants to meet the emission reductions called for in SB 1383.

Collectively, any continued addition of legislation or prescriptive policies for sectors, delays in successful implementation of non-Cap-and-Trade programs and policies, increased incentive program funding, and lingering or delays in economic recovery from the pandemic will continue to affect the role the Cap-and-Trade Program will need to play over this decade to meet the state's GHG reduction obligations. The forthcoming uncertainty analysis will quantify the uncertainty factors for each sector, and then in aggregate, for the non-Cap-and-Trade policies with respect to achieving the projected GHG emission reductions they were anticipated to deliver as presented in the 2017 Scoping Plan.

Figure 2-10: Comparison of 2017 Scoping Plan with Draft 2022 Scoping Plan Reference Scenario without uncertainty bounds



As shown below in Table 2-4, the 2017 Scoping Plan update projected that the non-Cap-and-Trade Program policies would reduce the state's GHG emissions to 320 $MMTCO_2e$ in 2030, requiring Cap-and-Trade to deliver 60 $MMTCO_2e$ that same year. The updated modeling indicates the non-Cap-and-Trade Program policies could potentially reduce the state's GHG emissions to 304 $MMTCO_2e$ in 2030 (i.e., reducing 16 $MMTCO_2e$ more than estimated in the 2017 Scoping Plan), leaving Cap-and-Trade to potentially deliver 44 $MMTCO_2e$ that same year. This is an approximate 27 percent reduction in the role of the Cap-and-Trade Program in 2030

compared to what was included in the 2017 Scoping Plan update without any consideration of the uncertainty factors, as previously described.[160]

Table 2-4: 2030 Comparison of the 2017 scoping plan and 2022 scoping plan modeling without uncertainty bounds[161]

	2030 GHG Emissions ($MMTCO_2e$) (2017 Scoping Plan)	2030 GHG Emissions ($MMTCO_2e$) (Reference Scenario)	Difference from the 2017 Scoping Plan and Reference Scenario
Non Cap-and-Trade Measures	320	304	~5% reduction
Role of Cap-and-Trade Program in 2030	60	44	~27% reduction

[160] See page 76 for additional discussion on modeling uncertainty

[161] Table 3 in *California's 2017 Climate Change Scoping Plan* included a 2030 range of 34–79 $MMTCO_2e$ for the role of the Cap-and-Trade Program.

Chapter 3: Economic and Health Evaluations

This chapter provides two approaches for comparing the relative differences between alternatives considered when developing the Draft 2022 Scoping Plan and identifying a Proposed Scenario. One approach is to consider the combined impact of all measures[162] in an alternative on the California economy. The other approach is required by AB 197, where each measure within an alternative is evaluated independently. In addition to these two evaluation approaches, this chapter also includes a discussion of the Public Health implications for the Proposed Scenario as well as the Environmental Analysis conducted in accord with California Environment Quality Act (CEQA).

It is important to note that all of the analyses in this chapter use a variety of data sources, but because the modeling is economy-wide at the state level, none of them produce community specific detail outputs. The AB 32 GHG Inventory Sector analysis relies on PATHWAYS data at the state level that is proportionally applied across all regions of the state to translate changes in state level fuel combustion to local level changes. The NWL analysis similarly utilizes a variety of data sources and a suite of models that produce data that are scaled up to the statewide level. All of the models, except the WUI defensible space model, which is conducted at the county level, create aspatial projections that are not applicable at the community level.

Economic Evaluation of Alternatives

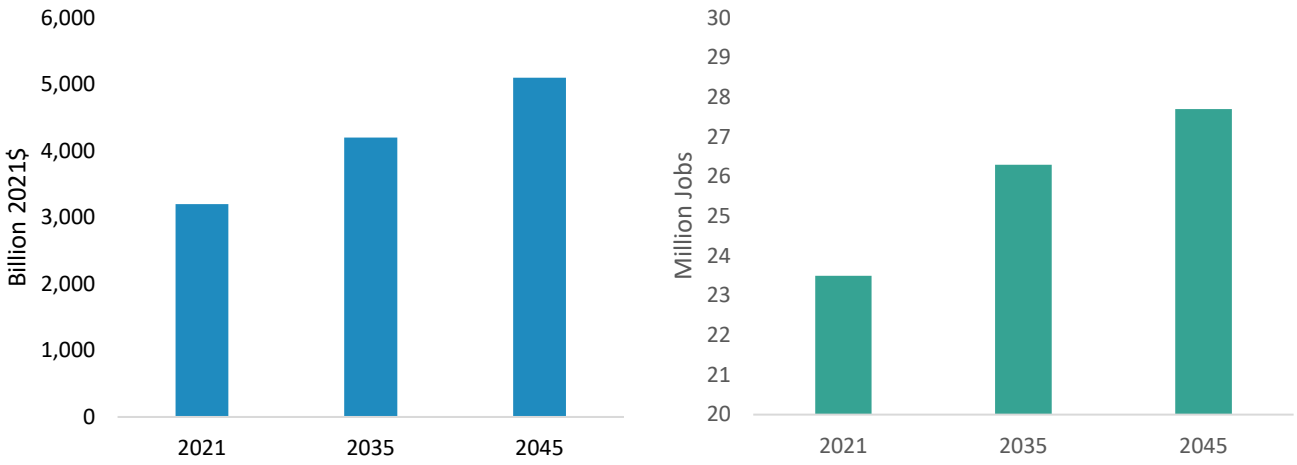
As part of the process to develop the Draft 2022 Scoping Plan, alternative scenarios that transition energy needs away from fossil fuels and achieve carbon neutrality no later than 2045 were developed. Alternative scenarios that assess the impact of different land management strategies on carbon stocks in NWL were also developed. These alternatives, and the Proposed Scenario, are described in Chapter 2. The following sections describe the differences among alternatives in terms of direct cost, the economy, employment, and health outcomes.

The California economy is growing, and it is projected to continue to grow about 3 percent each year, from $3.2 trillion in 2021 to $5.1 trillion in 2045, as shown in Figure 3-1. Similarly, employment in California is anticipated to grow 0.7 percent per year, from 23.5 million jobs in 2021 to 27.7 million jobs in 2045. It is in this context, termed the *Reference Scenario,* that CARB evaluates the alternative scenarios in terms of their impact on economic growth and

[162] AB 197 calls for the evaluation of "measures." This Draft 2022 Scoping Plan treats each action and its variants on stringency as measures for the purposes of this chapter. Appendix C (AB 197 Measure Analysis) lists the measures and corresponding modeling assumptions for each alternative and the Proposed Scenario.

employment. The projections shown in Figure 3-1 were produced by CARB to evaluate the incremental impact of regulations.

Figure 3-1: Projected California gross state product (left) and employment growth (right) from 2021 to 2035 and 2045



Source: California Air Resources Board

Transitioning away from fossil fuels to alternatives and increasing action on NWL will affect employment opportunities, household spending, businesses, and other economic aspects of our lives. Sectors expected to see growth include renewable electricity and hydrogen production, while other sectors may shrink. The deployment of clean technology may require higher upfront costs for things like heat pumps and induction stoves, but those could be offset by energy efficiency savings. Employment and economic development in NWL-related industries and sectors are expected to increase as land management actions increase, especially for the Forestry sector (in which a significant increase is called for under NWL Alternatives 2 and 4 and the Proposed Scenario). The net impact of these actions on employment and jobs is presented in this chapter.

Estimated Direct Costs

One key metric for evaluating scenarios is the direct cost, or net investment reflecting any savings that result from actions. Similar approaches were used to estimate direct costs for the AB 32 GHG Inventory sectors and for the NWLs as described in this section.

AB 32 GHG Inventory Sectors

Transitioning away from fossil fuels requires investment in new equipment and infrastructure throughout the economy. It involves developing the capacity to produce fuels and electricity from renewable sources rather than producing fossil energy. This transition also takes time. One approach is to eliminate combustion of fossil fuels by replacing all equipment in a specified year.

Another approach is to establish a future point at which all sales of new equipment rely on alternative energy sources and allow the transition to occur over time as equipment is replaced upon its end of life.

To evaluate the investment required through 2045, the PATHWAYS model was used to represent equipment stock and its turnover to non-fossil fuel alternatives over time. The annualized, incremental cost of infrastructure in excess of the annualized cost of the Reference Scenario[163] was computed for each year from 2022 through 2045. These costs are computed by first taking the absolute cost in each year—which includes both new equipment investment and also expenditures on energy, operations, and maintenance in each year—and then levelizing these costs (in the same way that car or house payments are annualized or spread out over time) to arrive at an annualized cost. Fuel savings, and resulting cost savings, associated with changing energy demand—from gasoline to electricity for vehicles, for example—are included as a result of this methodology. Carbon dioxide removal equivalent to the remaining GHG emissions in 2035 (for Alternatives 1 and 2) and in 2045 (for the Proposed Scenario and Alternative 4) was represented as an investment cost representative of DAC technology powered primarily by off-grid solar.[164,165]

The stock investment cost, fuel/efficiency savings, and CDR cost are shown for each alternative in 2035 and in 2045 in Figure 3-2. Stock costs are highest in Alternative 1 in both 2035 and in 2045, where new zero-emission vehicles, electric appliances, and other alternatives are needed by 2035 to nearly eliminate combustion of fossil fuels. Much of this equipment begins to require replacement as 2045 approaches, leading to additional stock costs. The Proposed Scenario and Alternative 4 allow end of life transition of equipment. In Alternative 2 most equipment is replaced at end of life, with early retirement of remaining medium- and heavy-duty vehicles by 2045. As a result, the annualized cost is more similar from one year to the next—there is no large replacement cost in a short time as in Alternative 1. The cost of investing in new equipment is partially offset by savings associated with efficiency gains and reduced demand for fuels like gasoline. This is particularly relevant in the transportation sector, which leads to the majority of

[163] The Reference Scenario described in Chapter 2 and in Appendix H (AB 32 GHG Inventory Sector Modeling) was the basis for the direct cost comparison.

[164] The modeled scenarios assume that residual emissions are compensated using DAC technologies by including the direct cost in terms of $ per ton of CO_2 removed. The energy source for DAC is not modeled, but renewable electricity and/or hydrogen produced from electrolysis are zero-carbon options consistent with the carbon neutrality targets in the Draft 2022 Scoping Plan. The economic analysis associated the investment in DAC with the solar industry for consistency with the carbon neutrality targets.

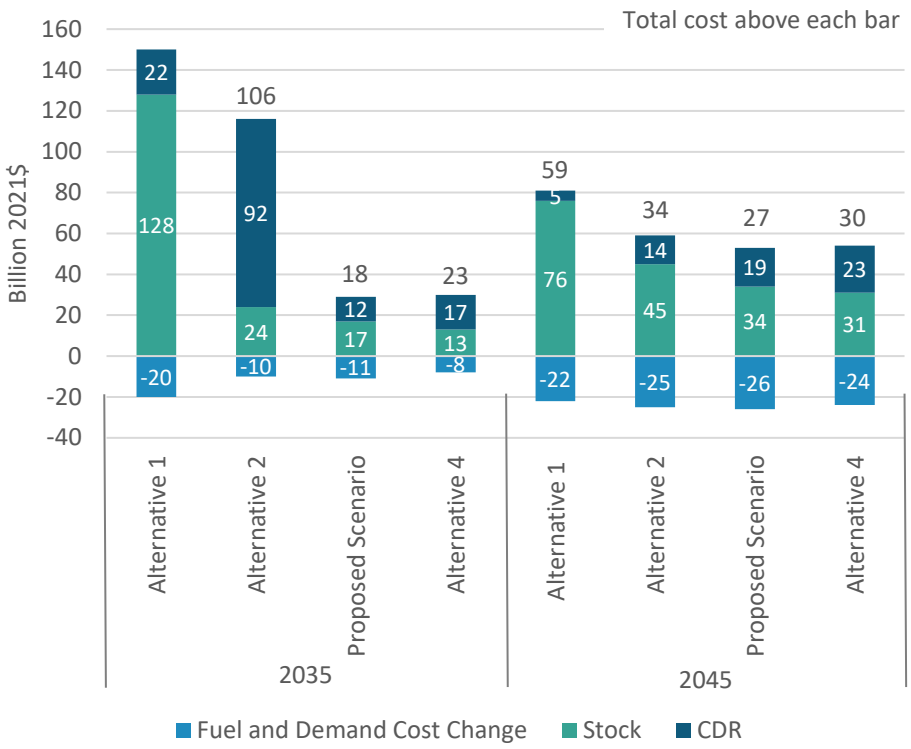
[165] For purposes of the Draft 2022 Scoping Plan, CARB assumed NWL could compensate for 15 $MMTCO_2e$ of residual emissions. This assumption was made prior to completion of the NWL GHG analysis described in Chapter 2.

savings in 2045 in the Proposed Scenario, the alternative that represents near complete electrification of transport relying only on end of life replacement of vehicles. Appendix H (AB 32 GHG Inventory Sector Modeling) includes additional detail on direct costs in each sector and how costs change over time.

While Alternative 1 achieves carbon neutrality through investment in new equipment to replace fossil fuel combustion, Alternative 2 relies heavily on CDR in 2035. The need for CDR decreases after 2035 as equipment that reaches its end of life is replaced with non-fossil fuel alternatives, so that by 2045, the need for CDR in Alternative 2 is similar to that for the Proposed Scenario and Alternative 4. Because CDR is critical for achieving carbon neutrality in all alternatives, it is important to begin investment soon to allow demonstration, deployment, and experience to reduce its cost as dependence on it grows toward 2045. Scaling this industry to the level needed in 2035 for Alternative 2 to reach carbon neutrality is extremely ambitious and subject to significant uncertainties due to the early development stage and implementation of these technologies today.

The Proposed Scenario has the lowest total cost in 2035 and in 2045. This scenario relies on transitioning to alternative vehicles and electric appliances as the equipment reaches its end of life. This scenario also ramps up sales of ZEVs and electric appliances quickly such that it achieves a more complete transition away from liquid fossil fuels by 2045 than Alternative 4, leading to greater fuel and efficiency savings. The Proposed Scenario also relies on direct emission reductions to a greater extent than Alternative 4, which reduces expenditures on CDR for the Proposed Scenario.

Figure 3-2: Cost and savings relative to the growing California economy for the Proposed Scenario and Alternatives in 2035 and 2045 (AB 32 GHG Inventory sectors)



Natural and Working Lands

For NWL, the direct costs of each management strategy are estimated using available academic literature, monitoring and reporting data, survey data, and cost data from existing subsidy programs on the per acre cost of implementing the management strategy. These cost data, in combination with the acreage of each management strategy under the scenarios, provided estimates of the overall direct cost to either the government or the private sector. The direct costs are independent of the policy lever used to implement the action and do not include many important benefits and externalities of the actions. They are assumed to be constant for each scenario and into the future. Avoided or secondary costs, such as those from reductions in wildfire suppression expenses, are not included. Appendix I (NWL Technical Support Document) includes additional direct cost details.

Table 3-1 includes the direct cost estimates for the Proposed Scenario compared to the Reference Scenario.[166] Direct costs for the NWL sector are expected to be significant due to the ambitious level of action for each land type. In NWL Alternative 1, all management action is stopped in forests, shrublands, and grasslands resulting in a lower cost (negative) relative to the Reference Scenario.

Table 3-1: Cost and savings relative to a growing California economy for the Proposed Scenario and NWL Alternatives (NWL)

Measure	NWL Alternative 1: Average Direct Annual Cost, 2025– 2045 (millions $/year)	NWL Alternative 2: Average Direct Annual Cost, 2025–2045 (millions $/year)	Proposed Scenario: Average Direct Annual Cost, 2025–2045 (millions $/year)	NWL Alternative 4: Average Direct Annual Cost, 2025–2045 (millions $/year)
Forests / Shrublands / Grasslands	-418	538	1,780	4,225
Annual Croplands	556	416	278	139
Perennial Croplands	8	6	4	2
Urban Forest	83,000	4,562	1,050	255
Wildland Urban Interface (WUI)	114	114	114	145
Wetlands	53	8	28	8
Sparsely Vegetated Lands	8	6	4	2
Totals	84,000	5,650	3,250	4,780
Note: Table values may not add to total due to rounding.				

NWL Alternative 1 is the most expensive, with a projected annual cost of $84 billion per year. This is almost entirely due to the large cost of spending on urban forests, as NWL Alternative 1

[166] The Reference Scenario described in Chapter 2 and in Appendix I (NWL Technical Support Document) was the basis for the direct cost comparison.

targeted the theoretical maximum urban tree cover by 2045. CARB estimates that the state currently spends approximately $4 billion dollars annually on planting, maintenance, sidewalk repair, tree removal, and other expenses related to urban forests and that reaching the theoretical maximum tree cover would require increasing that spending by a factor of 20.

NWL Alternative 2, the Proposed Scenario, and NWL Alternative 4 would cost $5.65 billion, $3.25 billion, and $4.78 billion, respectively. The cost of NWL Alternative 2 is predominately made up of urban forestry spending, and the cost of NWL Alternative 4 is predominantly made up of spending on forests, shrublands, and grasslands. The cost of the Proposed Scenario is predominantly a mix of urban forests and forests, shrubland, and grasslands spending.

Economy and Employment

Two different models were used to estimate the overall impact that investing in a transition away from fossil fuels and in our NWL may have on the growing California economy. The transition away from fossil fuels was evaluated using IMPLAN. The NWL investments were evaluated using REMI PI+. These models are similar in nature and provide comparable results relative to the same economic and employment Reference Scenario.

AB 32 GHG Inventory Sectors

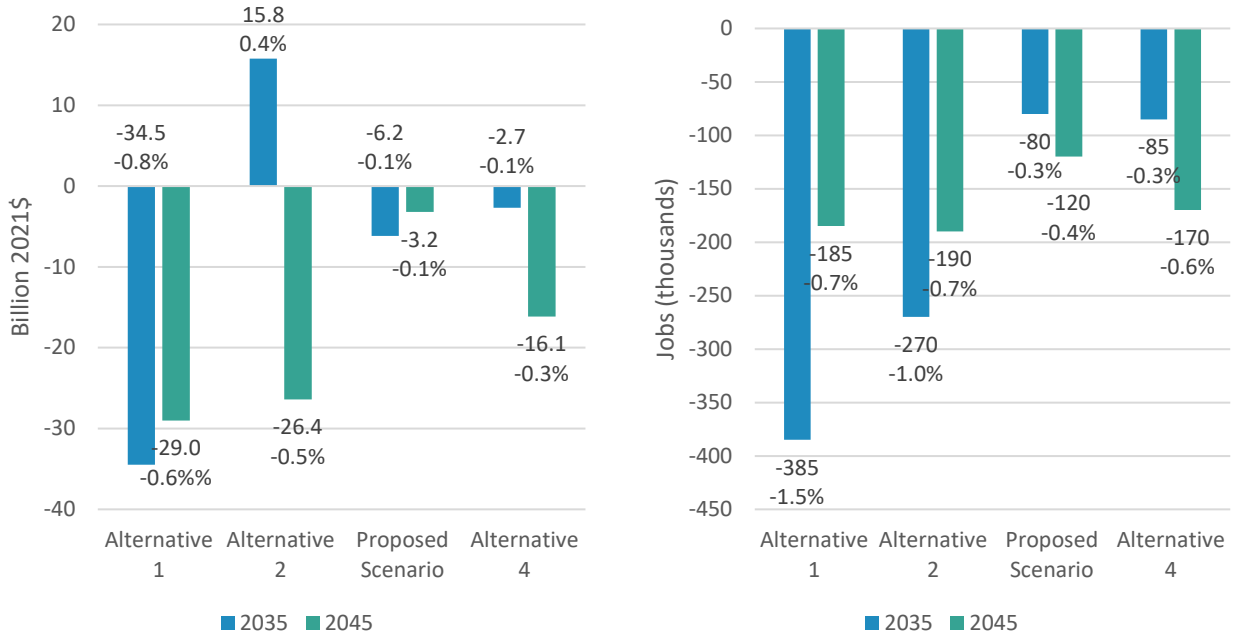
To estimate the overall impact that investing in a transition away from fossil fuels may have on the California economy, CARB used the IMPLAN model. Additional detail regarding the model, assumptions, and methodology are included in Appendix H (AB 32 GHG Inventory Sector Modeling). The IMPLAN model is a multisector representation of private industries in the U.S. economy that maps economic relationships across industries, households, and governments. This model translates direct costs and savings associated with transitioning away from fossil fuels with indirect effects such as wages, purchases of goods and services, business tax impacts, and supply chain effects. In addition, the induced effects of household purchases, local and import purchases, wages paid, and household tax impacts are estimated. This comprehensive assessment of the interactions between capital investment in fossil fuel alternatives and household purchases provides an indication of the response of the California economy to the four AB 32 GHG Inventory alternatives.

The Proposed Scenario and the three alternatives all result in a small impact on the GSP and employment relative to the Reference Scenario, as shown in Figure 3-3. All scenarios slow the growth of the economy by less than 1 percent, or about four months lag behind the Reference Scenario. Alternative 1 has the largest impact on growth in both 2035 and 2045 related to the high investment cost associated with early retirement of vehicles and appliances. Alternative 2's reliance on CDR in 2035 to achieve carbon neutrality results in a positive impact on the GSP, because of the large influx of investment to the California solar industry. Overall, Alternative 2 slows economic growth by 2045, by which time emissions have declined and the need for CDR

is reduced. The Proposed Scenario and Alternative 4 have a similar impact on economic growth in 2035, but by 2045, Alternative 4 slows growth more than the Proposed Scenario.

Employment growth is slowed in all four scenarios, but the impact is small, resulting in at most a 1.5 percent slowing of job growth relative to projected levels in 2035 and 2045. Alternative 1 has the greatest impact, and the Proposed Scenario has the smallest impact. Assuming annual growth rates of 0.7 percent means that there would be more than 193,000 additional jobs in 2045. Alternatives 1 and 2 contribute to job losses that nearly eliminate that projected annual job growth in 2045. The Proposed Scenario, on the other hand, reduces annual job growth in 2045 by a much lower amount.

Figure 3-3: Gross state product (left) and employment (right) relative to a growing California economy for the Proposed Scenario and Alternatives in 2035 and 2045 (AB 32 GHG Inventory sectors)



Additional macroeconomic indicators included in Table 3-2 provide insights into the impact of the alternatives on California households. Personal income represents the total value of wages, benefits, and proprietor income paid to Californians over a year. Personal income in California is projected to grow from $2.7 trillion in 2021 to $4.4 trillion in 2045. This reflects changes in wages and changes in the size of the California workforce. Table 3-2 presents the change in personal income across alternatives as a percentage of personal income in the Reference Scenario in 2035 and 2045. There is a modest slowing of growth in personal income across alternatives for both 2035 and 2045, ranging from a -0.4 percent to 0.0 percent change. The variation across alternatives is due to the varying reliance on CDR, as well as different levels of electrification, which may result in changes in sectors that have different direct, indirect, and

induced income impacts. Table 3-2 also outlines the change in personal income by household for the Proposed Scenario and other alternatives. Household projections are based on California Department of Finance population projections, which estimate the state's population to grow an average of 0.3 percent each year from 2021 to 2045.[167] California households are projected to increase from 13.3 million in 2020 to 14.6 million in 2035 and 15 million in 2045. There is a cost to California household personal income across all alternatives. The annual cost ranges from $65 to $950 based on variation in CDR and electrification across alternatives.

Table3-2: Household impacts relative to a growing California economy for the Proposed Scenario and Alternatives in 2035/2045 (AB 32 GHG Inventory sectors)

	Alternative 1	Alternative 2	Proposed Scenario	Alternative 4
Personal Income (%)	-0.4/-0.2	0.0/-0.2	-0.1/0.0	-0.1/-0.2
Change in Household Personal Income (2021$)	-950/-537	-65/-622	-187/-76	-153/-462
Note: Reference Scenario personal income is $3,600 trillion in 2035 and $4,400 trillion in 2045.				

Natural and Working Lands

The macroeconomic impact of the NWL alternatives was evaluated separately in the REMI PI+ model. For each alternative, the macroeconomic impact was modeled by assuming that economic activity in the relevant industries grows in proportion to the proposed implementation spending in that industry. All funds for implementing the actions are assumed to be sourced from within the state. For urban forests, the funds were modeled as being sourced from a combination of state government and private property owners in proportion to the current estimated private/public spending ratio. For all other actions, funds were assumed to be sourced from the state government. In each modeled scenario, government spending and income to property owners were reduced relative to the Reference Scenario in proportion to the annual costs of implementation. None of the proposed spending was modeled as being sourced from increased

[167] California Department of Finance. Population Projections (Baseline 2019). https://dof.ca.gov/forecasting/demographics/projections/.

taxes. Additional details on the methodology for evaluating macroeconomic impacts are in Appendix I (NWL Technical Support Document).

While the macroeconomic model does count the increased economic activity in the affected industries as part of GSP, it does not quantify many of the important economic, health, and environmental benefits that would occur if these actions were implemented. While these benefits—like the reduced use of pesticides, value of urban trees, and increased recreational opportunities—would be very significant, they are outside the scope of the macroeconomic model.

Table 3-3 shows that the largest impacts on the macroeconomy are observed in NWL Alternative 1, with a projected increase in the level of GSP of 1 percent relative to the Reference Scenario in 2045. Because of the high cost of urban forests, NWL Alternative 1 is projected to decrease the level of personal income per capita by 3.1 percent. NWL Alternative 1 induces an increase in California population to meet labor demands over the long run, such that total personal income increases but personal income per capita decreases. Besides NWL Alternative 1, impacts on the macroeconomy of the state are projected to be modest, with no more than a .03 percent change in GSP in NWL Alternative 1, NWL Alternative 2, and the Proposed Scenario by 2045.

The macroeconomic model also makes projections about the total level of employment in the state. Again, the largest impacts are observed in NWL Alternative 1, with projected increase in the level of total employment of 3.3 percent. The model forecasts that NWL Alternatives 1 and 2, which channel economic activity toward labor-intensive industries like landscaping for urban forests, would increase total employment, while the Proposed Scenario and NWL Alternative 4, which channel economic activity toward capital intensive industries like forestry, would lead to a slight decrease in total employment. While the model does aim to accurately represent many labor market dynamics, including adjustments of wages and migration rates, it does not account for many costs that might be associated with dramatically scaling up employment in a particular industry, such as the cost of job training.

Table 3-3: Gross state product and employment relative to a growing California economy for the Proposed Scenario and Alternatives in 2035 / 2045 (NWL)

	NWL Alternative 1 (%)	NWL Alternative 2 (%)	Proposed Scenario (%)	NWL Alternative 4 (%)
Gross State Product	0.98 / 0.91	0.04 / 0.01	-0.01 / -0.04	-0.03 / -0.03
Employment	3.67 / 3.31	0.18 / 0.12	0.01 / -0.01	-0.07 / -0.07
Personal Income	0.06 / 0.41	-0.02 / 0.00	-0.04 / -0.03	-0.09 / -0.08

Personal Income per Capita	-3.24 / -3.08	-0.18 / -0.14	-0.04 / -0.03	-0.02 / -0.01

Health Analysis

Air quality is affected by pollutant emissions from various processes associated with energy systems, including the combustion of fossil fuels, as well as the combustion of vegetation biomass from NWL during wildfires. Pollutants that are important contributors to degraded air quality in California include nitrogen oxides (NO_x), particulate matter (PM), reactive organic gasses (ROG), and others. Further, in the atmosphere these pollutants are transported away from the locations of the emissions by wind and other phenomena and undergo chemical reactions that result in the formation of new pollutants such as ground-level ozone and fine PM ($PM_{2.5}$). Both primary (emitted) and secondary (formed) pollutants are important from a public health standpoint and contribute to the incidence of air pollution-related mortality and disease within California populations. Measures focused on GHGs do not incorporate specific targets to reduce emissions of $PM_{2.5}$ or air toxics like benzene. These co-pollutants, which are emitted from many of the same pollution sources as GHGs, affect local air quality and pose known risks to public health, such as the risk of asthma and cardiovascular disease. Generally, for stationary sources, certain harmful pollutants are regulated via local rules and regulations that are reflected in permits for stationary sources and are enforced by local air districts, with CARB also regulating air toxics contaminants from stationary sources with the air districts.[168]

AB 32 GHG Inventory Sectors

To assess health impacts for the AB 32 GHG Inventory sectors, an integrated modeling approach was used to quantify and value the air pollution-related public health benefits of the four alternatives relative to the Reference Scenario. Additional detail about the models, assumptions, and methodology are included in Appendix H (AB 32 GHG Inventory Sector Modeling). Using output from the PATHWAYS model, projections of pollutant emissions to 2045 were developed for stationary, area, and mobile source emissions using a detailed base year CARB pollutant emissions inventory. Further, the emissions are processed, including for where and when they occur in California, using the Sparse Matrix Operator Kernels Emissions (SMOKE) model. For example, on-road vehicle emissions were allocated along existing roadways and refining emissions were assigned to the locations of existing refineries. It should be noted that the emissions projections represent statewide average reductions associated with high-level assumptions about alternative fuels and technologies. For example, emissions

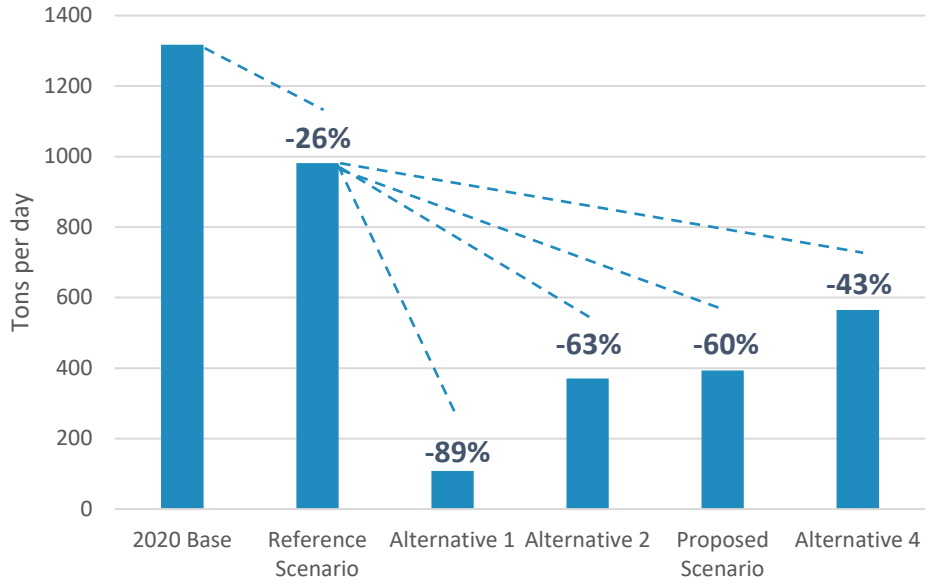
[168] OEHHA. 2022. *Impacts of Greenhouse Gas Emissions Limits Within Disadvantaged Communities: Progress Toward Reducing Inequities.* https://oehha.ca.gov/media/downloads/environmental-justice//impactsofghgpoliciesreport020322.pdf.

occurring from refineries to produce liquid fuels are reduced in line with petroleum demand. This reduction is applied equally to all refineries in each alternative and does not specify individual facility responses to changing demand. Similarly, the alternatives do not specify which refineries transition to biofuel production or where new electricity generation facilities are built.

Next, emission changes were translated into impacts on atmospheric pollution levels, including ground-level ozone and $PM_{2.5}$, via an advanced photochemical air quality model called the Community Multiscale Air Quality (CMAQ) model that accounts for atmospheric chemistry and transport. The months of July and January were chosen for assessment as the conditions during these months typically result in the highest concentrations of ozone and $PM_{2.5}$, and allow for a comparison of the maximum air quality impact the alternatives may achieve. Health benefits were estimated using EPA's BenMAP model to translate pollutant changes into avoided incidence of mortality, hospital admissions, emergency room visits and other outcomes as a result of reduced exposure to ozone and $PM_{2.5}$. These outcomes are associated with avoided cost in order to aggregate health impacts for each alternative and to compare between the alternatives.

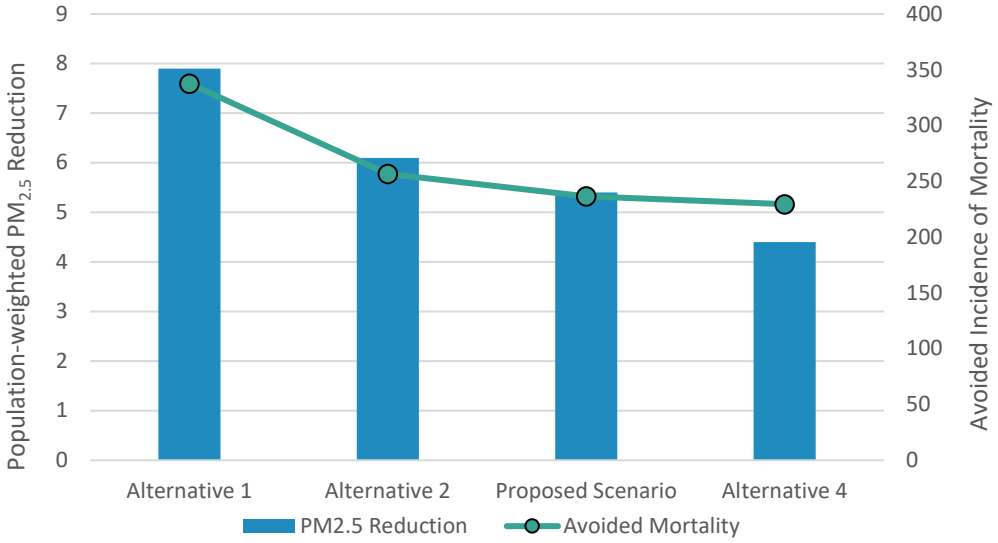
All four alternatives show a substantial reduction in pollutant emissions relative to the Reference Scenario including NO_x, $PM_{2.5}$, and ROG, as shown in Figure 3-4. Even under a business-as-usual trajectory, emissions are reduced from present by 26 percent in 2045 in the Reference Scenario, demonstrating the impact of current regulations and trends in energy sectors. The alternatives further reduce NO_x emissions from the Reference Scenario, from almost 90 percent in Alternative 1 to over 40 percent in Alternative 4. Emission reductions occur throughout the state with particular prominence in urban areas, including the South Coast Air Basin due to the large presence and activity of emission sources. Appendix H (AB 32 GHG Inventory Sector Modeling) contains additional information about the pollutant emissions modeling and results.

Figure 3-4: Illustration of NOx emission reductions from current levels for the Reference Scenario, the Proposed Scenario, and Alternatives in 2045 (AB 32 GHG Inventory sectors)



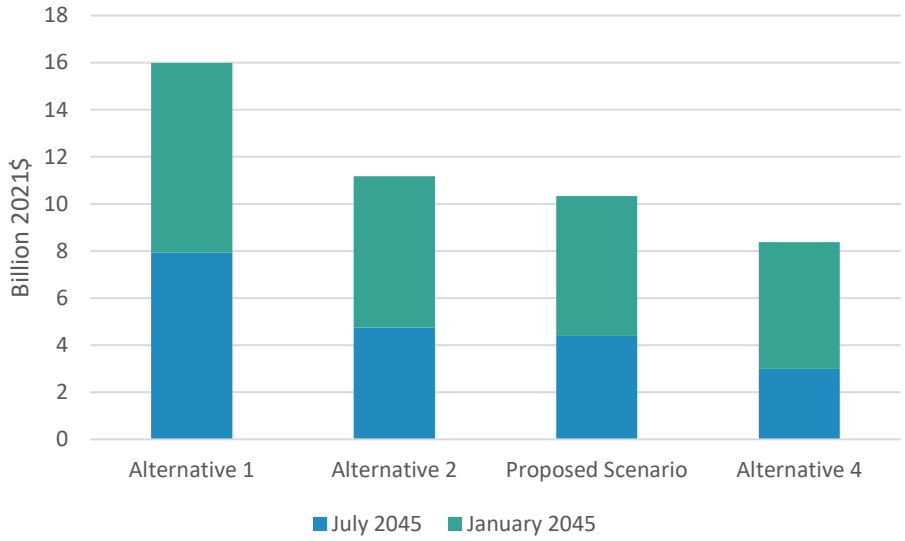
The emission reductions in all four alternatives achieve important improvements in air quality throughout California, including reductions in the levels of ozone and $PM_{2.5}$. For example, Figure 3-5 demonstrates the population-weighted reduction in $PM_{2.5}$ and the associated avoided incidence of premature mortality that result from reduced $PM_{2.5}$ exposure in January 2045. Note that episodic analysis of a single month provides a useful way of comparing alternatives, but it does not provide a comprehensive accounting of the air quality and health benefits that span an entire year. Appendix H (AB 32 GHG Inventory Sector Modeling) provides details regarding the atmospheric modeling and results including differences in ozone and $PM_{2.5}$.

Figure 3-5: Reductions in population-weighted $PM_{2.5}$ in January 2045 and the associated avoided incidence of premature mortality for the Proposed Scenario and Alternatives (AB 32 GHG Inventory sectors)



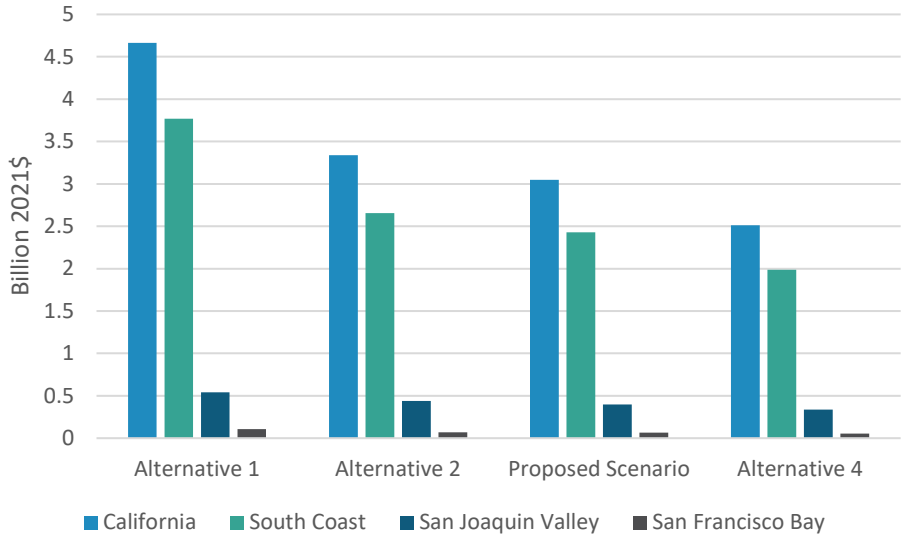
Notable health benefits representing the economic value of the avoided incidence of health effects are associated with all four alternatives. These generally scale with the level of combustion remaining in each scenario. The combined benefits, from July and January in 2045, for the four alternatives range from $8.3 billion in Alternative 4 to $15.9 billion in Alternative 1, as shown in Figure 3-6. Alternative 1 attains the highest benefits due to the near elimination of combustion emissions. Alternative 2 attains similar benefits to the Proposed Scenario in 2045. Alternative 4 attains the lowest health benefits of the four alternatives, but the benefits are still substantial overall. Improvements are greater in January due to large reductions in $PM_{2.5}$ concentrations. While these results are useful for scenario comparison, it is important to note that the benefits shown here represent only those occurring for two months in 2045, and the comprehensive benefits of the four alternatives will be much larger in total. Additional details regarding the health impact assessment are provided in Appendix H (AB 32 GHG Inventory Sector Modeling).

Figure 3-6: Total health benefits in July and January 2045 relative to the Reference Scenario for the Proposed Scenario and Alternatives (AB 32 GHG Inventory sectors)



Furthermore, these benefits accrue within socially and economically disadvantaged communities as identified by CalEnviroScreen (CES), where they are most needed. Total health benefits in July and January within census tracts identified as disadvantaged communities using CalEnviroScreen 4.0 range from $2.5 billion to $4.7 billion, as shown in Figure 3-7. Communities in the Southern California Air Basin (SoCAB) benefit more due to preexisting air quality challenges, significant emission sources and activity, and large, dense populations. It should again be noted that the health benefits reported here represent only a fraction of the total benefits that will result in disadvantaged communities from the four alternatives. Additional information on the health benefits within disadvantaged communities can be found in Appendix H (AB 32 GHG Inventory Sector Modeling).

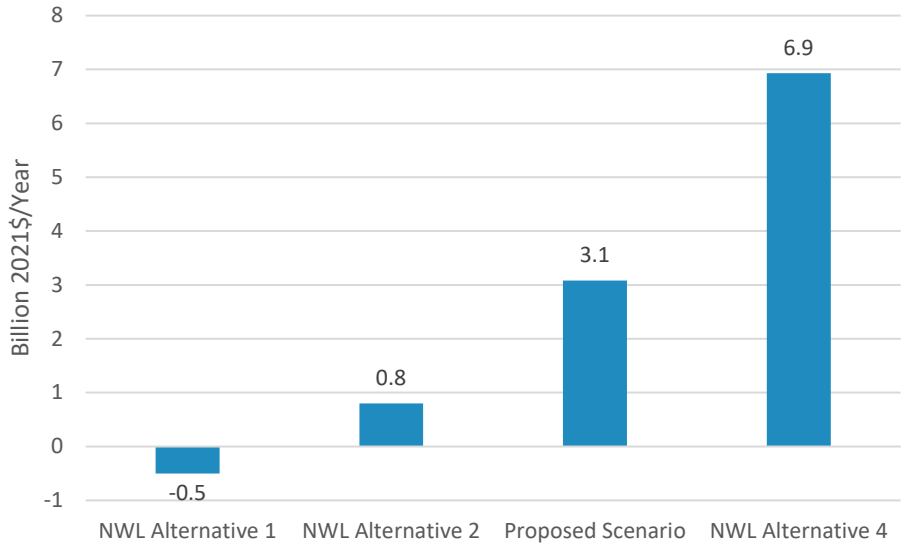
Figure 3-7: Disadvantaged community health benefits in July and January 2045 relative to the Reference Scenario for the Proposed Scenario and Alternatives (AB 32 GHG Inventory sectors)



Natural and Working Lands

For NWL, health benefits were evaluated based on projected $PM_{2.5}$ wildfire emissions on forests, shrublands, and grasslands, discussed in the AB 197 Measure Analysis section of the chapter that follows. The health endpoints for the Proposed Scenario and in Appendix I (NWL Technical Support Document) for the alternative scenarios were the basis for the estimated health benefits shown in Figure 3-8. Health benefits were derived from the preliminary University of California, Los Angeles (UCLA) study that estimated annual health impacts and associated costs from California's wildfires from 2008–2018. Additional details are included in Appendix I (NWL Technical Support Document). These costs were applied to the health endpoints discussed in the AB 197 Measure Analysis section of the chapter for each alternative in Figure 3-8.

Figure 3-8: Total average annual health benefits relative to the Reference Scenario for the Proposed Scenario and Alternatives (NWL)



As health impacts analyzed here are driven by wildfire emissions, the health benefits for the alternatives are directly related to the amount of forest, shrubland, and grassland management action included in each alternative. These management actions reduce vegetation fuels and, as a result, wildfire activity. NWL Alternative 1, which did not have any forest, shrubland, and grassland management, results in health costs over the Reference Scenario because increased wildfire emissions lead to higher incidence of emission-related health effect. The Proposed Scenario, as well as NWL Alternatives 2 and 4, increase in management intensity, reducing wildfire emissions and avoiding incidence of emission-related health effects. The health benefits, or economic value of the avoided incidence of health effects, correspondingly increase with an increasing management implementation rate. NWL Alternative 4, with 5–5.5 million acres of forest, shrubland, and grassland management, has the highest health benefits. Additional details are included in Appendix I (NWL Technical Support Document).

Estimated health benefits do not include the direct impact of wildfires on injuries, deaths, or mental health, nor the indirect costs of lost ecosystem benefits to wildfire. Additional direct health costs may result from wildfire that would likely increase the health benefits from increased forest, shrubland, and grassland management to reduce wildfire activity. Nonetheless, the conservative health benefits under the Proposed Scenario nearly offset the direct costs of implementation (see Table 3-3) for all NWL actions identified in the Proposed Scenario.

AB 197 Measure Analysis

This section provides the required AB 197 (E. Garcia, Chapter 250, Statutes of 2016) estimates for measures evaluated in this Draft 2022 Scoping Plan.[169] These estimates provide information on the relative impacts of the evaluated measures when compared to each other. To support the design of a suite of policies that result in GHG reductions, air quality co-benefits, and cost-effective measures it is important to understand if a measure will increase or reduce criteria pollutants or toxic air contaminant emissions, or if increasing stringency at additional costs yields few additional GHG reductions. To this end, AB 197 requires the following for each potential reduction measure evaluated in any Scoping Plan update:

- The range of projected GHG emissions reductions that result from the measure
- The range of projected criteria pollutant emission reductions that result from the measure
- The cost-effectiveness, including avoided social costs, of the measure

The following sections describe the evaluation of measures for the AB 32 GHG Inventory sectors and NWL alternatives.

Four alternative scenarios that transition energy needs away from fossil fuels and achieve carbon neutrality no later than 2045 were developed. Each alternative incorporates the same seven key measures to achieve GHG emission reductions; however, the pace and magnitude of transition away from fossil fuels differs among the alternatives. Appendix C (AB 197 Measure Analysis) summarizes the modeling assumptions associated with each measure for each of the four alternatives. The estimated emission reductions, health endpoints, and costs by measure for the Proposed Scenario are presented in this chapter, and the corresponding estimates for Alternatives 1, 2, and 4 are included in Appendix C (AB 197 Measure Analysis).

Each measure is evaluated independently by examining the change in fuel combustion, cost, and emissions associated with just that measure using the PATHWAYS model. The difference between the Proposed Scenario and the Reference Scenario is estimated for each measure. Starting from the Proposed Scenario or Alternative, the modeling assumptions for an individual measure are reverted to the Reference Scenario values, resulting in GHG reductions, changes to fuel combustion, and costs (or savings). This approach does not reflect interactions between sectors in PATHWAYS that influence the results for each complete alternative, presented earlier.

[169] AB 197 calls for the evaluation of "measures." This Draft 2022 Scoping Plan treats each action and its variants on stringency as measures for the purposes of this chapter. Appendix C (AB 197 Measure Analysis) lists the measures and corresponding modeling assumptions for each alternative and the Proposed Scenario.

As such, the values associated with independent measures should not be added to obtain an overall scenario estimate.

To arrive at the 2045 target for NWL, CARB modeled the ecological impact that climate smart land-based management strategies (suites of on-the-ground actions, or *treatments,* that are used across the landscape to manipulate an ecosystem) will have on ecosystem carbon under various climate change alternatives, and whenever possible, additional co-benefits from those actions. Four alternatives that explore how NWL can contribute to carbon neutrality in 2045 and beyond were developed. Each alternative incorporates a set of land management actions at varying scales of implementation for each land type, to achieve the GHG emission reductions. Each land type, and its associated management actions, was considered a measure for this analysis. For modeling individual landscapes and management actions, CARB used a suite of models. The complexity of these models varies by land type, depending on the existing science, data, and availability of existing models to use. Appendix I (NWL Technical Support Document) provides detailed modeling assumptions for each NWL type. The estimated emission reductions, health endpoints, and costs by measure under the Proposed Scenario for each NWL type are presented in this chapter, and the corresponding estimates for NWL Alternatives 1, 2, and 4 are included in Appendix C (AB 197 Measure Analysis).

Estimated Emissions Reductions

Both GHG emissions reductions and emissions of criteria air pollutants were evaluated for the AB 32 GHG Inventory sectors and for NWL. The methods and results are described in this section.

AB 32 GHG Inventory Sectors

In the absence of having direct modeling results for criteria pollutant estimates from PATHWAYS, CARB estimated criteria pollutant emissions impacts by using changes in fuel combustion in units of exajoules (EJ) from PATHWAYS and emission factors in units of tons per EJ to estimate the change in emissions in tons per year. Emission factors from a variety of sources for each sector were utilized, including but not limited to CARB's mobile source emissions models,[170] U.S. EPA's AP 42 Emissions Factors,[171] and the South Coast Air Quality Management District's (AQMD's) District Rules.[172] These emission factors were applied to fuel

[170] CARB. MSEI - Modeling Tools. https://ww2.arb.ca.gov/our-work/programs/mobile-source-emissions-inventory/msei-modeling-tools.
[171] U.S EPA. AP-42: Compilation of Air Emissions Factors. https://www.epa.gov/air-emissions-factors-and-quantification/ap-42-compilation-air-emissions-factors.
[172] South Coast AQMD. South Coast AQMD Rule Book. https://www.aqmd.gov/home/rules-compliance/rules/scaqmd-rule-book.

burn change by fuel type, sector, equipment type, and process, where applicable. Statewide annual average emissions were estimated for three criteria pollutants: NOx, $PM_{2.5}$, and ROG.

Table 3-4 provides the estimated GHG and criteria pollutant emission reductions for the measures in the Proposed Scenario in 2035 and 2045. The other alternatives are presented in Appendix C (AB 197 Measure Analysis). Based on the estimates below, these measures are expected to provide air quality benefits. The estimates provided in this chapter and Appendix C (AB 197 Measure Analysis) are appropriate for comparing across alternatives considered for the development of the Draft 2022 Scoping Plan, but they are not precise estimates.

Table 3-4: Estimated GHG and criteria pollutant emission reductions relative to the Reference Scenario for the Proposed Scenario in 2035/2045

Measure	GHG Reductions ($MMTCO_2$)	NOx Reductions (Short Tons/Year)	$PM_{2.5}$ Reductions (Short Tons/ Year)	ROG Reductions (Short Tons/Year)
Deploy ZEVs and reduce driving demand	-42 / -78	-49,458 / -119,882	-1,873 / -6,535	-16,576 / -29,246
Coordinate supply of liquid fossil fuels with declining California fuel demand	-26 / -32	-1,502 / -2,852	-617 / -1,504	-653 / -1,338
Generate clean electricity	N/A[a] / -6	-116 / -534	-95 / -440	-30 / -140
Decarbonize industrial energy supply	-7 / -16	-15,981 / -30,588	-848 / -2,234	-3,102 / -5,840
Decarbonize buildings	-14 / -29	-7,424 / -94,200	-686 / -6,903	-1,007 / -8,100
Reduce non-combustion emissions[b]	-0.40 / -0.52 ($MMTCH_4$)	N/A	N/A	N/A

Compensate for remaining emissions	-17 / -80	N/A	N/A	N/A

[a] SB100 does not lead to further GHG emissions reductions than the Reference Scenario until after 2035.

[b] Methane emissions reductions are reported for this measure.

The measures related to reducing non-combustion emissions and compensating for remaining emissions do not include changes to fuel combustion, and therefore are not associated with changes to air pollutants. Biomethane combustion is captured in measures that reduce combustion of fossil gas, such as decarbonizing industrial energy supply and buildings.

Natural and Working Lands

NWL ecosystems naturally vary between being a source and a sink for carbon over time. The NWL ecosystem carbon stock changes projected through mid-century by the suite of models were used to estimate net emissions or emissions reductions relative to the Reference Scenario. These changes in carbon stocks were affected by projected climate change; the implementation of management actions under the various scenarios; land conversion; and for forests, shrublands, grasslands, and wildfire. Each NWL type was evaluated, and an overview of all NWL is presented in Table 3-5. More detailed results for each NWL type can be found in Appendix C (AB 197 Measure Analysis).

Table 3-5: Estimated average annual GHG and criteria pollutant emission reductions relative to the Reference Scenario for the Proposed Scenario from 2025–2045

Measure	GHG Reductions ($MMTCO_2e$/year)	$PM_{2.5}$ Reductions (MT/Year)
Forests/Shrublands/Grasslands	0.12	17,500
Annual Croplands	0.23	N/A
Perennial Croplands	0.01	N/A
Urban Forest	0.52	N/A
Wildland Urban Interface (WUI)	-0.75	N/A

Wetlands	0.43	N/A
Sparsely Vegetated Lands	<0.01	N/A

Fine particulate wildfire emissions were evaluated for forests, shrublands, and grasslands only. Wildfire emissions decreased under the Proposed Scenario compared to the Reference Scenario. The Proposed Scenario's higher level of management actions that reduce tree or shrub densities, protect large trees, reintroduce fire to the landscape, and diversify species and structures result in greater reductions in wildfire emissions.

Estimated Health Endpoints

Climate change mitigation will result in both environmental and health benefits. This section provides information about the potential health benefits of the Proposed Scenario. Health benefits are primarily the result of reduced $PM_{2.5}$ pollution, both from stationary and mobile sources, as well as wildfire in forests, shrublands, and chaparral.

AB 32 GHG Inventory Sectors

CARB used the criteria pollutant emissions in Table 3-4 to understand potential health impacts. Similar to the air quality estimates, this information should be used to understand the relative health benefits of the various measures and should not be taken as absolute estimates of health outcomes. CARB used the incidence-per-ton (IPT) methodology to quantify the health benefits of emission reductions. The IPT methodology is based on a methodology developed by U.S. EPA.[173,174,175,176] Under the IPT methodology, changes in emissions are approximately proportional to the resulting changes in health outcomes. IPT factors are derived by calculating the number of health outcomes associated with exposure to $PM_{2.5}$ for a baseline scenario using measured ambient concentrations and dividing by the emissions of $PM_{2.5}$ or a precursor. To estimate the reduction in health outcomes, the emission reductions are multiplied by the IPT

[173] CARB. CARB's Methodology for Estimating the Health Effects of Air Pollution. Retrieved February 9, 2021. https://ww2.arb.ca.gov/resources/documents/carbs-methodology-estimating-health-effects-air-pollution.
[174] Fann, N., C. M. Fulcher, and B. J. Hubbell. 2019. "The influence of location, source, and emission type in estimates of the human health benefits of reducing a ton of air pollution." *Air Quality, Atmosphere & Health* 2:169–176. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2770129/.
[175] Fann, N., K. R. Baker, and C. M. Fulcher. 2012. "Characterizing the $PM_{2.5}$-related health benefits of emission reductions for 17 industrial, area and mobile emission sectors across the U.S." *Environ Int*. 49:141–51. November 15. https://www.sciencedirect.com/science/article/pii/S0160412012001985.
[176] Fann, N., K. Baker, E. Chan, A. Eyth, A. Macpherson, E. Miller, and J. Snyder. 2018. "Assessing Human Health $PM_{2.5}$ and Ozone Impacts from U.S. Oil and Natural Gas Sector Emissions in 2025." *Environ. Sci. Technol.* 52 (15), 8095–8103. https://pubs.acs.org/doi/abs/10.1021/acs.est.8b02050.

factor. For future years, the number of outcomes is adjusted to account for population growth. IPT factors were computed for the two types of $PM_{2.5}$: primary $PM_{2.5}$ and secondary $PM_{2.5}$ of ammonium nitrate aerosol formed from precursors.

For this AB197 analysis, CARB calculated the health benefits associated with the five key measures that are represented by changes to fuel combustion. The health benefits associated with emission reductions for the Proposed Scenario were estimated for each air basin and then aggregated for the entire state of California. CARB assumed that the statewide emission reductions distribution among the air basins is proportional to the baseline emissions in that air basin.

Calculated health endpoints include premature mortality, cardiovascular emergency department (ED) visits, acute myocardial infarction, respiratory ED visits, lung cancer incidence, asthma onset, asthma symptoms, work loss days, hospitalizations due to cardiopulmonary illnesses, hospitalizations due to respiratory illnesses, hospital admissions for Alzheimer's disease, and hospital admissions for Parkinson's disease.[177,178 ,179] These health endpoints were calculated using the IPT method for estimated emission reductions. Table 3-6 compares the health benefits of emission reductions associated with each measure for the Proposed Scenario in the year specified (2035 or 2045). The other Alternatives are presented in Appendix C (AB 197 Measure Analysis).

[177] CARB. CARB's Methodology for Estimating the Health Effects of Air Pollution. Retrieved February 9, 2021. *https://ww2.arb.ca.gov/resources/documents/carbs-methodology-estimating-health-effects-air-pollution*.
[178] CARB. 2022. Updated Health Endpoints in CARB's Health Benefits Methodology. *Proposed 2021-2024 Triennial Strategic Research Plan and Proposed Research for Fiscal Year 2021-2022*
[179] Cardio-pulmonary mortality, hospitalizations due to cardiopulmonary illnesses, and hospital admissions due to respiratory illnesses endpoints utilize studies documented in CARB's methodology document. For future assessments, CARB will use more recent studies to estimate cardiovascular hospital admissions and respiratory hospital admissions, as documented in CARB's updated health endpoints memo.

Table 3-6: Estimated avoided incidence of mortality, cardiovascular and respiratory disease onset, work loss days and hospital admissions relative to the Reference Scenario for the Proposed Scenario

Measure	Mortality	Cardiovascular ED Visits	Acute Myocardial Infarction	Respiratory ED Visits	Lung Cancer Incidence	Asthma Onset	Asthma Symptoms	Work Loss Days	Hospital Admissions, Cardiovascular	Hospital Admissions, Respiratory	Hospital Admissions, Alzheimer's Disease	Hospital Admissions, Parkinson's disease
Deploy ZEVs and reduce driving demand in 2035	600	160	65	380	45	1,400	122,460	87,870	95	110	235	40
Deploy ZEVs and reduce driving demand in 2045	1,800	470	195	1,100	130	3,945	338,845	252,630	290	345	735	125
Coordinate supply of liquid fossil fuels with declining CA fuel demand in 2035	75	20	10	50	5	185	15,655	11,230	10	15	30	5
Coordinate supply of liquid fossil fuels with	195	50	20	120	15	440	36,825	27,435	30	35	85	15

declining CA fuel demand in 2045												
Generate clean electricity in 2035	10	5	-	5	-	25	2,225	1,595	-	-	5	-
Generate clean electricity in 2045	55	15	5	35	5	125	10,265	7,650	10	10	25	5
Decarbonize industrial energy supply in 2035	220	60	25	140	15	515	44,740	32,100	35	40	85	15
Decarbonize industrial energy supply in 2045	525	135	55	320	40	1,150	98,550	73,465	85	100	215	35
Decarbonize buildings in 2035	135	35	15	85	10	310	27,010	19,380	20	25	55	10
Decarbonize buildings in 2045	1,610	420	175	985	120	3,555	303,960	226,595	260	310	665	115
Note: All values are rounded to the nearest 0 or 5.												

The measures related to reducing non-combustion emissions and compensating for remaining emissions do not include changes to fuel combustion and therefore are not associated with changes to air pollutants or health endpoints. Biomethane combustion is captured in measures that reduce combustion of fossil gas, such as decarbonizing industrial energy supply and buildings.

Although the estimated health outcomes presented are based on a well-established methodology, they are subject to uncertainty. For instance, future population estimates are subject to increasing uncertainty as they are projected further into the future, and baseline incidence rates can experience year-to-year variation. Also, the relationship between changes in pollutant concentrations and changes in pollutant or precursor emissions is assumed to be approximately proportional.

In addition, emissions are reported at an air basin level and do not capture local variations. These estimates also do not account for impacts from global climate change, such as temperature rise, and are only based on the scenarios in this Draft 2022 Scoping Plan.

The fuel changes for each AB 197 measure are estimated based on the impact of each measure compared to the Reference Scenario for the years 2035 and 2045. Therefore, aggregating the effect of each measure would overestimate the impacts of the Proposed Scenario because the implementation of each measure would affect the level of benefits of the other measures. This measure-by-measure analysis uses a different methodology for calculating health endpoints than does the health analysis for the complete alternatives provided earlier.

Natural and Working Lands

Implementation of NWL management strategies to mitigate and adapt to climate change will result in both environmental and health benefits. This section provides information about the potential health benefits of measures evaluated for the Proposed Scenario. For this analysis, health benefit estimates were focused on increases or decreases to $PM_{2.5}$ resulting from wildfire emissions on forests, shrublands, and grasslands. Other health benefits resulting from NWL management actions in the Proposed Scenario are not quantified here but are important for all Californians. This includes, but is not limited to, reductions in exposure to synthetic pesticides when switching to organic agricultural systems, improvements in shade availability and mental health with increasing urban forest cover, improved mental health from opportunities for recreation in resilient and healthy environments, and protection from floods and rising sea levels. These examples are by no means exhaustive, as our natural and working lands provide immense health benefits to everyone.

For this analysis, CARB used the $PM_{2.5}$ emissions in Table 3-5 to understand potential health impacts. This information should be used to understand the relative health endpoints of the various measures and should not be taken as absolute estimates of

health outcomes of the Draft 2022 Scoping Plan statewide or within a specific community. The IPT methodology was used to calculate health endpoints, similar to the AB 32 GHG Inventory Sector analysis. CARB calculated the annual health endpoints associated with the wildfire emissions changes resulting from the implementation of management strategies on forests, shrublands, and grasslands under each alternative. The annual health endpoints associated with emission reductions for the Proposed Scenario were estimated for the entire state. Calculated health endpoints include emissions-caused mortality, hospital admittance, and emergency room visits from asthma; hospital admittance from chronic obstructive pulmonary disease; and emergency room visits from respiratory and cardiovascular outcomes. Table 3-7 compares the average annual health endpoints of wildfire emission reductions associated with the Proposed Scenario over the period 2025–2045. The other alternatives are presented in Appendix C (AB 197 Measure Analysis).

Table 3-7: Estimated average annual avoided incidence of hospital admissions, emergency room visits, and mortality relative to the Reference Scenario for the Proposed Scenario resulting from forest, shrubland, and grassland wildfire emissions

Health Endpoints from Forest, Shrubland, and Grassland Wildfire Emissions	Average Annual Avoided Incidence
Hospital admissions from asthma	16
Hospital admissions from chronic obstructive pulmonary disease without asthma	14
Hospital admissions from all respiratory outcomes	47
Emergency room visits from asthma	115
Emergency room visits from all respiratory outcomes	311
Emergency room visits from all cardiovascular outcomes	116

All cause mortality	292

Estimated Social Cost

Social costs are generally defined as the cost of an action on people, the environment, or society and are widely used to understand the impact of regulatory actions. One tool, the social cost of greenhouse gases (SC-GHG), is an estimate of the present value of the costs associated with the emission of GHGs in future years. It combines climate science and economics to help understand the benefits of reducing GHG emissions. The estimates of the social cost of carbon (SC-CO_2) and social cost of methane (SC-CH_4), two types of SC-GHGs, presented here estimate the value of the net harm to society associated with adding GHGs to the atmosphere in a given year; they do not represent the cost of actions taken to reduce GHG emissions (known as the *cost of abatement*) nor the cost of GHG emissions reductions. In principle, the SC-GHG includes the value of climate change impacts, including but not limited to, changes in net agricultural productivity, human health effects, property damage from increased flood risk and other natural disasters, disruption of energy systems, risk of conflict, environmental migration, and the value of ecosystem services. It reflects the societal value of reducing emissions of the gas in question by one metric ton.[180] Many of these damages from GHG emissions today will affect economic outcomes throughout the next several centuries.

In 2008, federal agencies began incorporating SC-CO_2 estimates into the analysis of their regulatory actions. U.S. EPA has used various models and discount rates to determine the value of future impacts. Generally, these models begin with assumptions to predict economic activity over time, along with projected GHG emissions. The modeled emissions are input into a model of the global climate system, which then translates into estimates of surface temperature, sea level rise, and other impacts. These outputs are used to estimate economic damages per ton of GHG emitted in a given year in the future. Since the models are calculating the present value of future damages, a discount rate is applied. For example, the SC-CO_2 for the year 2045 represents the value of climate change damages from a release of CO_2 in 2045 discounted back to today. The present value is significantly affected by the discount rate used; a higher discount rate results in a lower present value. For example, in 2021 dollars the SC-CO_2 in 2045 is $31 using a 5 percent discount rate, $88 using a 3 percent discount rate, and $122 using a 2.5 percent discount rate. Additional detail is included in Appendix C (AB 197 Measure Analysis).

[180] U.S. Government. Interagency Working Group on Social Cost of Greenhouse Gases. February 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide – Interim Estimates under Executive Order 13990. *https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf*

The 2017 Scoping Plan utilized SC-CO_2 and SC-CH_4 Obama Administration-era values developed by the Council of Economic Advisors and the Office of Management and Budget-convened Interagency Working Group on the Social Cost of Greenhouse Gases (IWG)[181] to consider the social costs of actions to reduce GHG emissions. The Biden Administration reinstated these values in February 2021, after they had been rescinded and significantly revised by Trump Administration.[182] The reinstatement was considered an interim step, and the Biden Administration also reconvened the IWG to continue its work to evaluate and incorporate the latest climate science and economic research and respond to the National Academies' recommendations from 2017 as it develops a more complete revision of the estimates.

It is important to note that the models used to produce SC-GHG estimates do not include all of the important physical, ecological, and economic impacts of climate change recognized in the climate literature. There are additional costs to society, including the costs associated with changes in co-pollutants and costs that cannot be included due to modeling and data limitations. The IWG has stated that the range of the interim SC-GHG estimates likely underestimates societal damages from GHG emissions.[183] The revised estimates were originally slated to be released in early 2022 but have stalled.[184] CARB staff is applying the interim values presented in the IWG February 2021 Technical Support Document (TSD), which reflect the best available science in the estimation of the socio-economic impacts of GHGs.[185] This Draft 2022 Scoping Plan utilizes the TSD

[181] Originally titled the "Interagency Working Group on the Social Cost of Carbon," the IWG was renamed in 2016.
[182] The White House. 2021. A Return to Science: Evidence-Based Estimates of the Benefits of Reducing Climate Pollution. *https://www.whitehouse.gov/cea/written-materials/2021/02/26/a-return-to-science-evidence-based-estimates-of-the-benefits-of-reducing-climate-pollution/*.
[183] Interagency Working Group on Social Cost of Greenhouse Gases. 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. *https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf*
[184] See *Louisiana v. Biden*, ___ F.Supp.3d___, 2022 WL 438313 (W.D. La. Feb. 11, 2022), stayed pending review 2022 WL 866282 (5th Cir. Mar. 16, 2022). A federal district court ruling issued in early February 2022, had granted a preliminary injunction blocking the Biden Administration from using the interim IWG SC-GHG estimates. However, a federal appeals court overturned the lower court's preliminary injunction in March 2022, which allows the Biden Administration to continue using the policy as legal proceedings continue. CARB will continue to monitor the litigation. However, the federal action does not prohibit CARB from using social cost of carbon and CARB will use the best available science regardless of politics.
[185] Interagency Working Group on Social Cost of Greenhouse Gases. 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide Interim Estimates under Executive Order 13990. *https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf*.

standardized range of discount rates, from 2.5 to 5 percent to represent varying valuation of future damages..

AB 32 GHG Inventory Sectors

Table 3-8 presents the estimated social cost for each measure of the Proposed Scenario. For each measure, Table 3-8 includes the range of the SC-CO_2 and SC-CH_4 that result from the GHG emissions reductions in 2035 and 2045 at 2.5 and 5 percent discount rates. Additional background on the SC-GHG and methodology for calculating the SC-CO_2 and SC-CH_4 estimates in this Draft 2022 Scoping Plan, as well as estimates for the alternatives, are provided in Appendix C (AB 197 Measure Analysis).

Table 3-8: Estimated social cost (avoided economic damages) of measures considered in the Proposed Scenario (AB 32 GHG Inventory sectors)

Measure	Social Cost of Carbon in 2035, 5%–2.5% discount rate billion USD (2021 dollars)	Social Cost of Carbon in 2045, 5%–2.5% discount rate billion USD (2021 dollars)
Deploy ZEVs and reduce driving demand	1.03–4.50	2.46–9.53
Coordinate supply of liquid fossil fuels with declining California fuel demand	0.64–2.78	0.99–3.84
Generate clean electricity	N/A[a]	0.20–0.79
Decarbonize industrial energy supply	0.18–0.78	0.49–1.89
Decarbonize buildings	0.35–1.50	0.91–3.52
Reduce non-combustion emissions	0.49–1.26 (SC-CH_4)	0.85–1.98 (SC-CH_4)
Compensate for remaining emissions	0.41–1.76	2.50–9.68
Proposed Scenario SC-CO_2	2.2–9.7	2.0–7.9
Proposed Scenario SC-CH_4	0.49–1.3	0.85–2.0
Proposed Scenario (Total)[b]	2.7–11.0	2.8–9.9

[a] SB100 does not lead to further GHG emissions reductions than the Reference Scenario until after 2035.

[b] CARB staff could not precisely separate some CO_2 and CH_4 from other GHGs from PATHWAYS outputs, but the contribution is believed to be small for purposes of calculating the social cost of carbon. The approach used to estimate GHG emissions reductions for individual measures in PATHWAYS does not reflect cross-sector interactions. Therefore, the GHG values for each measure do not sum to the overall scenario total. The total GHG emissions reduction used in this calculation is 91 $MMTCO_2e$ in 2035 and 65 $MMTCO_2e$ in 2045.

Natural and Working Lands

The SC-CO_2 estimates for the NWL measures shown in Table 3-9 reflect 2021 IWG interim values, updated for inflation, similar to the AB 32 GHG Inventory Sector analysis. This analysis utilizes the 2.5 percent and 5 percent discount rate and the average annual emissions reductions from each NWL type from 2025–2045. Estimates for all alternatives are included in Appendix C (AB 197 Measure Analysis).

Table 3-9: Estimated social cost (avoided economic damages) of measures considered in the Proposed Scenario (NWL)

Measure	Social Cost of Carbon in 2035, 5%–2.5% discount rate Billion USD (2021 dollars)	Social Cost of Carbon in 2045, 5%–2.5% discount rate Billion USD (2021 dollars)
Forests/Shrublands/Grasslands	0.003–0.012	0.004–0.014
Annual Croplands	0.006–0.025	0.007–0.028
Perennial Croplands	<0.001–0.001	0.000–0.001
Urban Forest	0.012–0.055	0.016–0.063
Wildland Urban Interface (WUI)	(0.018) – (0.080)	(0.023) – (0.090)
Wetlands	0.011–0.046	0.014–0.053
Sparsely Vegetated Lands	<0.001	<0.001

Social Costs of GHGs in Relation to Cost-Effectiveness

AB 32 includes a requirement that rules and regulations "achieve the maximum technologically feasible and cost-effective" greenhouse gas emissions reductions.[186] Under AB 32, *cost-effectiveness* means the relative cost per metric ton of various GHG reduction strategies,[187] which is the traditional cost metric associated with emission control. In contrast, the SC-CO_2, SC-CH_4, and social cost of nitrous oxide (SC-N_2O), because they are estimates of the cost to society of additional GHG emissions, can be used to estimate of the economic benefits of reducing emissions, but do not take into account the cost of the actions that must be taken to achieve those GHG emissions reductions.

There may be technologies or policies that do not appear to be cost-effective when compared to the SC-CO_2, SC-CH_4, and SC-N_2O associated with GHG reductions. However, these technologies or policies may result in other benefits that are not reflected in the IWG social costs. Examples include the evaluation of social diversification of the portfolio of transportation fuels (a goal outlined in the Low Carbon Fuel Standard) and reductions in criteria pollutant emissions from power plants (as in the Renewables Portfolio Standard). Additionally, costs for new technology may be higher early on in a technology's development cycle and may drop over time as use of the technology is scaled up.

Estimated Cost per Metric Ton

AB 197 requires an estimation of the cost-effectiveness of the measures evaluated for the Draft 2022 Scoping Plan. The cost (or savings)[188] per metric ton of CO_2e reduced for each measure is one metric for comparing the performance of the measures. Additional factors beyond the cost per metric ton that could be considered include continuity with existing laws and policies, implementation feasibility, contribution to fuel diversity and technology transformation goals, and health and other benefits to California. These considerations are not reflected in the cost per metric ton estimates presented below. It is important to understand the relative cost-effectiveness of individual measures as presented in this section. However, the economic analysis presented earlier in this

[186] AB 32 Air pollution: greenhouse gases: California Global Warming Solutions Act of 2006. (AB 32, Nuñez, Chapter 488, Statutes of 2006). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200520060AB32.

[187] Health & Saf. Code § 38505(d).

[188] Similarly, to the direct costs reported earlier, the cost per metric ton of a measure reflects the stock costs and any fuel or efficiency savings associated with a measure divided by the GHG emission reduction achieved by the measure. Costs are reported as positive values, and savings are reported as negative values.

chapter, in Appendix H (AB 32 GHG Inventory Sector Modeling), and in Appendix I (NWL Technical Support Document) provides a more comprehensive analysis of how the Proposed Scenario and alternative scenarios affect the state's economy and jobs.

AB 32 GHG Inventory Sectors

The cost per metric ton for the AB 32 GHG Inventory sectors is computed for each measure independently relative to the Reference Scenario using the sensitivity calculations based on PATHWAYS and RESOLVE outputs. The difference in the annualized cost between the Proposed Scenario and the Reference Scenario is computed for each measure in 2035 and in 2045. The incremental cost is divided by the incremental GHG emissions impact to calculate the cost per metric ton in each year. To capture the fuel and GHG impacts of investments made from 2022 through 2035, or from 2022 through 2045, CARB computed an average annual cost per metric ton. The incremental cost in each year is averaged over the period. This value is divided by the corresponding annual, incremental GHG impact averaged over the same period.

The cost metric includes the annualized incremental cost of energy infrastructure, such as zero-emission vehicles, electric appliances, and required revenue to support all electric assets. A residual value for equipment such as vehicles or appliances that are retired early is included. The annual fuel cost or avoided fuel cost that results from efficiency improvements or changes to demand for fuels associated with transitioning to alternative fuels is included. Not included in this cost metric are costs that represent transfers within the state, such as incentive payments for early retirement of equipment.

It is important to note that this cost per metric ton does not represent an expected market price value for carbon mitigation associated with these measures. In addition, the values do not capture fuel savings or GHG reductions associated with the full economic lifetime of measures that have been implemented by the target date of 2035 or 2045 but whose impacts extend beyond the target date.

Table 3-10 includes the cost per metric ton and annual average cost per metric ton estimates for the Proposed Scenario. The other alternatives are presented in Appendix C (AB 197 Measure Analysis). Measures that are relatively less costly in 2035 or 2045 are also less costly over the extended period. As noted earlier, incremental costs of new vehicles are generally offset by gains in efficiency and avoided fuel consumption resulting in negative cost per metric ton.

Table 3-10: Estimated cost per metric ton of reduced CO_2e relative to the Reference Scenario for measures considered in the Proposed Scenario (AB 32 GHG Inventory sectors)

Measure	Annual Cost, 2035 ($/ton)	Average Annual Cost, 2022–2035 ($/ton)	Annual Cost, 2045 ($/ton)	Average Annual Cost, 2022–2045 ($/ton)
Deploy ZEVs and reduce driving demand	-157	-85	-121	-128
Coordinate supply of liquid fossil fuels with declining CA fuel demand	36	91	-38	38
Generate clean electricity[a]	N/A	N/A	450	497
Decarbonize industrial energy supply	290	240	429	356
Decarbonize buildings	595	754	463	598
Reduce non-combustion emissions	93	95	109	100
Compensate for remaining emissions	745	945	236	745

[a] SB100 does not lead to further reductions than the Reference Scenario until after 2035. NOTE: The denominator of this calculation (2045) does not include GHG reductions occurring outside of California resulting from SB 100. If these reductions were included, this number would be lower.

Natural and Working Lands

The cost per metric ton for NWL measures are computed for the Proposed Scenario relative to the Reference Scenario using the projected carbon stock/sequestration data from the NWL modeling and the direct cost estimates for each management action, described earlier. Direct costs represent the cost of implementing a certain management action. The projected emissions reductions take into account the loss of carbon that results from the management action, such as fuels reduction treatments in forests, as well as climate change effects on growth. The direct cost for each NWL measure was divided by the average annual emission reductions presented in Table 3-5 to produce the cost

per metric ton. The increasing effect of climate change on diminished future growth reduces the ability of the land to sequester or store carbon, driving up the cost per ton.

It is important to note that this cost per metric ton does not represent an expected market price value for carbon mitigation associated with these measures. In addition, emissions benefits of NWL management actions often take longer time periods to accrue, and these values only capture GHG reductions up to 2045.

Table 3-11 includes the average cost per metric ton estimates for the average annual CO_2e reductions from 2025 through 2045 for the Proposed Scenario. The other alternatives are presented in Appendix C (AB 197 Measure Analysis).

Table 3-11: Estimated average cost per metric ton of reduced CO_2e relative to the Reference Scenario for measures considered in the Proposed Scenario (NWL)

Measure	Average Cost per Reduced Ton CO_2e ($/Ton)
Forests/Shrublands/Grasslands	15,500
Annual Croplands	1,210
Perennial Croplands	412
Urban Forest	2,030
Wildland Urban Interface (WUI)	N/A
Wetlands	64
Sparsely Vegetated Lands	451,000

Public Health

Health Analysis Overview

Taking action to address climate change presents one of the most significant opportunities to improve public health outcomes.[189] Transitioning to clean energy and technology and improving land and ecosystem management will lead to a much healthier future. Many actions to reduce greenhouse gas (GHG) emissions also have health co-benefits that can improve the health and well-being of populations across the state, as well as address climate change. By taking action to reduce climate change threats to public health and addressing systemic inequities, California is pursuing win-win strategies that solve multiple problems. This section and the accompanying Appendix G (Public Health) provide qualitative analysis of health benefits to accompany the quantitative health analysis included in this chapter, Appendix C (AB 197 Measure Analysis) and Appendix H (AB 32 GHG Inventory Sector Modeling). Together the qualitative and quantitative analyses of benefits are demonstrating the many ways that climate action and health improvements go hand in hand.

Climate change can lead to a wide range of direct health impacts such as increased heat-related illnesses (i.e., heat exhaustion and heat stroke), and injuries and deaths from extreme weather events or disasters (e.g., severe storms, flooding, wildfires). Indirect impacts include more air pollution-related exacerbations of cardiovascular and respiratory diseases (e.g., due to increased smog, wildfire smoke); increased vector-borne and fungal diseases due to changes in the distribution and geographic range of disease-carrying species (e.g., mosquitoes, ticks, fungi in dust); negative nutritional consequences related to decreases in agricultural food yields; stress and mental trauma due to extreme weather-related catastrophes as well as anxiety, depression, and other mental health impacts associated with gradual changes in the climate that result in unemployment and income loss (e.g., prolonged drought or temperature shifts affecting jobs and industries), and residential displacement and home loss (e.g., sea level rise impacting coastal communities).

Wildfires and wildfire smoke are one area where we have already seen and expect to see even further drastic impacts on the health of Californians. According to CalFire, since 1932 the top eight largest wildfires in California have occurred in the past five years (2017-2022) with 151 deaths due directly to fires during that period.190 Researchers estimate

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[189] Watts N, Adger WN, Agnolucci P, et al. 2015. Health and climate change: policy responses to protect public health. Lancet: 386, 1861-1914.

[190] California Department of Forestry and Fire Protection (CAL FIRE). “Stats and Events.” *Cal Fire Department of Forestry and Fire Protection*, https://www.fire.ca.gov/stats-events/

that wildfire smoke during Fall 2020 may have led to as many as 3,000 excess deaths with at least 95% of Californians suffering unhealthy levels of particle pollution due to wildfires in 2020. Continued climate change is projected to further increase smoke exposure from wildfires through the end of the century.[191] Wildfires also create a high-risk environment for outdoor workers including agricultural workers. While the direct medical and physical health impacts are often most noticeable, the psychological impacts can develop and persist well after the event. Estimates indicate that 20-65% of survivors of extreme weather events have mental health issues following the event.[192]

Extreme heat, drought, and associated worsened air quality impacts are among the most serious climate-related exposures affecting the health of Californians. Numerous studies find a wide range of adverse health effects accompanying extreme heat including heat stroke and adverse birth outcomes and find that extreme heat can harm most body systems. Climate change exacerbates air pollution problems that cause difficulty breathing and can lead to serious illness and death in many parts of California. Increasing temperatures cause increases in ozone and other pollution concentrations, including for California's most polluted regions and heighten health risks for the vulnerable and marginalized populations living in these areas.[193] In 2020, there were 157 ozone polluted days across Los Angeles, Orange, Riverside and San Bernardino Counties—the most days since 1997. In addition, particulate matter exposure is a heightened problem during droughts, which are expected to increase over this century.[194,195] Worse air quality leads to illnesses, emergency room visits, and hospitalizations for chronic health conditions including Chronic Obstructive Pulmonary Disease (COPD), asthma, chronic bronchitis, and other respiratory and cardiovascular conditions as well as increased risk for

[191] M. D. Hurteau, A. L. Westerling, C. Wiedinmyer, B. P. Bryant, Projected effects of climate and development on California wildfire emissions through 2100. *Environ. Sci. Technol.* 48, 2298–2304 (2014)
[192] American Public Health Association. 2019. Addressing the Impacts of Climate Change on Mental Health and Well-Being. Policy No: 20196. Available at: *https://www.apha.org/policies-and-advocacy/public-health-policy-statements/policy-database/2020/01/13/addressing-the-impacts-of-climate-change-on-mental-health-and-well-being*
[193] American Lung Association, State of the Air 2021, *https://www.lung.org/research/sota*
[194] I. Cvijanovic, B.D. Santer, C. Bonfils, C. et al., Future Loss of Arctic Sea-ice Cover Could Drive a Substantial Decrease in California's Rainfall, 8 NAT. COMMUN. 1947 (2017), https://doi.org/10.1038/s41467-017-01907-4.
[195] *A.P. Williams, et al.,* Contribution of Anthropogenic Warming to California Drought During 2012-2014*, 42 GEOPHYS. RES. LETT. 6819–28 (2015), http://doi.org/10.10022015GL064924*.

respiratory infections which all result in greater health costs to the State.[196,197,198] These and other climate-related health impacts are discussed in more detail in Appendix G (Public Health).

Health Analysis Components

The Draft Scoping Plan health analysis focuses on the contrast between a California that is still dependent on a fossil fuel-based economy and a California that is transitioned to a carbon-neutral, clean energy future. This qualitative analysis evaluates and demonstrates the broad range of benefits of a dramatic reduction in fossil fuels by 2045 combined with healthier ecosystem management, comparing health outcomes for a "no action" scenario (Reference) to a "take action" decarbonization scenario. As this is a qualitative analysis, it looks more broadly at the public health benefits of a drastic reduction in fossil fuel combustion. The analysis provides information to help achieve the goal of equitable distribution of benefits across the state. While this analysis provides scientific evidence for Draft Scoping Plan benefits based on achieving carbon neutrality by 2045, it does not analyze a specific scenario (See quantitative analysis section for a comparison of the 4 alternative scenarios).

The key areas of focus for the analysis are: heat impacts, children's health and development, economic security, food security, mobility and physical activity, urban greening, wildfires and smoke impacts and housing affordability. For each area of focus, the analysis covers the scientific evidence and compares expected health effects between the Reference and decarbonization scenarios. This analysis looks at the major health outcomes, provides directional effects for each health outcome, and where possible provides information on the strength and scale of health impacts. Some areas include quantitative information where tools are available to measure health outcomes. While the analysis is focused on health outcomes state-wide, it also includes discussion of benefits to community health and climate resilience as well as potential inequities experienced at a community level. Figure 3-9 shows the co-benefit areas covered in the

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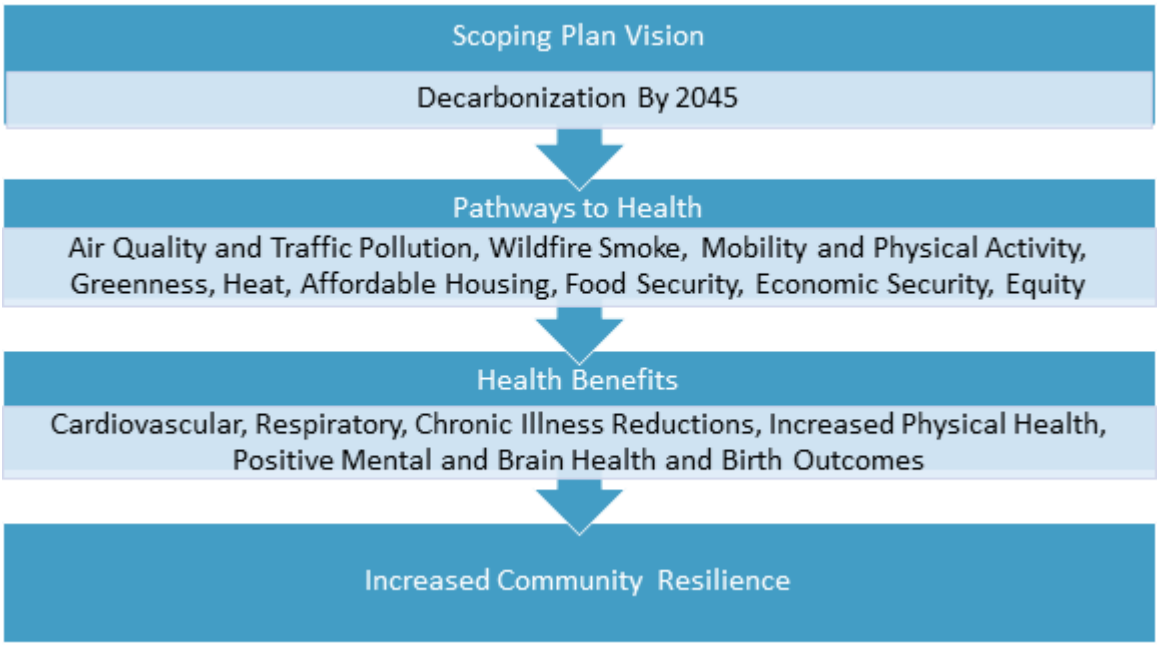
[196] *John A. Romley, Andrew Hackbarth & Dana P. Goldman,* Cost and Health Consequences of Air Pollution in California*, Santa Monica, CA, RAND Corp. (2010),* *https://www.rand.org/pubs/research_briefs/RB9501.html.*

[197] *M. Wang, C.P. Aaron, J. Madrigiano, et al.,* Association Between Long-term Exposure to Ambient Air Pollution and Change in Quantitatively Assessed Emphysema and Lung Function*, 322(6) J. AM. MED. ASSOC.*
546-56 (2019), doi:10.1001/jama.2019.10255.

[198] *A. Inserro,* Air Pollution Linked to Lung Infections, Especially in Young Children*, AM. J. MANAGED CARE (May 6, 2018), https://www.ajmc.com/newsroom/air-pollution-linked-to-lung-infections-especiallyin-young-children.*

Draft Scoping Plan and the path to health improvements and increased community resilience.

Figure 3-9. Draft Scoping Plan outcome and the path to health improvements



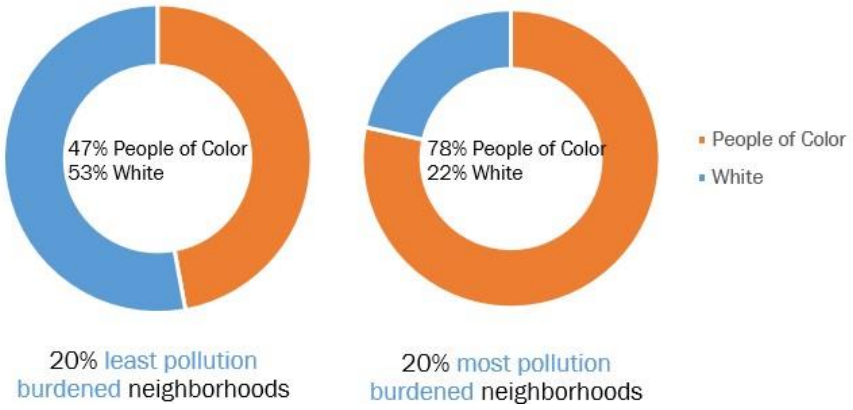
Social and Environmental Determinants of Health Inequities

Communities across the state do not experience exposure to pollution sources and the resulting effects equally. Low-income communities and communities of color (including Black, Latino and Indigenous communities) consistently experience significantly higher rates of pollution and adverse health conditions than others due to factors including historic marginalization rooted in systemic racism. As shown in Figure 3-10, the most impacted neighborhoods according to CalEnviroScreen (CES) are home to very high percentages of people of color while the least impacted neighborhoods are predominantly White. Recent findings show that Black Californians have 19% higher $PM_{2.5}$ exposure from vehicle emissions than the state average, and the census tracts with the highest $PM_{2.5}$ pollution burden from vehicle emissions have a high proportion of people of color.[199] Air pollutant emissions from mobile sources have disproportionate impacts on low-income communities and communities of color due to their proximity.[200] Diesel-fueled vehicles

[199] Reichmuth. 2019. Inequitable exposure to air pollution from vehicles in California. Available: https://www.ucsusa.org/resources/inequitable-exposure-air-pollution-vehicles-california-2019.
[200] CARB. 2017b. California's 2017 climate change scoping plan. Available: https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf.

traveling on California's freeways and major roads expose nearby residents to pollution that is linked to lung cancer, hospitalizations and emergency department visits for chronic heart and lung disease, and premature death.[201,202] A combination of historical and social inequities are evident in communities of color disproportionately living close to freeways and other major sources of vehicle pollution. Environmental exposures and contaminants are one component of a broader set of social, economic, and environmental factors that can amplify health conditions and the combination of all these factors can compound the health effects of individual exposures. This broader set of community factors can be referred to as "cumulative impacts." In addition, specific populations are more sensitive to pollution and face greater susceptibility. This includes young children, older adults, and individuals with existing health conditions.

Figure 3-10. Least and most impacted neighborhoods from CalEnviroScreen



Social Determinants of Health Inequities

The physical and mental health of individuals and communities is shaped, to a great extent, by the social, economic, and environmental circumstances in which people live, work, play, and learn. According to the World Health Organization, these same circumstances—or social determinants of health—are "mostly responsible for health inequities: the unfair and avoidable differences in health status seen within and between countries." In fact, a strong body of research demonstrates that more than 50 percent of

[201] CARB. 2020a. Overview: Diesel exhaust & health. Available: https://ww2.arb.ca.gov/resources/overview-diesel-exhaust-and-health
[202] Kagawa J. 2002. Health effects of diesel exhaust emissions--a mixture of air pollutants of worldwide concern. Toxicology 181-182:349-353.

long-term health outcomes are the result of social determinants affecting an individual.[203] Race/ethnicity and socioeconomic status, for example, have been found to amplify impacts from long- and short-term environmental exposures for several health outcomes, such as mortality and birth outcomes.[204,205,206,207] Social factors combine in low-income communities and communities of color to create levels of toxic chronic stress and limit opportunities for healthy food and healthy lifestyles. Social factors can also cause health disparities through psychosocial pathways such as discrimination and social exclusion.[208] While the importance of social determinants is well known, measuring the specific and cumulative impacts of social determinants is challenging.

One of the root causes of conditions that many communities experience today is historical land use decisions including redlining. The current makeup of our cities – their patterns of racial and social segregation, investment and underinvestment, and residents' varying rates of income, education, and health – is heavily rooted in legacy federal urban renewal, housing, and mortgage insurance programs that codified and advanced racial discrimination dating back to the 1930s and states' efforts to implement those programs.

There are several important tools to evaluate and map cumulative impacts and factors contributing to those impacts, and these tools have been used for air quality and climate planning, community protection and investments. CalEnviroScreen (CES) is a tool that maps cumulative pollution burdens and vulnerabilities on a statewide basis and ranks census tracts based on environmental, exposure, population and socioeconomic indicators. An analysis using CES shows a direct, persistent relationship between exposure to environmental burdens and socio-economic and health vulnerabilities affecting communities of color and historical redlining practices. OEHHA has evaluated health impacts of certain climate change policies on disadvantaged communities and communities of color utilizing CES rankings.[209] The Healthy Places Index (HPI) maps

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[203] California Department of Public Health (CDPH). 2015. The Portrait of Promise: The California Statewide Plan to Promote Health and Mental Health Equity. A Report to the Legislature and the People of California by the Office of Health Equity. Sacramento, CA: California Department of Public Health, Office of Health Equity.

[204] O'Neill MS , Jerrett M , Kawachi I , Levy JI , Cohen AJ , Gouveia N , et al. Health, wealth, and air pollution: advancing theory and methods . Environ Health Perspect . 2003 ; 111 (16): 1861 – 70 .

[205] Ponce NA , Hoggatt KJ , Wilhelm M , Ritz B . Preterm birth: the interaction of traffic-related air pollution with economic hardship in Los Angeles neighborhoods . Am J Epidemiol . 2005 ; 162 (2): 140 – 8 .

[206] Morello-Frosch R , Jesdale B , Sadd J , Pastor M . Ambient air pollution exposure and full-term birth weight in California . Environ Health . 2010 ; 9 : 44 .

[207] Finkelstein MM , Jerrett M , DeLuca P , Finkelstein N , Verma DK , Chapman K , et al. Relation between income, air pollution, and mortality: a cohort study . CMAJ . 2003 ; 169 (5): 397 – 402 .

[208]Clougherty J , Kubzansky L . A framework for examining social stress and susceptibility in air pollution and respiratory health . Environ Health Perspect . 2009 ; 117 (9): 1351 – 8 .

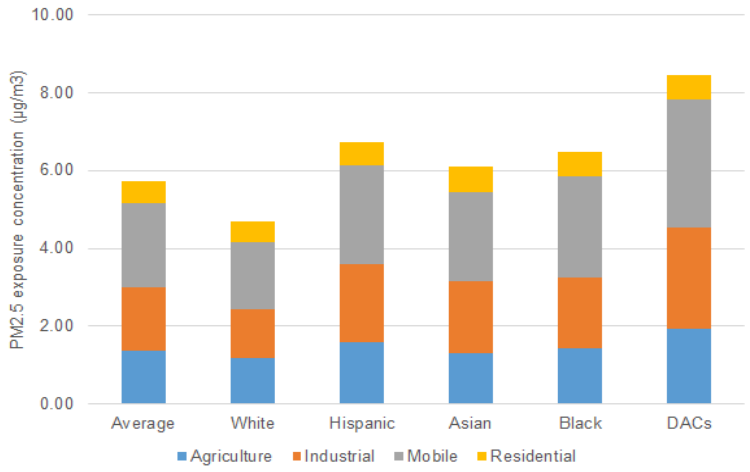
[209] *https://oehha.ca.gov/media/downloads/environmental-justice//impactsofghgpoliciesreport020322.pdf*

indicators that affect life expectancy on a statewide basis. In the future, these and other tools can be helpful to prioritizing investments and informing implementation efforts for GHG emission reductions policies.

Environmental Determinants of Health Inequities

Communities with large percentages of Black and other socially vulnerable and marginalized groups are disproportionately located near pollution sources, such as traffic and freight facilities, industrial facilities, hazardous waste sites etc.[210,211,212,213] Research shows large disparities in exposure to pollution between white and non-white populations in California, and between low-income and communities of color (Figure 3-11). The research also shows Black and Latino populations experience significantly greater air pollution impacts than white populations in California.

Figure 3-11. Top sources of $PM_{2.5}$ and their contribution to $PM_{2.5}$ exposures by race and in disadvantaged communities (DACs)



[210] Mohai P , Lanz PM , Morenoff J , House JS , Mero RP . Racial and socioeconomic disparities in residential proximity to polluting industrial facilities: evidence from the Americans' Changing Lives Study . Am J Public Health . 2009 ; 99 (Suppl 3): S649 – 56.
[211] Mohai P , Saha R . Racial inequality in the distribution of hazardous waste: a national-level reassessment . Soc Probl . 2007 ; 54 (3): 343 – 70.
[212] Morello-Frosch R , Pastor M , Porras C , Sadd J . Environmental justice and regional inequality in southern California: implications for future research . Environ Health Perspect . 2002 ; 110 (Suppl 2): 149 – 54.
[213] Gunier RB , Hertz A , von Behren J , Reynolds P . Traffic density in California: socioeconomic and ethnic differences among potentially exposed children . J Expo Anal Environ Epidemiol . 2003 ; 13 (3): 240 – 6.

These disparities in exposure to pollution sources generate health inequities. Communities located near major roadways are at increased risk of asthma attacks and other respiratory and cardiac effects. Studies consistently show that mobile source pollution exposure near major roadways or freight sources contributes to and exacerbates asthma, impairs lung function, and increases cardiovascular mortality.[214] The exposure to mixtures of gaseous and particulate pollutants in mobile sources (including PM, NOx, and benzene) is associated with higher rates of heart attacks, strokes, lung cancer, autism, and dementia.[215]

Environmental hazards found in communities can also include exposures to toxic substances and emissions as well as occupational exposures. Due to historical inequities, under-resourced communities and communities of color are often located close to sources of toxic pollution including chrome platers, metal recycling facilities, oil and gas operations, agricultural burning, railyards, facilities transporting, managing, or disposing of hazardous waste, areas impacted by pesticides, among other sources. Some populations may be at increased risk of exposure to pollutants both at work and home.

Children are more susceptible to environmental pollutants for many reasons, including the ongoing development of their nervous, immune, digestive, and other bodily systems. Moreover, children eat more food, drink more fluids, and breathe more air relative to their body weight, as compared to adults.[216] Exposure to high levels of air pollutants, including indoor air pollutants, increases the risk of respiratory infections, heart disease, and asthma.[217] Children living in low-income communities near industrial operations, rail yards, and heavily trafficked freeways and streets in urban areas are at especially high risk of chronic respiratory conditions. Black children are four times more likely to be hospitalized for asthma compared with White children, and urban Black and Latino children are two to six times more likely to die from asthma than White children.[218]

For older adults, increased vulnerability is linked to respiratory, cardiovascular and immune systems weakened by aging.[219] Pre-existing health conditions interact with

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[214] Hot Spot Pollution, 1052 and 1057.
[215] USC Environmental Health Centers. (2018). Living Near Busy Roads or Traffic Pollution.
[216] Blaisdell RJ. Air Toxics Hot Spots Program Risk Assessment Guidelines. Technical Support Document for Exposure Assessment and Stochastic Analysis. Oakland, CA: California Environmental Protection Agency, Office of Environmental Health Hazard Assessment; August 2012.
[217] Woodruff TJ, Axelrad DA, Kyle AD, Nweke O, Miller GG. America's Children and the Environment: Measures of Contaminants, Body Burdens, and Illness. 2nd ed. Washington, DC: United States Environmental Protection Agency; February 2003.
[218] Pacific Southwest, Region 9, children and asthma: California U.S. Environmental Protection Agency Website. http://www. epa.gov/region9/childhealth/asthma-california.html. Updated July 30, 2013.
[219] Sandström T , Frew AJ , Svartengren M , Viegi G . The need for a focus on air pollution research in the elderly . Eur Respir J Suppl . 2003 ; 40 : 92s – 5s.

environmental pollutants to enhance risks of adverse health outcomes.[220,221] The recent COVID-19 pandemic has highlighted the heightened vulnerability of older adults as well as communities of color to respiratory disease as hospital admissions and mortality data linked to COVID-19 cases for these groups have been higher than other groups. Research has also underscored the important link between COVID-19 mortality and morbidity and air pollution, demonstrating significantly higher mortality and morbidity for COVID-19 in areas of elevated PM 2.5 pollution.

Climate Vulnerabilities

Climate change is expected to exacerbate the existing disparities of health conditions and worsen climate vulnerability which is "the degree to which people or communities are at risk of experiencing the negative impacts of climate change".[222] A report from the California Climate Change Center warned that the impacts of climate change will likely create especially heavy burdens on low-income and other vulnerable populations: "*Without proactive policies to address these equity concerns, climate change will likely reinforce and amplify current as well as future socioeconomic disparities, leaving low-income, minority, and politically marginalized groups with fewer economic opportunities and more environmental and health burdens*.[223]"

In the U.S. Environmental Protection Agency's "Climate Change and Social Vulnerability in the US, A Focus on Six Impacts"[224], investigators analyzed risks of six primary climate change impacts disproportionately impacting communities across income, educational attainment, race/ethnicity and age groups. Four socially vulnerable populations - low income, communities of color, no high school diploma, and age 65 and older - were identified as having a higher likelihood of experiencing the greatest impacts of a changing climate (according to the projected 2°C of global warming or 50 cm of global sea level rise). Disproportionate impacts were projected for climate events including air quality, extreme temperature, coastal flooding and other impacts leading to increased risk of health and other adverse outcomes. The study projected significant health impacts for

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[220] Zanobetti A , Schwartz J . Are diabetics more susceptible to the health effects of airborne particles? Am J Respir Crit Care Med . 2001 ; 164 (5): 831 – 3 . Crossref, Medline, Google Scholar

[221] Zanobetti A , Schwartz J , Gold D . Are there sensitive subgroups for the effects of airborne particles? Environ Health Perspect . 2000 ; 108 (9): 841 – 5 .

[222] CARB. 2017b. California's 2017 climate change scoping plan. Available: https://www.arb.ca.gov/cc/scopingplan/scoping_plan_2017.pdf.

[223] Shonkoff S, Morello-Frosch R, Pastor M, and Sadd J. 2011. The climate gap: environmental health and equity implications of climate change and mitigation policies in California—a review of the literature. Climatic Change, 109 (Suppl 1):S485-S503.

[224] EPA. 2021. Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts. U.S. Environmental Protection Agency, EPA 430-R-21-003.

low-income communities, certain racial and ethnic sub-groups, and those with lower educational attainment.

Several climate vulnerability tools have been developed, or are under development to better understand and map areas at higher risk of climate impacts. The Climate Change and Health Vulnerability Indicators Tool *(CCHVIz*) for California helps state and local health officials prepare for and reduce adverse health impacts due to a changing climate.[225] For example, Los Angeles County shows higher than state average climate vulnerability overall, particularly for those who are linguistically isolated (more than twice the state average).

In summary, there are many environmental, social, individual, and economic factors affecting health and equity in California and contributing to worsening health outcomes from climate change impacts. This section and Appendix G (Public Health) references a substantial and growing body of research documenting the different social and environmental factors affecting health outcomes and the many groups that are vulnerable to increased effects or that experience health inequities in California (see Figure 3-12).

Figure 3-12. Examples of vulnerable groups due to socio-economic, environmental, developmental and climate change factors

Examples of Vulnerable Groups Due to Socio-economic, Environmental, Developmental and Climate Change Factors		
Older People	People with existing chronic illness	People Impacted Due to Working Conditions
Tribal Groups	Infants and Children	Low-Income People
People with Disabilities	Homeless People	Pregnant People
Communities of Color	Marginalized People	Immigrants/Refugees
People with Less Educational Options	Linguistically Isolated Households	People Impacted Due to Poor Housing Conditions

[225] EPA. 2021. Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts. U.S. Environmental Protection Agency, EPA 430-R-21-003. *https://www.cdc.gov/climateandhealth/brace.htm*

Summary of the Qualitative Health Analysis

CARB has developed a detailed health analysis that covers eight social and environmental co-benefit areas that impact public health as listed below. These co-benefit areas were selected due to ongoing research in these areas as well as discussion in a public workshop on climate change and health impacts held in Summer 2018. For each social and environmental area, the analysis includes a discussion of health impacts and disparities, key health metrics or epidemiological research on this topic, a discussion of how these areas would be affected by "no action" i.e. Reference scenario compared to a "take action" i.e. Proposed Scenario, a discussion of where there are actions to consider for further success, and the types of mitigation actions that can help reduce or eliminate disparities and promote greater health equity and resilience. All co-benefit areas are interconnected and pursuing benefits in all areas has the potential to multiply positive results and further support building community resilience. Community resilience is the ability of a community to reduce harm and maintain an acceptable quality of life in the face of climate-induced stresses, which vary depending on that community's circumstances and location. Below is a brief description of the evaluated areas for public health co-benefits. Specific health outcomes impacted by each area and directional health benefits are included in the Summary of Health Benefits section of the chapter and covered in more detail in Appendix G (Public Health).

Heat impacts

Globally, increased GHG concentrations in the atmosphere are causing a continuing increase of the planet's average temperature. California temperatures have risen since records began in 1895, and the rate of increase is accelerating. Recent heat waves have broken heat records and caused serious illness across the state, and these events are becoming more frequent. Heat waves have a particularly high impact in Southern California, where they have become more intense and longer lasting. In the past two years, Los Angeles recorded 121°F, and the Coachella Valley had its hottest year ever, with temperatures reaching 123°F. Heat island effects in urbanized areas can elevate heat effects and disproportionately affect low-income communities and communities of color. Heat events exacerbate respiratory and cardiac illness and cause emergency room visits to soar. Strategies that reduce the impacts of heat exposure promote improved health outcomes.

Wildfires and smoke

California's natural and working lands (NWL) cover more than 90 percent of California and include rangeland, forests, woodlands, grasslands, and urban green space. They provide biodiversity and ecosystem benefits, including their ability to sequester carbon from the atmosphere. Protecting and managing California's forests and other natural lands and maintaining their ecosystem health are key practices for maximizing GHG benefits and minimizing negative climate change impacts. Vegetation plays an important

role in storing carbon; however, it can also release CO_2 back into the atmosphere when it dies or is burned by fires. California's wildfires are getting worse with increased fire risks, higher frequency of occurrence, larger burn areas, more costly damage, and a longer fire season due to climate change. Strategies that promote healthy ecosystem management of natural and working lands and increased greening promote improved health outcomes. Healthy ecosystems provide many health and environmental benefits and are not managed to maximize carbon sequestration.

Children's health and development

There are a wide range of interconnected environmental, social, biological, and community factors due to climate change that are adversely affecting children's health. This section focuses on air pollution and near-roadway or traffic pollution as environmental impacts that have a profound effect on children's health. Children's bodies and lungs are still developing and they take in more air per body weight than adults do. Many low-income communities and communities of color in California experience disproportionately high levels of air pollution as well as high levels of traffic and freight that impact children. This excess exposure harms children's development and predisposes them to increased risk of illness throughout their lives. Strategies that reduce air pollution and traffic emissions promote improved health outcomes for children.

Economic security

Climate change is expected to result in serious adverse socioeconomic effects across many sectors. Economic factors, such as income inequality (among geographic regions), Climate change is expected to result in serious adverse socioeconomic effects across many sectors. Economic factors, such as income inequality (among geographic regions), poverty, wealth, debt, unemployment rate, and job security are among the strongest determinants of health. Along the entire income spectrum, higher income is associated with increased life expectancy and improved health outcomes in the U.S. Additionally, economic insecurity and negative health impacts are more pronounced in low-income communities and communities of color. Economic strategies, such as the promotion of clean energy and other green jobs and investments in low-income communities and communities of color, and promoting a transition to high roads jobs in economic sectors tied to the current fossil fuel economy, can promote improved health outcomes.

Food security

The food system is under pressure from numerous factors, and climate change is a key concern. Climate change can affect food production and agricultural yield and exacerbate factors that limit food availability, such as supply chain disruption. Food security is defined as stable access to affordable, sufficient food for an active, healthy life. Many Californians routinely experience food insecurity and while it impacts Californians of all races and groups, low-income communities and communities of color and children are

disproportionately impacted by food insecurity. Strategies that promote sustainable agriculture, access to healthy foods and reduced organic food waste promote improved health outcomes.

Mobility and physical activity

Physical activity is one of the most important factors for a healthy lifestyle, and lack of activity increases the risk of chronic illness and premature death. Research shows that regular physical activity improves health in people of all ages by improving heart and lung function, muscle fitness, mental health and brain function, and sleep quality. A sedentary lifestyle contributes to chronic illnesses including obesity, heart disease and Type 2 diabetes among other chronic illnesses. Promoting community design that supports sustainable patterns of land use and transportation enables active transportation choices like walking, biking, as well as public transit over driving and can significantly increase physical activity leading to many valuable health benefits.

Affordable housing

Housing is an important social determinant of health. The stability of housing, housing quality, conditions inside and outside the home, the cost of housing, and the environmental and social characteristics of the places people live all affect health (including energy efficiency and insulation, cooler building material, tree canopy, home size). Housing affordability is a key factor, and this section highlights how housing affordability supports not only improved health but also more sustainable land use and transportation patterns. A lack of affordable housing is increasing commute distances for low-income renters and creating health burdens. Strategies that support sustainable transportation and housing patterns together with increased housing affordability promote improved health outcomes.

Urban Greening

Urban Greening is well recognized as an important amenity, but the inherent health benefits are not always well understood. Under-resourced and vulnerable areas consistently show of lack of greenness and higher percentages of concrete, asphalt, and impervious surfaces. Under-resourced communities have a greater proportion of concrete and heat-trapping surfaces and a lower amount of tree cover in the neighborhoods in which they live. Areas with reduced greenness have the potential to create areas of higher temperatures as heat is reflected from pavements and buildings. By contrast, increasing urban greenness can provide air pollution buffers and promote physical activity. Strategies that preserve and create urban parks, green space, natural infrastructure, and sustainable agricultural practices support improved physical and mental health outcomes.

No Action Scenario (Reference)

In a No Action scenario, California would remain dependent on fossil fuels and other greenhouse gas emitting technologies. Fossil-fuel powered mobile sources including cars, trucks, trains, tractors, and a myriad of other on-road and off-road vehicles and equipment are the largest source of criteria pollutants and toxic air contaminants that directly impact community health and contribute the largest portion of greenhouse gas (GHG) emissions. Other key GHG emission sources include buildings, natural and working lands, and power production and industry. The no action scenario reflects a continued reliance on fossil fuels in mobile and stationary sectors including buildings. The continued production and use of fossil fuels, ongoing dependence on gasoline and diesel cars, trucks, buses and equipment, continuing releases of short-lived climate pollutants, and decreased emphasis on forest and ecosystem health will impact communities by reducing climate resilience and health benefits. Green space will likely remain at the same levels or degrade and urban heat islands will likely increase. With continued growth of vehicle miles travelled, physical activity and the accompanying health benefits will not increase. Exposure to wildfire smoke will increase and air quality is expected to worsen as increasing temperatures will impact levels of harmful air pollution. Jobs and economic security will be impacted by the continuing potential for price spikes in fossil fuels, impacts to the economy from climate change, and fewer job opportunities in green technologies such as solar and electric vehicles. Food security will feel the effects of accelerating climate impacts to agriculture and will not benefit from increased emphasis on recovering organic waste, which would help reduce food deserts and promote sustainable agriculture. All these impacts can be linked to worse health outcomes. Adverse health impacts are often most felt by Black, Latino, Native American and other people of color and low-income communities. These groups are impacted more intensely by the physical stress of environmental pollution, social inequities and the psychological stress of extreme weather events and food and economic insecurity.

Take Action Scenario (Proposed)

In the Take Action scenario, California will drastically reduce reliance on fossil fuels for motor vehicles, freight, buildings, electricity or other sectors. This scenario is not a specific scenario within the Draft Scoping Plan but examines the broad outcomes of actions to achieve carbon neutrality in 2045. Implementation of the Draft Scoping Plan would achieve an overwhelming and rapid transition to zero emission vehicles (ZEVs) with 100% sales of light duty zero emission vehicles by 2035 and 100% sales of truck zero emission vehicles (MD/HDV) by 2040 along with 22% VMT reductions below 1990 levels by 2045. The dramatic reduction in fossil fuel combustion combined with reductions in vehicle miles traveled and freight and traffic emissions projected in the Draft Scoping Plan will significantly reduce air pollution and the health impacts on a statewide basis and in communities near freight sources. Coordinated action strategies will emphasize natural and working lands management changes including healthy forests, increased vegetative

cover, and increased organic farming. Wildfire smoke exposure will reduce significantly with healthy ecosystem management strategies. Since many communities in California are disproportionately impacted by high levels of traffic pollution, the reduction in petroleum fueled vehicles will reduce the additional impacts of living or going to school near historically highly polluting sources. Indoor air quality is also likely to improve through a shift to non-fossil fuel appliances. Concerted state and local action to support sustainable land use and transportation patterns can enable more active transportation with health benefits from physical activity.

Overall community resilience is expected to increase as physical activity increases and green space increases - potentially decreasing urban heat islands. Efforts to support VMT reduction will include coordination across state agencies on affordable housing measures. Reduced fossil fuel dependence will reduce economic pressure from wildfires, droughts, and price spikes in fossil fuels especially as more jurisdictions implement plans with similar actions. Investment in sustainable agriculture, healthy forests, urban greening, and clean energy technologies will add sustainable jobs and further promote economic security. More sustainable agriculture and food recovery efforts will add to food security. All these impacts can be linked to wide ranging health benefits including positive respiratory and cardiovascular effects, healthier birth and brain outcomes, improved mental health indicators, improved life expectancy, reductions in chronic illness and cancers, improved children's health and development, reduced depression and other benefits. The magnitude of the possible co-benefits is extremely large especially in areas that are currently the most impacted.

Summary of Health Benefits

Below in Tables 3-12 and 3-13 are overall summaries of the directional benefits by co-benefit area estimated for the Draft Scoping Plan. Supporting epidemiological studies that were used for qualitative or quantitative analysis of each co-benefit area are included in Appendix G (Public Health). Another section of Chapter 3 together with Appendix C (AB 197 Measure Analysis) and Appendix H (AB 32 GHG Inventory Sector Modeling) also include the quantitative analysis of air pollution related health impacts including recently added health endpoints for CARB's ongoing analysis.

Table 3-12. Draft Scoping Plan directional benefits for health co-benefit areas (heat, affordable housing, food security, economic security, and urban greening)

	Health Co-benefit Areas*				
Quantitative vs. Qualitative	**Reduced Heat Impacts**	**Increased Affordable Housing**	**Increased Food Security**	**Increased Economic Security**	**Increased Urban Greening**
Research was used	↓ Mortality	↓ Infectious Disease	↓ Mental Illness	↑ Life Expectancy	↓ Mortality

for Qualitative Analysis	↓ Emergency Room Visits for cardiovascular and respiratory causes and intestinal infections ↓Hospitalization for cardiovascular, respiratory causes ↓ Preterm Birth ↓ Mental Illness	↓ Chronic Illness ↓ Asthma ↓ Injuries ↓ Mental Illness ↑ Children's Performance in Schools ↑ Children's Health ↓ Children's Behavioral Problems	↓ Iron Deficiency ↓ Chronic Diseases ↑ Life Expectancy ↓ Children's Mental Illness ↓ Children's Cognitive Problems ↓ Children's Behavioral Health Problems ↓ Children's Iron Deficiency ↓ Children's Oral Health Problems	↑ Health Status ↑ Mental Health	↓ Asthma Prevalence ↓ Depression ↓ Adverse Birth Outcomes including low birth weight and small for gestational age ↑ Life Expectancy

HA, Hospital Admissions; ERV, Emergency Room Visits.
*See Appendix G (Public Health) for table with references to research for each health outcome listed

Table 3-13. Draft Scoping Plan directional benefits for health co-benefit areas (traffic pollution, wildfire, and active transportation)

Health Co-benefit Areas*			
Quantitative vs. Qualitative	**Reduced Traffic Pollution**	**Reduced Wildfire Smoke**	**Increased Active Transportation**
Research was used for Quantitative Analysis	↓ Children's Respiratory Outcomes, HA ↓ Children's Respiratory Outcomes, ERV ↓ Children's Asthma Onset ↓ Children's Asthma Symptoms	↓ All-Cause Mortality ↓ Asthma, HA ↓ COPD, HA ↓ All Respiratory Outcomes, HA ↓ Asthma, ERV ↓ All Respiratory Outcomes, ERV	↓ Cardiovascular Diseases ↓ Colon Cancer ↓ Breast Cancer ↓ Diabetes ↓ Dementia ↓ Lung Cancer ↓ Respiratory Disease

		↓ All Cardiac Outcomes, ERV	↓ Depression ↑ Traffic Accidents
Research was used for Qualitative Analysis	↑ Children's Lung Function Growth ↓ Children's Bronchitic Symptoms ↓ Children's Impaired Cognitive Development ↓ Children's Adverse Birth Outcomes including low birth weight and preterm birth		

*See Appendix G (Public Health) for table with references to research for each health outcome listed

In summary, the qualitative health analysis of the no-action versus take-action scenarios for the Draft Scoping Plan shows an overwhelming benefit for the state by taking action to move forward to carbon neutrality while continuing efforts to increase health equity and resilience in individual communities. Taking action can improve physical and mental health for adults and children, reduce a range of chronic illnesses, and promote improvements in life expectancy. Development and implementation of actions to achieve the outcomes called for in the Final 2022 Scoping Plan should consider how to engage affected communities in implementation, address the existing health and opportunity gaps, and pursue equitable implementation statewide and locally. The Draft 2022 Scoping Plan deployment of clean technology and fuels together with improved land management will reduce greenhouse gases and air pollution and create more resilient communities that are better able to prepare for and recover from extreme climate events.

Environmental Analysis

CARB, as the lead agency for the Draft Scoping Plan, prepared a Draft Environmental Analysis (EA) in accordance with the requirements of the California Environmental Quality Act (CEQA) and CARB's regulatory program certified by the Secretary of Natural Resources (California Code of Regulation, title 17, sections 60006–60008; California Code of Regulation, title 14, section 15251, subdivision (d)). The resource areas from the CEQA Guidelines Environmental Checklist were used as a framework for a programmatic environmental analysis of the reasonably foreseeable compliance responses resulting from implementation of the proposed measures discussed in the Draft 2022 Scoping Plan. The Draft EA provides an analysis of both the beneficial and adverse impacts and feasible mitigation measures for the reasonably foreseeable compliance responses associated

with the proposed measures. Collectively, the Draft EA concluded that implementation of these actions could result in the following short-term and long-term beneficial and adverse impacts:

- Beneficial impacts to: air quality (long-term operational-related) and GHG emissions (short-term construction-related and long-term operational-related)
- Less than significant impacts to: energy demand, mineral resources, population and housing, public services, recreation (short-term construction-related), and wildfire (short-term construction-related)
  Potentially significant and unavoidable adverse impacts to aesthetics, agriculture and forest resources, air quality (construction-related and operational odors), biological resources, cultural resources, geology and soils, hazards and hazardous materials, hydrology and water quality, land use and planning, noise, recreation (long-term operational-related), transportation and traffic, tribal cultural resources, utilities and service systems, and wildfire (long-term operational-related

Please refer to the Draft EA in Appendix B (Draft Environmental Analysis) for further details. CARB will prepare written responses to all comments received on the Draft EA, which will be presented to the Board for consideration along with the Final EA.

Chapter 4: Key Sectors

Chapter 4 provides an overview of the major energy sources and technology in use today and of alternative clean technology and fuels to support decarbonization based on the latest information available. Every sector of the economy will need to stay on track to meet our 2030 GHG reduction target and achieve carbon neutrality no later than 2045. AB 32 requires climate change mitigation policies to be considered in the context of the sector's contribution to the state's total GHG emissions. The transportation, electricity (in-state and imported), and industrial sectors are the largest contributors to the GHG inventory and present the largest opportunities for GHG reductions. Actions to reduce fossil fuel combustion in these sectors also can provide critical air pollution reductions in low-income communities and communities of color, which are often located adjacent to these sources. A carbon neutrality framework also elevates the role of CO_2 removal through natural and working lands and mechanical capture and storage. Actions that support energy efficiency, reduced VMT, alternative fuels, and renewable power also can provide benefits by reducing both criteria and toxic air pollutants.

It is clear that what sets this plan apart from previous Scoping Plans is the focus on the accelerated rate of deployment of clean technology and energy within every sector. As a result, specific actions, including accelerated rates of deployment of clean technology and fuels identified within the final plan, will need to be translated into both new and amended regulations, policies, and incentive programs. State agencies will need to evaluate current authority to align existing policies or develop new ones to achieve outcomes called for in the final plan. Legislative support may be needed in some cases to ensure authority and funding is sufficient to ensure the final plan is translatable to action on the ground. Most regulations, or change to existing regulations, ultimately considered by the Board or other state agencies for adoption will be subject to administrative procedure requirements, and accordingly must rely on specific subsequent supporting analysis and extensive public processes to develop and identify appropriate proposals for effective implementation. For example, any proposal to strengthen the LCFS regulations through amendments increasing the stringency of the carbon intensity (CI) targets would be considered on the basis of a public process, including workshops, and focused environmental, economic, and public health analyses.

Policies that ensure economy-wide investment or program decisions that incorporate consideration of GHG emissions are particularly important. As we pursue GHG reduction targets, we must acknowledge the manner in which built and natural environments are connected, how changes in one may impact the other, and how policy choices in one sector can and do impact other sectors. For example, fostering more compact, transportation-efficient development in infill areas and increasing transportation choices with the goal of reducing VMT not only reduces demand for transportation fuel but also requires less energy for buildings and helps to conserve natural and working lands that

sequester carbon. Therefore, the multiple and often interwoven actions that reduce VMT both reduce emissions from the transportation sector and support reductions needed in other sectors.

Recent legislation, such as SB 350[226] (De León and Leno, Chapter 457, Statutes of 2015), has recognized the need for CARB, the California Energy Commission (CEC), and the California Public Utilities Commission (CPUC) to work together to ensure the state's energy and climate goals were integrated in procurement decisions by load serving entities as part of Integrated Resource Plans. Moving forward, it is especially critical that similar approaches are adopted to break down silos across state agencies to ensure policies and programs are aligned with multiple state priorities outlined in this plan. Finally, supportive legislative direction may also benefit emerging areas of policy, such as CO_2 removal, to provide agency authority and roles for these nascent efforts, including streamlining of permitting, while ensuring that protections for communities are in place.

Unlike previous Scoping Plans that separated out individual economic sectors, this Draft 2022 Scoping Plan approaches decarbonization from two perspectives: (1) managing a phasedown of existing energy sources and technology and (2) ramping up, developing, and deploying alternative clean energy sources and technology over time. This approach supports a more comprehensive consideration of our energy infrastructure, the ability to repurpose existing assets, and the need to build new assets. It also provides multiple metrics beyond just the annual AB 32 GHG Inventory to better enable tracking progress. For example, it clearly demonstrates the production and distribution rates of specific types of clean energy, such as adding 7 GW of renewables and 2 GW of storage year-over year between now and 2045, and does the same for technology deployment, such as 11 million ZEVs in 2035.

The sections below include key actions to support success in the necessary transition away from fossil combustion, which is an overriding goal of this plan. The wide array of complementary and supporting actions being contemplated or to be undertaken across state government are detailed here. The broad view of actions described in this chapter thus provides context for the specific deployment of clean technology and fuels identified in the Proposed Scenario described in Chapter 2. Actions identified in the Draft 2022 Scoping Plan are based on currently known options and the latest science. As part of future Scoping Plan updates, additional clean technology and fuels may be identified and added to the mix of needed tools to continue to reduce the state's GHG emissions, support air quality co-benefits, and remove carbon from the atmosphere.

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[226] California Air Resources Board. SB 350 Electricity Sector Greenhouse Gas Planning Targets. https://ww2.arb.ca.gov/our-work/programs/sb350.

Transportation Sustainability

The transportation sector has long relied on liquid petroleum fuels as the primary energy source for internal combustion engine (ICE) vehicles, including cars, trucks, locomotives, marine equipment, and aircraft. Combustion of fossil fuels in vehicles emits significant amounts of GHGs, criteria pollutants, and toxic air contaminants. In 2019, the transportation sector accounted for over 50 percent of statewide GHG emissions[227] and thus was by far the single largest sector source of carbon pollution in the state. In addition, the transportation sector accounted for over 75 percent of statewide NOx emissions and the vast majority of particulate matter emissions, 30 percent of which was toxic diesel particulate matter.[228] Communities adjacent to congested roadways, including ports and distribution centers, are exposed to the highest concentration of toxic pollutants from vehicles and equipment consuming fossil fuels, leading to a number of demonstrated health impacts such as respiratory illnesses, higher likelihood of cancer development, and premature death. In addition, communities located near oil extraction operations or crude oil refineries often experience higher exposure to poor air quality. While CARB's programs, along with local action, have made substantial progress over the past few decades, it is clear that California must transition away from fossil fuels to zero-emission technologies with all possible speed, and pursue policies that result in less driving, in order to meet our GHG and air quality targets.

The transportation sector can be divided into three general categories: Technology, Fuels, and Vehicle Miles Traveled.

- *Technology* refers to the vehicles themselves, as well as the associated refueling infrastructure for those vehicles.
- *Fuels* refers to the energy source used to power vehicles and the facilities that produce them.
- Vehicle travel is measured as *vehicle miles traveled* (VMT), and is a product of development patterns and available transportation options.

[227] CARB. 2021. California Greenhouse Gas Emissions for 2000 to 2019: Trends of Emissions and Other Indicators. https://ww3.arb.ca.gov/cc/inventory/pubs/reports/2000_2019/ghg_inventory_trends_00-19.pdf. This includes upstream oil extraction and refining emissions.
[228] CARB. CARB Emissions Inventory Program. https://ww2.arb.ca.gov/our-work/programs/ghg-inventory-program.

Sector Transformation

Technology

Vehicles must transition to zero emission technology to decarbonize the transportation sector.[229] Executive Order (EO) N-79-20[230] reflects the urgency of transitioning to zero emission vehicles (ZEV) by establishing target dates for reaching 100 percent ZEV sales or wholesale fleet transitions to ZEV technology. The primary ZEV technologies available today are battery-electric and hydrogen fuel cell electric vehicles (FCEVs), both of which emit zero GHGs, criteria pollutants, or toxic air contaminants from their operation, as they do not burn fuel. These vehicles are rapidly growing in performance, affordability, and popularity.[231] Plug-in hybrid electric vehicles also offer a limited but increasing range of zero emission operation and can play a role as a bridge technology in the transition to complete ZEVs.

Light-duty passenger vehicles consume the majority of gasoline in the state—12.9 billion gallons in 2019[232]—and are well-suited for transitioning to ZEVs. EO N-79-20 calls for 100 percent ZEV sales of new light-duty vehicles by 2035, and this target is reflected in the Draft 2022 Scoping Plan.[233] The proposed Advanced Clean Cars II regulation matches the target in the Executive Order and is intended to serve as the primary mechanism to help deploy ZEVs. A number of existing incentive programs also support this transition, including the Clean Cars 4 All Program.[234] Heavy-duty trucks are the largest source of diesel particulate matter, a toxic air contaminant that is directly linked to a number of adverse health impacts. Replacing heavy-duty vehicles with ZEV technology will significantly reduce GHG emissions and diesel PM emissions in low-income communities and communities of color adjacent to ports, distribution centers, and highways. The existing Advanced Clean Trucks regulation, paired with the proposed Advanced Clean Fleets regulation, are designed to transition a significant amount of the California truck fleet to ZEV technology. As with the LDV sector, a number of incentive

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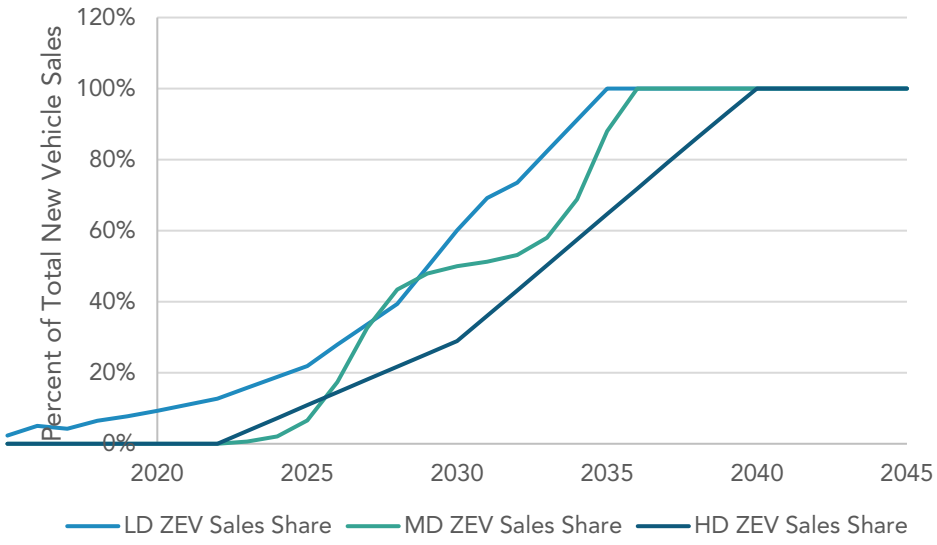
[229] AB 32 Environmental Justice (EJ) Advisory Committee. Draft Recommendations, NF8. *ejacrecsrevised.pdf (ca.gov)*.
[230] Executive Order N-79-20. *https://www.gov.ca.gov/wp-content/uploads/2020/09/9.23.20-EO-N-79-20-Climate.pdf*.
[231] Public Workshop for Advanced Clean Cars II. May 6, 2021. *https://ww2.arb.ca.gov/sites/default/files/2021-05/acc2_workshop_slides_may062021_ac.pdf*.
[232] CARB. 2021. *Fuel Combustion and Heat Content.* Fourteenth Edition. *https://ww3.arb.ca.gov/cc/inventory/data/tables/fuel_activity_inventory_by_sector_all_00-19.xlsx*.
[233] AB 32 EJ Advisory Committee. Draft Recommendations, F1A, with reference to the date at which all new vehicle sales are ZEVs. *ejacrecsrevised.pdf (ca.gov)*.
[234] CARB. Clean Cars 4 All Program. *https://ww2.arb.ca.gov/our-work/programs/clean-cars-4-all*. The Clean Vehicle Rebate Project (CVRP) also supports the transition to ZEVs. *https://cleanvehiclerebate.org/en*.

programs support this transition, such as the Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project (HVIP).[235]

Figure 4-1 below illustrates the pace of transition in vehicle technology needed to drastically reduce GHG emissions from vehicles. All vehicle classes reach 100 percent ZEV sales before 2045, with some achieving this well before. The ZEV technology across the vehicle classes is primarily battery electric and hydrogen fuel cell.[236]

Figure 4-1: Transition of on-road vehicle sales to ZEV technology in the Proposed Scenario



Today, off-road vehicles also rely heavily on ICE technology. Executive Order N-79-20 sets an off-road equipment target of transitioning the entire fleet to ZEV technology by 2035, where feasible. There is a great need for both investment and innovation in the off-road space in order to develop and commercialize zero emission equipment types that meet or exceed the performance of existing equipment. A number of funding sources currently support this transition, including programs such as FARMER, Carl Moyer, and the Community Air Protection Program (CAPP), as well as Low Carbon Transportation Incentives including the Clean Off-Road Equipment (CORE) program. In addition, the 2021–22 California budget provided record-high allocations for funding ZEVs, including off-road equipment, and the proposed budget for the following year is similarly

[235] California HVIP. Home - Hybrid and Zero-Emission Truck and Bus Voucher Incentive Project. *https://californiahvip.org/?msclkid=efaf65f2c26f11eca6bdd08ecc323864*.
[236] The light-duty fleet includes at least 3 million FCEVs on the road in 2045.

ambitious.[237] Several regulations focused on transitioning to zero emission off-road equipment have recently been adopted or are in the works, and apply to locomotives, forklifts, ocean-going vessels at berth,[238] commercial harbor craft, small off-road engines,[239] and more.

Refueling infrastructure is a crucial component of transforming transportation technology. Electric vehicle chargers and hydrogen refueling stations must become easily accessible for all drivers to support a wholesale transition to ZEV technology. Deployment of ZEV refueling infrastructure is currently supported by a number of existing public funding mechanisms, and several companies, such as Tesla, Ford, FirstElement, Chevron, Shell, and Iwatani are investing substantial private resources into developing these networks. Private investment in reliable, affordable and ubiquitous refueling infrastructure must drive the transition as the business case for ZEVs continues to strengthen.

Strategies for Achieving Success

- Achieve 100 percent ZEV sales of light-duty vehicles by 2035[240] and medium-heavy-duty vehicles by 2040.
- Develop a rapid and robust network of ZEV refueling infrastructure to support the needed transition to ZEVs.
- Ensure that the transition to ZEV technology is affordable for low-income households and meets the needs of communities and small businesses.[241]
- Prioritize incentive funding for heavy-duty ZEV technology deployment in regions of the state with the highest concentrations of harmful criteria and toxic air contaminant emissions.[242]
- Promote private investment in the transition to ZEV technology, undergirded by regulatory certainty, such as infrastructure credits in the Low Carbon Fuel Standard for hydrogen and electricity,[243] and hydrogen station grants from the

[237] AB 32 EJ Advisory Committee, Draft Recommendations, F1C. CARB and the Administration are committed to increasing focus on transportation equity investment as was reflected in the Governor's 2022–23 proposed budget. *ejacrecsrevised.pdf (ca.gov)*.
[238] CARB. Ocean-Going Vessels At Berth Regulation. *https://ww2.arb.ca.gov/our-work/programs/ocean-going-vessels-berth-regulation*.
[239] CARB. Small Off-Road Engines (SORE). *https://ww2.arb.ca.gov/our-work/programs/small-off-road-engines-sore*.
[240] AB 32 EJ Advisory Committee, Draft Recommendations, F1A. *ejacrecsrevised.pdf (ca.gov)*.
[241] AB 32 EJ Advisory Committee, Draft Recommendations, NF6, in the context of communities. *ejacrecsrevised.pdf (ca.gov)*.
[242] AB 32 EJ Advisory Committee, Draft Recommendations, NF7. *ejacrecsrevised.pdf (ca.gov)*.
[243] CARB. LCFS ZEV Infrastructure Crediting. *https://ww2.arb.ca.gov/resources/documents/lcfs-zev-infrastructure-crediting*.

California Energy Commission's Clean Transportation Program[244] pursuant to Executive Order B-48-18.[245]

- Evaluate and continue to offer incentives similar to those through FARMER,[246] Carl Moyer,[247] the Clean Fuel Reward Program,[248] CAPP,[249] and Low Carbon Transportation,[250] including CORE.[251,252]
- Continue and accelerate funding support for zero emission vehicles and refueling infrastructure through 2030 to ensure the rapid transformation of the transportation sector.
- Evaluate and align with the Draft 2022 Scoping Plan relevant policies such as Advanced Clean Cars II,[253] Innovative Clean Transit,[254] Zero Emission Airport Shuttle,[255] California Phase 2 GHG Standards,[256] Advanced Clean Trucks, Advanced Clean Fleets, Zero Emission Forklifts,[257] In-use Locomotives,[258] Off-Road Zero-Emission Targeted Manufacturer rule, Clean Off-Road Fleet Recognition Program, In-use Off-Road Diesel-Fueled Fleets Regulation,[259] Commercial Harbor Craft,[260], Off-Road Zero-Emission Targeted Manufacturer rule, Clean Off-Road Fleet Recognition Program, Amendments to the In-use Off-

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[244] California Energy Commission (CEC). Clean Transportation Program. https://www.energy.ca.gov/programs-and-topics/programs/clean-transportation-program.
[245] EO B-48-18 calls for 200 hydrogen refueling stations by 2025. https://www.library.ca.gov/wp-content/uploads/GovernmentPublications/executive-order-proclamation/39-B-48-18.pdf.
[246] CARB. FARMER program. https://ww2.arb.ca.gov/our-work/programs/farmer-program.
[247] CARB. Carl Moyer program. https://ww2.arb.ca.gov/our-work/programs/carl-moyer-memorial-air-quality-standards-attainment-program.
[248] California Clean Fuel Reward Program. https://cleanfuelreward.com/.
[249] CARB. Community Air Protection Program. https://ww2.arb.ca.gov/capp.
[250] CARB. Low Carbon Transportation Investments and Air Quality Improvement Program. https://ww2.arb.ca.gov/our-work/programs/low-carbon-transportation-investments-and-air-quality-improvement-program.
[251] Clean Off-Road Equipment Voucher Incentive Program. https://californiacore.org/.
[252] AB 32 EJ Advisory Committee, Draft Recommendations, F1C. ejacrecsrevised.pdf (ca.gov).
[253] CARB. Advanced Clean Cars Program. https://ww2.arb.ca.gov/our-work/programs/advanced-clean-cars-program.
[254] CARB. Innovative Clean Transit. https://ww2.arb.ca.gov/our-work/programs/innovative-clean-transit.
[255] CARB. Zero-Emission Airport Shuttle. https://ww2.arb.ca.gov/our-work/programs/zero-emission-airport-shuttle.
[256] CARB. California Phase 2 Greenhouse Gas Standards. https://ww2.arb.ca.gov/our-work/programs/greenhouse-gas-standards-medium-and-heavy-duty-engines-and-vehicles/phase2.
[257] CARB. Zero-Emission Forklifts. https://ww2.arb.ca.gov/our-work/programs/zero-emission-forklifts.
[258] CARB. Reducing Rail Emissions in California. https://ww2.arb.ca.gov/our-work/programs/reducing-rail-emissions-california.
[259] CARB. In-use Off-Road Diesel-Fueled Fleets Regulation. https://ww2.arb.ca.gov/our-work/programs/use-road-diesel-fueled-fleets-regulation.
[260] CARB. Commercial Harbor Craft. https://ww2.arb.ca.gov/our-work/programs/commercial-harbor-craft.

Road Diesel-Fueled Fleets Regulation[261], carbon pricing through the Cap-and-Trade Program,[262] and the Low Carbon Fuel Standard.[263]

- Identify and address permitting and market barriers to successful rapid ZEV technology deployment while protecting public health and the environment.

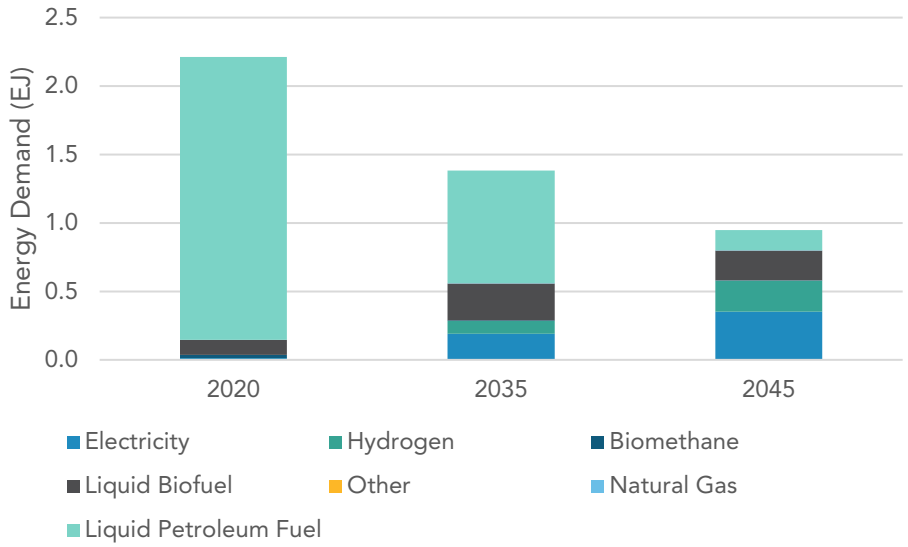
Fuels

Transitioning away from ICE vehicles is part of the solution, but we must ensure that an adequate supply of zero-carbon alternative fuel is available to power these vehicles. Electricity and hydrogen are the primary fuels for ZEVs, and both fuels must be produced using low-carbon technology and feedstocks to minimize upstream emissions as the LCFS calculates life-cycle carbon intensity of fuels.

The transition to complete ZEV technology will not happen overnight. ICE vehicles from legacy fleets will remain on the road for some time, even after all new vehicle sales have transitioned to ZEV technology. In addition, some equipment types are only now in the initial stages of development of ZEV technology for propulsion, such as commercial aircraft or ocean-going vessels. In addition to building the production and distribution infrastructure for zero-carbon fuels, the state must continue to support low-carbon liquid fuels during this period of transition and for much harder sectors for ZEV technology such as aviation, locomotives, and marine applications. Biomethane currently displaces fossil fuels in transportation and will largely be needed for hard-to-decarbonize sectors but will likely continue to play a targeted role in some fleets while the transportation sector transitions to ZEVs. Figure 4-2 provides the detail on fuels used in 2020 and the fuel mix under the Proposed Scenario for 2035 and 2045.

[261] CARB. In-use Off-Road Diesel-Fueled Fleets Regulation. *https://ww2.arb.ca.gov/our-work/programs/use-road-diesel-fueled-fleets-regulation*n
[262] CARB. Cap-and-Trade Program. *https://ww2.arb.ca.gov/our-work/programs/cap-and-trade-program*.
[263] CARB. Low Carbon Fuel Standard. *https://ww2.arb.ca.gov/our-work/programs/low-carbon-fuel-standard*.

Figure 4-2: Transportation fuel mix in 2020, 2035, and 2045 in the Proposed Scenario



Private investment in alternative fuels will play a key role in diversifying the transportation fuel supply away from fossil fuels. The Low Carbon Fuel Standard is the primary mechanism for transforming California's transportation fuel pool with low-carbon alternatives and has fostered a growing alternative fuel market. Partially as a result of the powerful market signals from the LCFS, fuels like renewable diesel, sustainable aviation fuel, renewable natural gas, and electricity have all gained significant market shares and continue to displace gasoline and diesel in both on- and off-road vehicles. In addition, Executive Order N-79-20 calls on state agencies to support the transition of existing fuel production facilities away from fossil fuels and directs that this transition also protect and support workers, public health, safety, and the environment. In line with this direction, existing refineries could be repurposed to produce sustainable aviation fuel, renewable diesel, and hydrogen. This trend has already begun and continuing to develop fuel production capacity in-state to support the energy transition while making the most efficient use of existing assets is critical to avoiding emissions leakage. If fuel demand persists after fuel production facilities have ceased operations, fuel demand will have to be met through imports.

As we transition or build new energy production facilities and infrastructure, it will be important to ensure low-income communities and communities of color do not experience increases in existing air pollution disparities and continue to experience a reduction in the air pollution disparities that exist today. California must use the best available science to ensure that raw materials used to produce transportation fuels do not incentivize

feedstocks with little to no GHG reductions from a life cycle perspective.[264] A dramatic increase in alternative fuel production must not come at the expense of global deforestation, unsustainable land conversion, or adverse food supply impacts, to name a few examples. Staff will continue to monitor scientific findings on these topics to ensure that California policies, such as the LCFS, send appropriate market signals and do not result in unintended consequences.[265]

Strategies for Achieving Success

- Accelerate the reduction and replacement of fossil fuel production and consumption in California.[266]
- Incentivize private investment in new zero-carbon fuel production in California.
- Incentivize the transition of existing fuel production and distribution assets to support deployment of low- and zero-carbon fuels while protecting public health and the environment.
- Invest in the infrastructure to support reliable refueling for transportation such as electricity and hydrogen refueling.
- Evaluate and propose, as needed, changes to strengthen the Cap-and-Trade Program.
- Initiate a public process focused on options to increase the stringency and scope of the LCFS:
    - Evaluate and propose accelerated carbon intensity targets pre-2030 for LCFS.
    - Evaluate and propose further declines in LCFS post-2030 carbon intensity targets to align with the Final 2022 Scoping Plan.
    - Consider integrating opt-in sectors into the program.
    - Provide capacity credits for hydrogen and electricity for heavy-duty fueling.
- Monitor for and ensure that raw materials used to produce low-carbon fuels or technologies do not result in unintended consequences.[267]

Vehicle Miles Traveled

Transforming the transportation sector goes beyond phasing out combustion technology and producing cleaner fuels. Reducing total demand for transportation energy by reducing the miles people drive on a daily basis is also critical as the state aims for a sustainable

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[264] AB 32 EJ Advisory Committee, Draft Recommendations, NF5. ejacrecsrevised.pdf (ca.gov).
[265] AB 32 EJ Advisory Committee, Draft Recommendations, F1E. ejacrecsrevised.pdf (ca.gov).
[266] AB 32 EJ Advisory Committee, Draft Recommendations, F3. ejacrecsrevised.pdf (ca.gov).
[267] AB 32 EJ Advisory Committee, Draft Recommendations, F1E. ejacrecsrevised.pdf (ca.gov).

transportation sector in a carbon neutral economy.[268] Though GHG emissions are declining due to cleaner vehicles and fuels, rising VMT can offset the effective benefits of adopted regulations.

Even under full implementation of Executive Order N-79-20 with 100 percent ZEV sales in the light-duty vehicle sector by 2035, a significant portion of passenger vehicles will still rely on ICE technology, as demonstrated in Figure 4-2 above. VMT reductions will play an indispensable role in reducing overall transportation energy demand and achieving our climate, air quality, and equity goals even as vehicles transition to ZEV technology. After a significant pandemic-induced reduction in VMT during 2020, passenger VMT has steadily climbed back up and is now closing in on pre-pandemic levels.[269] Driving alone with no passengers remains the primary mode of travel in California, amounting to 75 percent of the mode share for daily commute trips. Conversely, transit ridership, which was also heavily affected during the lockdown months, has not recovered at the same pace as VMT, and roughly averages two-thirds of pre-pandemic levels of ridership.[270] [271]

Sustained VMT reductions have been difficult to achieve for much of the past decade, in large part due to entrenched transportation, land use, and housing policies and practices. Specifically, historic decision-making favoring single-occupancy vehicle travel has shaped development patterns and the transportation options available to support them. Single-use zoning (where only one kind of land use–be it housing, offices, shopping, or another use–is allowed per zone) and lower-density environments (with fewer people working or living near each other) are both commonly promoted through existing land use regulations in California. This type of zoning forces people to drive farther distances to meet their daily needs, and makes transit, bicycling, and walking less viable. California's transportation system has also generally been developed in service of private cars and its users, with accompanying planning and funding.

Where and how communities plan and build housing and transportation services also imposes and reinforces long-standing racial and economic injustices that leave residents with little choice but to spend significant time and money commuting long distances from a place where they can afford to live. This places a disproportionate burden on low-

[268] See Appendix E (Sustainable Communities).
[269] U.S. Department of Transportation. 2021. December 2021 Traffic Volume Trends. Figure 3 - Seasonally Adjusted Vehicle Miles Traveled by Month. *https://www.fhwa.dot.gov/policyinformation/travel_monitoring/21dectvt/figure3.cfm*.
[270] U.S. GAO. January 25, 2022. During COVID-19, Road Fatalities Increased and Transit Ridership Dipped. *https://www.gao.gov/blog/during-covid-19-road-fatalities-increased-and-transit-ridership-dipped*.
[271] American Public Transportation Association. APTA - Ridership Trends. *https://transitapp.com/APTA*.

income Californians, who pay the highest proportion of their wages for housing and transportation.

Strategies for Achieving Success

- Achieve a per capita VMT reduction of at least 22 percent below 2019 levels by 2045.
- Implement equitable roadway pricing strategies based on local context and need, reallocating revenues to improve transit, bicycling, and other sustainable transportation choices.[272]
- Reimagine new roadway projects that increase VMT in a way that meets community needs and reduces the need to drive Invest in making public transit a viable alternative to driving by increasing affordability, reliability, coverage, service frequency, and consumer experience.[273]
- Expand and complete planned networks of high-quality active transportation infrastructure.[274]
- Channel the deployment of autonomous vehicles, ride-hailing services, and other new mobility options toward high passenger-occupancy and low VMT-impact service models that complement transit and ensure equitable access for priority populations.
- Streamline access to public transportation, through programs such as the California Integrated Travel Project. Ensure alignment of land use, housing, transportation, and conservation planning in adopted regional plans, such as regional transportation plans (RTP) or sustainable communities strategies (SCS) and regional housing needs assessments (RHNA) and local plans (e.g., general plans, zoning, and local transportation plans), and develop tools to support implementation of these plans.
- Accelerate infill development and housing production at all affordability levels in transportation-efficient places, with a focus on housing for lower-income residents.

Clean Electricity Grid

Much of the state's success to date in reducing GHGs is due to decarbonization of the electricity sector as a result of the RPS, integrated resources planning, and the Cap-and-Trade Program. Moving forward, a clean, affordable, and reliable electricity grid will serve as a backbone to support deep decarbonization across California's economy. Additionally, unprecedented load growth must be met to achieve the outcomes called for in the Draft 2022 Scoping Plan. At the same time, other clean energy options, such as

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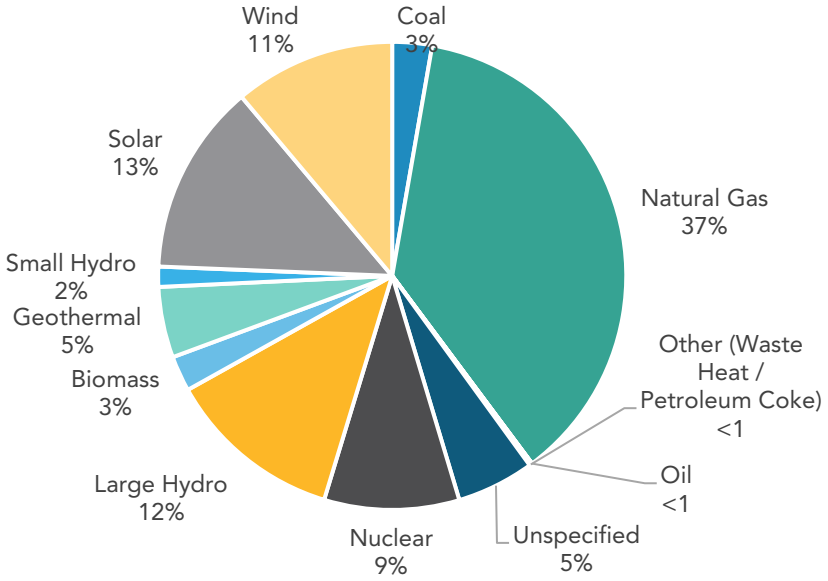
[272] AB 32 EJ Advisory Committee, Draft Recommendations, F1D. ejacrecsrevised.pdf (ca.gov).
[273] AB 32 EJ Advisory Committee, Draft Recommendations, F1D. ejacrecsrevised.pdf (ca.gov).
[274] AB 32 EJ Advisory Committee, Draft Recommendations, F1F. ejacrecsrevised.pdf (ca.gov).

hydrogen and renewable natural gas must remain options as we transition away from fossil fuels.

Electricity pulses through the state, driving its manufacturing capability and providing heating and cooling for all Californians. Under the Draft 2022 Scoping Plan, its role in underpinning the economy will grow in almost every sector. In 2020, 70 percent of California electricity demand was served by in-state power plants totaling about 80 GW, with the rest coming from out-of-state imports.[275] Additionally, approximately 8 GW of customer solar photovoltaic capacity has been installed to date to help with in-state demand.[276] The breakdown of in-state and imported sources of electricity is shown in Figure 4-3.

Figure 4-3: 2020 total system electric generation (based on GWh)[277]



Note: Imports contributing to total system generation are comprised of 62% zero-carbon energy and 38% non-renewable and unspecified energy. Percentages do not add to exactly 100 due to rounding.

[275] CEC. 2020. Electric Generation Capacity and Energy. Data available at: https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/electric-generation-capacity-and-energy and CEC. 2020. Total System Electric Generation. Data available at: https://www.energy.ca.gov/data-reports/energy-almanac/california-electricity-data/2020-total-system-electric-generation . Capacity values are nameplate capacity from sources 1 MW and larger.

[276] CEC. 2021. *SB 100 Joint Agency Report Summary: Achieving 100% Clean Electricity in California, An Initial Assessment.* 10. https://www.energy.ca.gov/publications/2021/2021-sb-100-joint-agency-report-achieving-100-percent-clean-electricity.

[277] *Total system generation* is the sum of all utility-scale, in-state generation, plus net electricity imports.

In 2020, about 45 percent of electricity generation serving California came from non-renewable and unspecified[278] resources, while 55 percent came from renewable and zero-carbon resources. Although fossil fuels still comprise a significant portion of the resource mix, the state's electric system is in a period of transition. Nearly 6,000 MW of firm and dispatchable resources[279] are expected to be retired over the next five years, including the remaining fossil-fueled once-through cooled (OTC) power plants within the California Independent System Operator (CAISO) balancing authority area and the Diablo Canyon Nuclear Power Plant. At the same time, the state continues to rapidly expand deployment of renewable resources and plan for increased electrification.[280]

While the electricity sector is using less fossil fuel due to increasing amounts of renewables,[281] in the near term, fossil gas generation will continue to play a critical role in grid reliability until other clean, dispatchable alternatives are available and can be deployed. The integration of greater amounts of variable renewable generation resources[282] is changing power system planning and operations, and system operators need resources with flexible attributes to balance shifting supply and demand. The influx of solar power is creating more frequent instances of oversupply during the middle of the day, when the sun is brightest.[283] During certain times of the year, the demand minus the variable generation is less during midday, but later quickly ramps up. For example, on hot summer days, demand met with customer solar generation during the day shifts back to the electric grid as the sun sets. Because customer demand remains high well into the summer evening period to power air conditioning, lights, and appliances, this can stress

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[278] *Unspecified power* refers to electricity that is not traceable to a specific generating facility, such as electricity traded through open market transactions. It typically consists of a mix of resources and may include renewables.

[279] *Dispatchable generators* can raise or lower power output on command from the system operator. *Firm generation* refers to a constant level of power output that a generator can guarantee for a specified time interval.

[280] In June 2021, the CPUC adopted D.21-06-035 directing procurement of 11,500 MW of new capacity between 2023 and 2026 to ensure systemwide electric reliability as Diablo Canyon and several OTC facilities retire. It requires that, out of the 11,500 MW, 2,500 MW must be from zero-emission resources. Additionally, 2,000 MW must be long lead-time resources, with at least 1,000 MW of long-duration storage and 1,000 MW of firm capacity with zero on-site emissions or that qualifies under the RPS eligibility requirements.

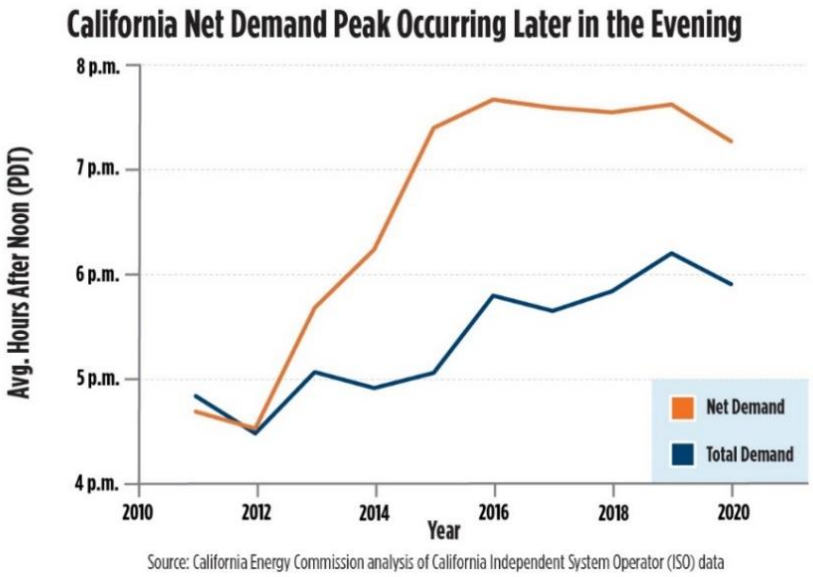
[281] CARB. 2021. California Greenhouse Gas Emissions for 2000 to 2019: Trends of Emissions and Other Indicators. *https://ww2.arb.ca.gov/sites/default/files/classic/cc/ca_ghg_inventory_trends_2000-2019.pdf*.

[282] A *variable renewable generation resource* is a renewable source of electricity that is non-dispatchable due to its fluctuating nature and only produces electricity when weather conditions are right, such as when the sun is shining or the wind is blowing. Renewable resources that can be controlled and are dispatchable include geothermal, biomass, and dam-based hydroelectric power.

[283] *Brightness* is used colloquially here; solar energy depends on insolation (e.g., sun-hours), which is the measurement of cumulative solar energy that reaches an area over a period of time.

the grid and lead to reliability concerns without adequate planning.[284] Figure 4-4 illustrates how the timing of California's demand peaks has shifted and why grid operators cannot turn to solar after the sun sets to fulfill the resulting net demand peak.[285] To help address this challenge, resource installations that pair solar with batteries, as well as a greater amounts of battery build-out, are coming online currently and over the next five years.

Figure 4-4: Average time (Pacific Daylight Time) of daily total and net peak electricity demand, July–September 2011–2020



Sector Transformation

Decarbonizing the electricity sector is a crucial pillar of this Draft 2022 Scoping Plan. It depends on both using energy more efficiently and replacing fossil-fueled generation with renewable and zero carbon resources, including solar, wind, energy storage,[286] geothermal, biomass, and hydroelectric power. The Renewables Portfolio Standard (RPS) Program[287] and the Cap-and-Trade Program continue to incentivize dispatch of renewables over fossil generation to serve state demand. SB 100 (De León, Chapter 312,

[284] CAISO, CPUC, and CEC. 2021. *Final Root Cause Analysis: Mid-August 2020 Extreme Heat Wave.* http://www.caiso.com/Documents/Final-Root-Cause-Analysis-Mid-August-2020-Extreme-Heat-Wave.pdf.

[285] The *net demand peak period* is the time frame between about 4:00–9:00 pm when variable generation (e.g., solar) is below its capacity value but demand is still relatively high.

[286] AB 32 EJ Advisory Committee, Draft Recommendations, NF1, NF2. ejacrecsrevised.pdf (ca.gov).

[287] The CEC estimates that 36 percent of California's 2019 retail electricity sales was served by RPS-eligible renewable resources (see https://ww2.arb.ca.gov/sites/default/files/2021-11/CPUC-sp22-electricity-ws-11-02-21.pdf).

Statutes of 2018) increased RPS stringency to require 60 percent renewables by 2030 and for California to provide 100 percent of its retail sales[288] of electricity from renewable and zero-carbon resources by 2045. In addition to grid-level resources, state efforts have supported rapid growth of the distributed solar industry through key actions like the California Solar Initiative (SB 1, Murray, Chapter 132, Statues of 2006).[289] Steps to commercialize microgrids powered by clean resources[290] are also being examined as part of SB 1339 (Stern, Chapter 566, Statutes of 2018).[291]

California also continues to advance its appliance and building energy efficiency standards to reduce growth in electricity consumption and meet the SB 350 (De León and Leno, Chapter 547, Statutes of 2015) goal to double statewide energy efficiency savings in electricity and fossil gas end uses[292] by 2030. In 2018, the CEC adopted a building energy efficiency code requiring most new homes to have solar photovoltaic systems[293] (or be powered by a solar array nearby) starting January 1, 2020. In 2019, California reached the milestone of 1 million solar rooftop installations.

SB 350 also aims to connect long-term planning for electricity needs with the state's climate targets. This is primarily accomplished through CARB's establishment of 2030 GHG emissions targets for the electricity sector in general and for each electricity provider, which inform the California Public Utilities Commission (CPUC) and publicly owned utilities' integrated resource planning (IRP). A GHG planning target range of 30 to 53 $MMTCO_2e$—informed by the 2017 Scoping Plan—was originally developed and adopted by CARB in 2018. In its 2021 IRP planning cycle, the CPUC adopted a 38 MMT GHG target for the electricity sector in 2030.[294]

The Proposed Scenario incorporates SB 350's energy efficiency doubling goal, the CPUC's IRP 2030 GHG target, and SB 100's 2030 RPS and 2045 zero-carbon retail sales targets to reduce dependence on fossil fuels in the electricity sector by transitioning

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[288] SB 100 speaks only to retail sales and state agency procurement of electricity. The *2021 SB 100 Joint Agency Report* interprets this to mean that other loads—wholesale or non-retail sales and losses from storage and transmission and distribution lines—are not subject to the law.

[289] More information on the program, which closed in 2016, can be found on the CPUC website, including annual program assessment reports, at: *https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/demand-side-management/california-solar-initiative*.

[290] AB 32 EJ Advisory Committee, Draft Recommendations, NF2, NF13. *ejacrecsrevised.pdf (ca.gov)*.

[291] CPUC. Resiliency and Microgrids. *https://www.cpuc.ca.gov/industries-and-topics/electrical-energy/infrastructure/resiliency-and-microgrids*.

[292] AB 32 EJ Advisory Committee, Draft Recommendations, NF1. *ejacrecsrevised.pdf (ca.gov)*.

[293] AB 32 EJ Advisory Committee, Draft Recommendations, NF2. *ejacrecsrevised.pdf (ca.gov)*.

[294] The Preferred System Plan adopted by the CPUC on February 10, 2022, completes the 2019–21 IRP cycle. The proposal voted on is available at: *https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M449/K173/449173804.PDF*.

substantial energy demand to renewable and zero-carbon resources.[295] Continued transition to renewable and zero-carbon electricity resources will enable electricity to become a zero-carbon substitute for fossil fuels across the economy.

Figure 4-5 shows the modeled resource capacity to meet the SB 100 retail sales target. Energy efficiency moderates some of the need for additional electricity generation. However, that is quickly surpassed by growing electricity demand of about 50 percent by 2035 to nearly 80 percent by 2045 from increased population and electrification of other sectors compared to today (2020), as shown in Figure 4-6. The estimated resource build needed to meet this level of demand amounts to approximately 90 GW of solar and 40 GW of battery storage by 2045. To reach the 2045 target, the state will need to more than triple its current level of in-state renewable and zero-carbon power capacity. Annual build rates for the Proposed Scenario will need to increase over 150 percent and over 500 percent for solar and battery storage, respectively, compared to historic maximum rates.[296] This does not include capacity associated with hydrogen production, which was modeled off-grid; assuming hydrogen production via electrolysis, this would roughly be equivalent to an additional 41 GW of solar generation needed in 2045. It also does not include any additional load to implement CO_2 removal through CCS or direct air capture. The scale of solar and battery build rates needed could be reduced through the commercialization of new zero-carbon technologies.

[295] CARB. 2021. PATHWAYS Scenario Modeling: 2022 Scoping Plan Update – Attachment B: Generation Technologies to be included in Modeling. *Revised PATHWAYS Scenario Modeling Assumptions (ca.gov)*.
[296] E3. 2022. CARB Draft Scoping Plan: AB32 Source Emissions Initial Modeling Results. PowerPoint. *https://ww2.arb.ca.gov/sites/default/files/2022-03/SP22-Model-Results-E3-ppt.pdf. Build rates are from EIA data historical builds in the 2012-2022 time frame*.

Figure 4-5: Projected electricity resources needed by 2045 in the Proposed Scenario

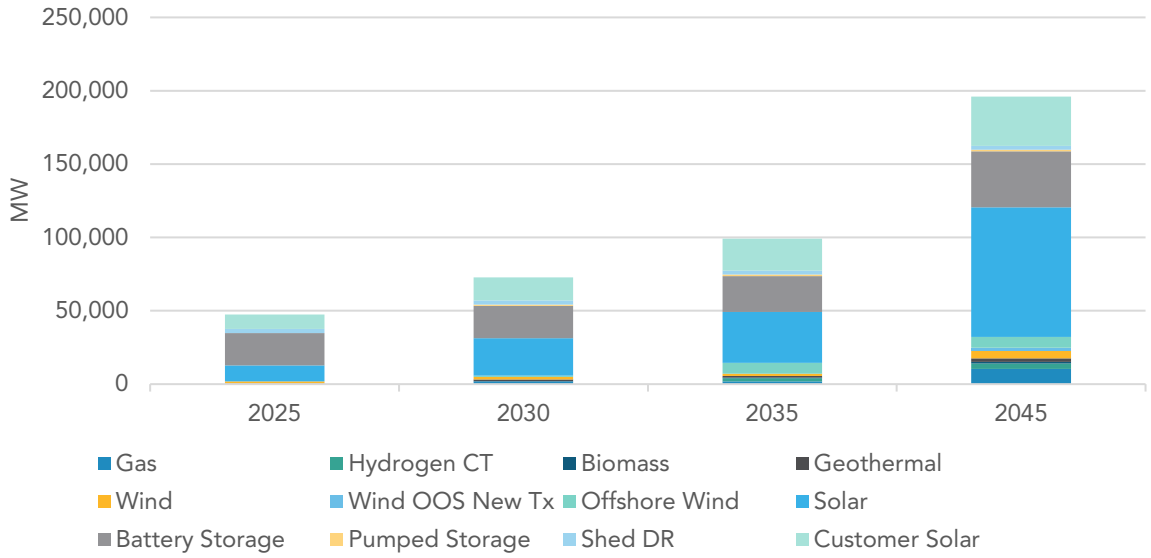
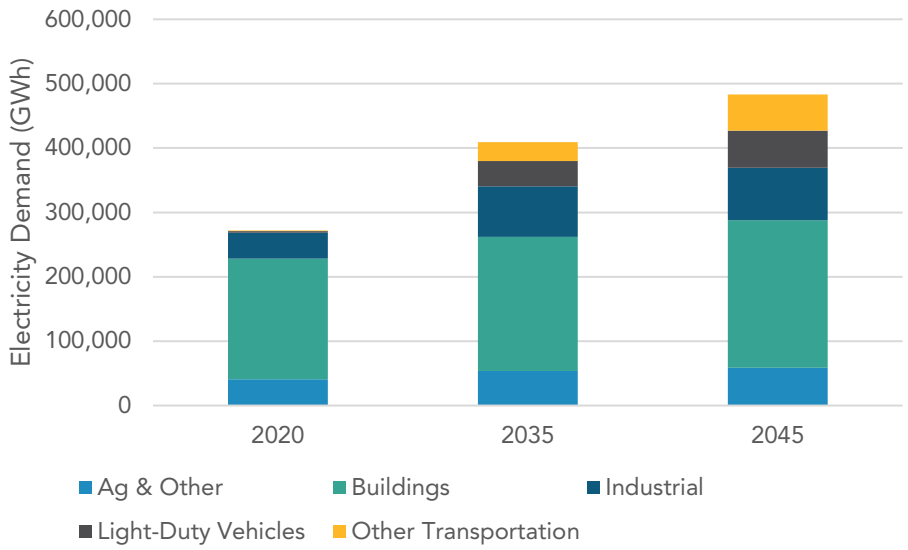


Figure 4-6: Electric loads in 2020, 2035 and 2045 for the Proposed Scenario[297]



This transformation will drive investments in a large fleet of generation and storage resources but will also require significant transmission to accommodate these new capacity additions. Transmission needs include high-voltage lines to access out-of-state

[297] *Other Transportation* includes all non-light-duty vehicles and reflects electrification of modes like passenger and freight rail, aviation, and ocean-going vessels.

resources and major in-state generation pockets. In consideration of typical 8- to 10-year lead times for many projects, the CAISO published its first draft 20-Year Transmission Outlook to inform transmission planning focused on meeting the needs identified through the 2021 SB 100 Joint Agency Report process. The outlook calls for significant transmission development to access offshore wind and out-of-state wind and reinforce the existing CAISO footprint at an estimated cost of $30.5 billion.[298]

In 2045, under SB 100, the electricity sector is predicted to emit approximately 30 $MMTCO_2e$ due to the difference between retail sales and the total load, which also includes pumping loads and transmission, distribution, and storage losses. Presently, fossil gas power plants provide about 75 percent of the flexible capacity for grid reliability as more renewable power enters the system. Moving forward, other resources such as storage and demand-side management are essential to maintain reliability with high concentrations of renewables. Hydrogen produced from renewable resources and renewable feedstocks can serve a dual role as a low-carbon fuel for existing combustion turbines or fuel cells, and as energy storage for later use. Reliability also can be supported through increased coordination and markets in the interconnected western power grid; this is already helping to better integrate renewables.[299]

Strategies for Achieving Success

- Use long-term planning processes (Integrated Energy Policy Report, IRP, CAISO Transmission Planning Process, AB 32 Climate Change Scoping Plan) to support grid reliability and expansion of renewable and zero-carbon resource and infrastructure deployment.
- Facilitate long lead-time resource development through the IRP and the SB 100 interagency process and through technology development and demonstration funding[300] that includes resources such as long-duration energy storage and hydrogen production.
- Continue coordination between energy agencies and energy proceedings to maximize opportunities for demand response.
- Continue to explore the benefits of regional markets to enhance decarbonization, reliability, and affordability.
- Address resource build-out challenges, including permitting, interconnection, and

[298] CAISO. 2022. Draft 20-Year Transmission Outlook. *http://www.caiso.com/InitiativeDocuments/Draft20-YearTransmissionOutlook.pdf*.
[299] CEC. 2021. 2021 SB 100 Joint Agency Report – Achieving 100 Percent Clean Electricity in California: An Initial Assessment. Publication Number: CEC-200-2021-001.
[300] AB 32 EJ Advisory Committee, Draft Recommendations, NF18. The committee recommendation speaks specifically to offshore wind production. *ejacrecsrevised.pdf (ca.gov)*.

transmission network upgrades.

- Explore new financing mechanisms and rate designs to address affordability.[301]
- Per SB 350, double statewide energy efficiency savings in electricity and fossil gas end uses by 2030, through a combination of energy efficiency and fuel substitution actions.[302]
- Per SB 100, achieve 100 percent renewable and zero-carbon retail sales by 2045.
- Evaluate and propose, as needed, changes to strengthen the Cap-and-Trade Program.
- Target programs and incentives to support and improve access to renewable and zero-carbon energy projects (e.g., rooftop solar, community solar, battery storage, and microgrids) for communities most at need, including frontline, low-income, rural, and indigenous communities.[303]
- Prioritize public investments in zero-carbon energy projects to first benefit the most overly burdened communities affected by pollution, climate impacts, and poverty.[304]

Sustainable Manufacturing and Buildings

Fossil gas is the primary gaseous fossil fuel used to produce heat at industrial facilities, as well as in residential and commercial buildings. In buildings, space and water heating, cooking, and clothes drying all rely on gaseous fuels today. Industrial processes that require heat for conventional boilers and other processes also rely on gaseous fuels. Refineries rely on fossil gas and other gaseous fossil fuels, like liquefied petroleum gas and refinery fuel gas, and fossil gas is also used to generate electricity, as discussed earlier.

Gaseous fossil fuel use can be displaced by four primary alternatives: zero-carbon electricity, solar thermal heat, hydrogen, and biogas/biomethane. Displacing gaseous fossil fuel use can yield indoor air quality benefits, protect public health and property from unexpected fossil gas leaks, and reduce short-lived climate pollutants, which are many times more potent in impacting climate change than CO_2. The Proposed Scenario reduces dependence on fossil gas in the industrial and building sectors by transitioning substantial energy demand to alternative fuels. Reducing fossil gas combustion will also help toward achieving our air quality goals and AB 617 goals. In addition, reduced

[301] AB 32 EJ Advisory Committee, Draft Recommendations, NF32, NF35. *ejacrecsrevised.pdf (ca.gov)*.
[302] AB 32 EJ Advisory Committee, Draft Recommendations, NF1, NF2. *ejacrecsrevised.pdf (ca.gov)*.
[303] AB 32 EJ Advisory Committee, Draft Recommendations, NF2, NF9, NF11, NF12, NF13. *ejacrecsrevised.pdf (ca.gov)*.
[304] AB 32 EJ Advisory Committee, Draft Recommendations, NF14, NF15. *ejacrecsrevised.pdf (ca.gov)*.

dependence on gasoline and diesel in the transportation sector diminishes the need for gaseous fossil fuels to support oil and gas production and petroleum refining operations as those are phased down relative to the demand.

Sector Transformation

Industry

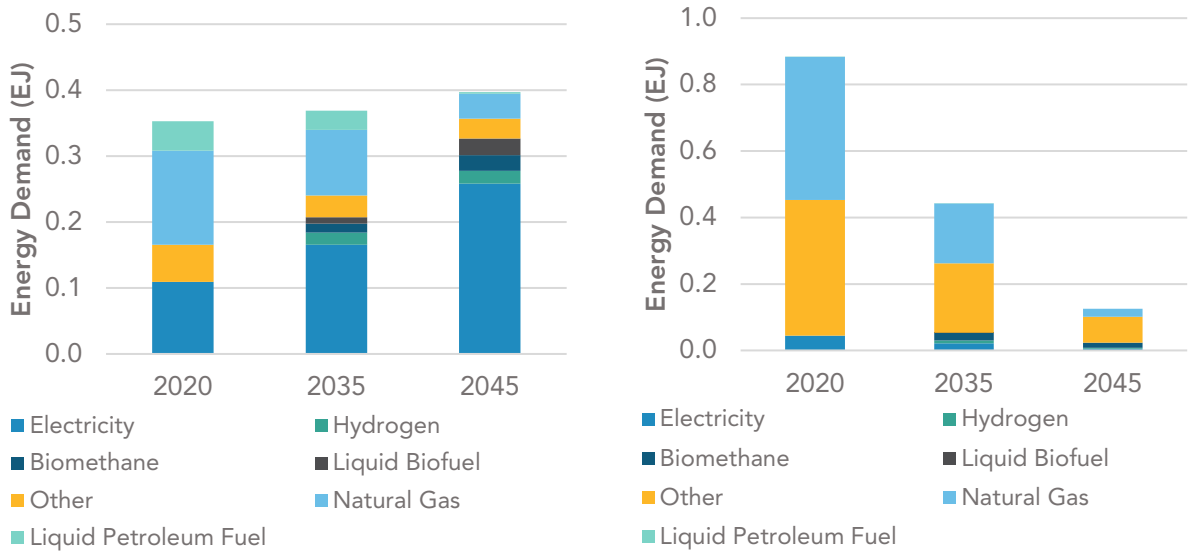
California's industrial sector contributes significantly to the state's economy, with a total output from manufacturing in 2019 of $324 billion (10.4 percent of the state total)[305] and employment of 1,222,000 manufacturing jobs (7.6 percent of the total state workforce).[306] California industry includes a diverse range of facilities, including cement plants, refineries, glass manufacturers, oil and gas producers, paper manufacturers, mining operations, metal processors, and food processors. Combustion of fossil gas, other gaseous fossil fuels, and solid fossil fuels provides energy to meet three broad industry needs: electricity, steam, and process heat. Non-combustion emissions result from fugitive emissions and from the chemical transformations inherent to some manufacturing processes. About 20 percent of the GHG emissions from the industrial sector are non-combustion emissions.

Decarbonizing industrial facilities depends upon displacing fossil fuel use with a mix of electrification, solar thermal heat, biomethane, low- or zero-carbon hydrogen, and other low-carbon fuels to provide energy for heat and reduce combustion emissions. Emissions can also be reduced by implementing energy efficiency measures and using substitute raw materials that can reduce energy demand and some process emissions. Some remaining combustion emissions and some non-combustion CO_2 emissions can be captured and sequestered. The strategy employed will depend on the industrial subsector and the specific processes utilized in production. The left side of Figure 4-7 illustrates the fuels used to meet industrial manufacturing energy demand in 2020.[307] Industrial manufacturing energy demand needs to transition to the fuel mix shown for 2035 and 2045. The right side of Figure 4-7 illustrates the fuel mix needed to meet the energy demand of oil and gas extraction and petroleum refining operations for the same years.[308] Energy demand in this portion of the industrial sector declines along with decreased demand for gasoline and diesel in the transportation sector. In both figures there is a

[305] National Association of Manufacturers. 2021 California Manufacturing Facts. https://www.nam.org/state-manufacturing-data/2021-california-manufacturing-facts/.
[306] National Association of Manufacturers. 2021 California Manufacturing Facts. https://www.nam.org/state-manufacturing-data/2021-california-manufacturing-facts/.
[307] *Other* fuel in the industrial manufacturing sector is primarily coke and coal for cement production.
[308] *Other* fuel in the petroleum refining sector is primarily fossil gas associated with refining petroleum products.

continuing demand for fossil gas due to lack of non-combustion technologically feasible or cost-effective alternatives for certain industrial sectors. Policies that support decarbonization strategies like electrification, use of renewable energy, and transition to alternative fuels are needed.

Figure 4-7: Final energy demand in industrial manufacturing (left) and in oil and gas extraction and petroleum refining (right) in 2020, 2035, and 2045 in the Proposed Scenario



Electrification and solar thermal heat are best-suited to industrial processes that have relatively low heat requirements, such as food processors, paper mills, and industries that use low-pressure steam in their processes. Approaches could include replacing fossil gas boilers with electric boilers, process heaters with industrial electric heat pumps, steel forging furnaces with induction heaters, and implementing other sector-specific process electrification. Under current rate structures for industrial electricity and fossil gas in California, most projects to electrify a fossil gas-powered industrial process will face operating cost barriers and potential reliability concerns. Microgrids powered by renewable resources and with battery storage are emerging as a key enabler of electrification and decarbonization at industrial facilities.

There are fewer commercially available and economically viable electrification options to replace industrial processes that require higher-temperature heat. For these processes, onsite combustion may continue to be needed, and decarbonization will require fuel

substitution to hydrogen,[309] biomethane, or other low-carbon fuels. Fuel substitution and continued combustion will require monitoring and mitigation of any potential air quality impacts, especially in low-income and communities of color which already face disproportionate air pollution burdens. Industries in California with high heat needs include steel forging, glass manufacturing, and industries with calcination processes, such as manufacturing lime and cement.

Onsite emissions from cement manufacturing derive from two main sources: (1) fuel combustion to heat the kiln to a very high temperature and (2) process CO_2 emissions from the chemical transformation of limestone. Over 60 percent of emissions from the sector are process emissions unrelated to fuel use, and most emissions related to fuel use are from coal and petroleum coke combustion. Process emissions from cement manufacturing are significant and will continue even if the sector were to operate using only zero-carbon fuels; thus carbon capture and use/sequestration will be a likely component of any strategy to fully decarbonize cement manufacturing. There are additional opportunities to reduce GHG emissions from cement manufacturing via the combination of fuel-switching to low-carbon fuels (e.g., biomethane, municipal solid waste, biochar), increased blending of non-clinker materials, and efficiency improvements. High technological and economic barriers exist to electrifying kiln process heat at cement plants, as clinker production requires temperatures in excess of 1,500°C. There are potential decarbonization opportunities throughout the value chain of cement use, including in cement manufacturing, concrete mixing, and construction practices.[310] SB 596 (Becker, Chapter 246, Statutes of 2021), which was signed by Governor Newsom in September 2021,[311] requires CARB to develop a comprehensive strategy for cement use in California to achieve a GHG intensity 40 percent below 2019 levels by 2035, and net-zero emissions by 2045.

Oil and gas extraction and refining make up over half of California's industrial GHG emissions. Reduced demand for transportation fossil fuels corresponds to reduced supply of fossil gas and other gaseous fossil fuels for refineries to produce these fuels. Some refining operations will continue to operate to produce fossil fuel for the remaining

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[309] Griffiths, Steve, Benjamin K. Sovacool, Jinsoo Kim, Morgan Bazilian, and Joao M. Uratani. 2021. "Industrial decarbonization via hydrogen: A critical and systematic review of developments, socio-technical systems and policy options." *Energy Research & Social Science* 80. 102208, ISSN 2214-6296. https://doi.org/10.1016/j.erss.2021.102208.

[310] California Nevada Cement Association. Achieving Carbon Neutrality in the California Cement Industry. https://cncement.org/attaining-carbon-neutrality.

[311] California Legislative Information. 2021. SB 596: Greenhouse gases: cement sector: net-zero emissions strategy. (SB 596, Becker, Chapter 246, Statutes of 2021). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB596.

transportation energy demands, along with renewable diesel and sustainable aviation fuel, as discussed in the Transportation Sustainability section of this chapter.

Across industrial subsectors and processes, California facilities also could realize significant reductions in GHG emissions and energy-related costs by implementing advanced energy efficiency projects and tools.[312] While enhanced operation and maintenance practices are typical at industrial facilities, additional strategic energy management practices offer greater efficiency gains by focusing on setting goals, tracking progress, and reporting results.

Strategies for Achieving Success

- Maximize air quality benefits using the best available control technologies for stationary sources in vulnerable communities.[313]
- Prioritize alternative fuel transitions in vulnerable communities first.[314]
- Invest in research and development and pilot projects to identify options to reduce materials and process emissions along with energy emissions in California's industrial manufacturing facilities, leveraging programs like the CEC's Electric Program Investment Charge (EPIC).[315]
- Evaluate and propose, as needed, changes to strengthen the Cap-and-Trade Program.
- Support electrification with changes to industrial rate structures.
- Develop infrastructure for CCS and hydrogen production to reduce GHG emissions where cost-effective and technologically feasible non-combustion alternatives are not available.
- Establish markets for low-carbon products and recycled materials using Buy Clean California Act and other mechanisms
- Develop a net-zero cement strategy to meet SB 596 targets for the GHG intensity of cement use in California.

[312] Therkelsen, Peter, Aimee McKane, Ridah Sabouini, and Tracy Evans. 2013. *Assessing the Costs and Benefits of the Superior Energy Performance Program.* United States: N. p. https://www.osti.gov/servlets/purl/1165470.

[313] AB 32 EJ Advisory Committee, Draft Recommendations, M15. ejacrecsrevised.pdf (ca.gov).

[314] AB 32 EJ Advisory Committee, Draft Recommendations, M16. ejacrecsrevised.pdf (ca.gov).

[315] AB 32 EJ Advisory Committee, Draft Recommendations, M22, M30. ejacrecsrevised.pdf (ca.gov).

- Continue to leverage energy-efficiency programs including the U.S. DOE's ENERGY STAR program,[316] U.S. DOE's Superior Energy Performance program,[317] and ISO 50001.[318]
- Evaluate and continue to offer incentives to install energy efficiency and renewable energy technologies through programs such as CPUC decisions as part of rulemaking R.19-09-009[319] and the California Solar Initiative Thermal Program, and the CEC's Food Production Investment Program (FPIP) and Electric Program Investment Charge (EPIC) programs.[320]
- Leverage low-carbon hydrogen programs, including the Bipartisan Infrastructure Law, for regional hydrogen hubs, hydrogen electrolysis, and - hydrogen manufacturing and recycling.
- Identify the feedstocks and technologies to produce low-carbon hydrogen until such time that sufficient renewable electricity is available for electrolysis.
- Address cost barriers to promote biomethane for hard-to-electrify industrial applications.

Buildings

Buildings have cross-sector interactions that influence our public health and well-being and affect land use and transportation patterns, energy use, water use, and indoor and outdoor environments.[321] There are about 14 million existing homes and over 7.5 billion square feet of existing commercial buildings[322] in California. Fossil gas supplies about half of the energy consumed by end uses in these buildings. In addition to GHG emissions, fossil gas usage in buildings also produces CO_2, NOx, $PM_{2.5}$, and

[316] ENERGY STAR. ENERGY STAR Guidelines for Energy Management. *https://www.energystar.gov/buildings/tools-and-resources/energy-star-guidelines-energy-management*.

[317] Energy.gov. Superior Energy Performance. *https://www.energy.gov/eere/amo/superior-energy-performance*.

[318] ISO. ISO 50001 Energy Management. *https://www.iso.org/iso-50001-energy-management.html*.

[319] CPUC. January 14, 2021. CPUC Adopts Strategies to Help Facilitate Commercialization of Microgrids Statewide. *https://docs.cpuc.ca.gov/PublishedDocs/Published/G000/M360/K370/360370887.PDF*.

[320] Bailey, Stephanie, David Erne, and Michael Gravely. 2021. *Final 2020 Integrated Energy Policy Report Update, Volume II: The Role of Microgrids in California's Clean and Resilient Energy Future, Lessons Learned From the California Energy Commission's Research.* California Energy Commission. Publication Number: CEC-100-2020-001-V2-CMF.

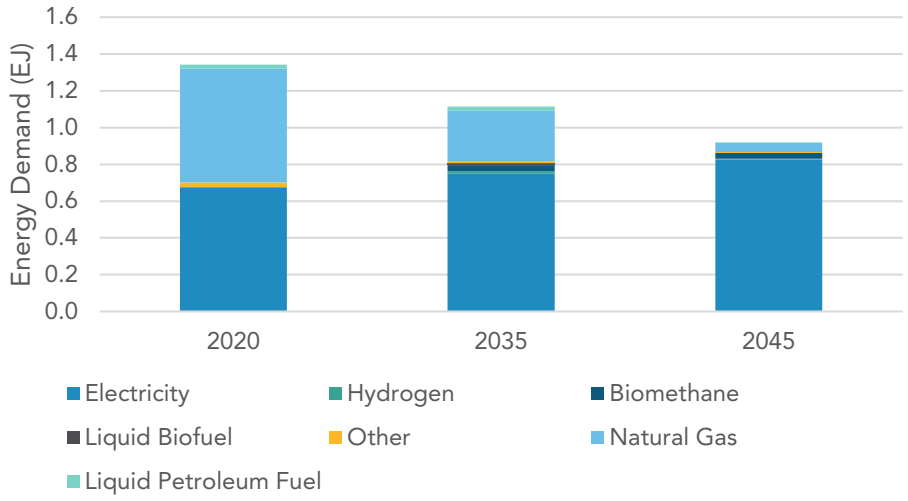
[321] See Appendix F (Building Decarbonization).

[322] California Energy Commission. 2021. California Building Decarbonization Assessment. *https://efiling.energy.ca.gov/GetDocument.aspx?tn=239311&DocumentContentId=72767*.

formaldehyde.[323] Each year, about 120,000 new homes[324] and more than 100 million-square feet[325] of commercial buildings are newly constructed across California. These new buildings will represent between a third to half of the total building stock by mid-century.

Achieving carbon neutrality must include transitioning away from fossil gas in residential and commercial buildings, and will rely primarily on advancing energy efficiency while replacing gas appliances with electric alternatives. This transition must include the goal of trimming back the existing gas infrastructure so pockets of gas-fueled residential and commercial buildings do not require ongoing maintenance of the entire limb for gas delivery. Blending low-carbon fuels, such as hydrogen and biomethane, into the pipeline further displaces fossil gas. Figure 4-8 illustrates the energy Californians use in buildings at present compared with the Proposed Scenario, which introduces alternatives to fossil gas. In that scenario almost 90 percent of energy demand is electrified by 2045, and the remaining energy demand is met with combustion of hydrogen, biomethane, and fossil gas.

Figure 4-8: Final energy demand in buildings in 2020, 2035, and 2045 in the Proposed Scenario



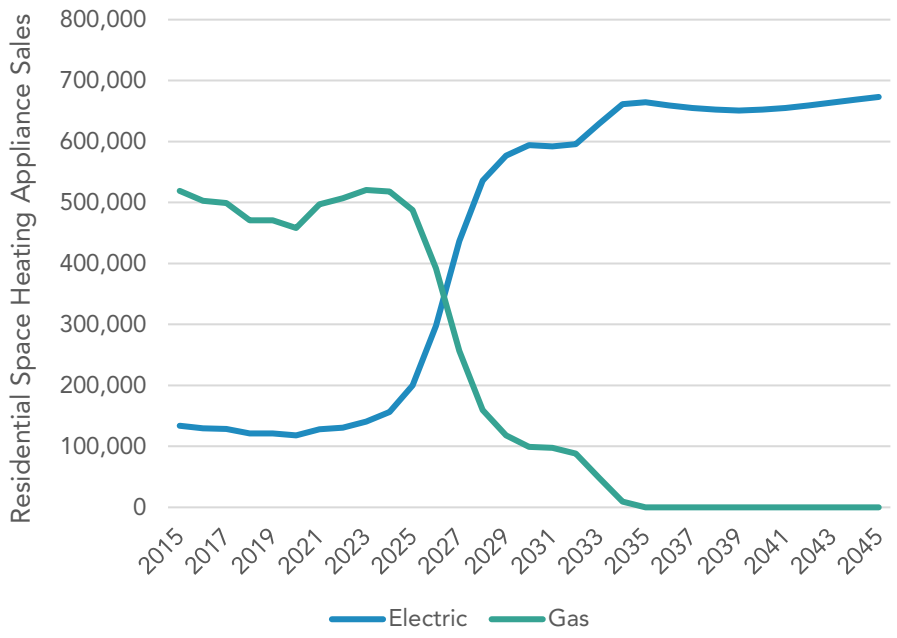
[323] Zhu, Yifang, et al. 2020. *Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California.* UCLA Fielding School of Public Health Department of Environmental Health Sciences.

[324] Construction Industry Research Board. 2018. Annual Building Permit Summary. http://www.cirbreport.org.

[325] Delforge, Pierre. August 11, 2021. California Forging Ahead on Zero Emission Buildings. Blog. NRDC. https://www.nrdc.org/experts/pierre-delforge/california-forging-ahead-zero-emission-buildings.

This transition is achieved when all new buildings constructed include electric appliances and appliances in the majority of existing buildings are replaced at the end of their useful life with electric alternatives. Figure 4-9 illustrates the pace at which electric space heating appliance sales increase and gas space heating appliance sales decrease in residences in the Proposed Scenario, such that by 2035 100 percent of residential home appliance sales are electric. The residential electric space heating appliance sales increases rapidly in the near-term as new all-electric buildings are constructed and as existing buildings are renovated to utilize electric appliances. A similar transition is envisioned for other home appliances. Commercial buildings also will undergo a transition away from gas appliances to electric appliances, achieving 80 percent sales of all-electric appliances by 2035 and 100 percent by 2045. Appendix D (Local Actions) describes a holistic policy approach to rapidly grow the number of zero emission appliances and buildings, to surmount the market barriers, and to prioritize an equitable transition for vulnerable communities.

Figure 4-9: Residential space heating appliance sales in the Proposed Scenario



Strategies for Achieving Success

- Prioritize California's most vulnerable residents with the majority of funds in the Governor's proposed Fiscal Year 2022–2023 Equitable Building Decarbonization program, $622.4 million over two years. This program is dedicated to a statewide direct-install building retrofit program for low-income households to replace fossil fuel appliances with electric appliances, energy-efficient lighting, and building insulation and sealing while also coordinating reductions in gas infrastructure in specific geographic areas.

- Expand incentive programs to support the holistic retrofit of existing buildings, especially for vulnerable communities.
- Ensure that incentive programs prioritize energy affordability and tenant protections, promote affordable and low-income household retrofits that improve habitability and reduce expenses, protect and empower small landlords and homeowners, address overlooked consumer groups, and pair decarbonization with other critically needed renovation efforts to ensure that buildings support human health and are climate- and weather-resistant.[326]
- End fossil gas infrastructure expansion for newly constructed buildings.[327]
- Evaluate and propose, as needed, changes to strengthen the Cap-and-Trade Program.
- Strengthen California's building standards to support zero-emission new construction.
- Develop building performance standards for existing buildings.
- Adopt a zero-emission standard for new space and water heaters sold in California beginning in 2030, as specified in the 2022 State Strategy for the State Implementation Plan.
- Expand use of low-GWP refrigerants within buildings.
- Support electrification with changes to utility rate structures and by promoting load management programs.
- Increase funding for incentive programs and expand financing assistance programs focused on existing buildings and appliance replacements.
- Expand consumer education efforts to raise awareness and stimulate the adoption of decarbonized buildings and appliances, especially in vulnerable communities.
- Implement renewable natural gas procurement targets as specified in SB 1440 (Hueso, Stats. of 2018, ch. 739, Public Utilities Code §§ 650) to reduce GHG emissions in remaining pipeline gas and reduce methane emissions from organic waste.

Carbon Dioxide Removal

Climate Change 2022: Mitigation of Climate Change,[328] a report by the IPCC released in early 2022, states "The deployment of CDR to counterbalance hard-to-abate residual emissions is unavoidable if net zero CO_2 or GHG emissions are to be achieved. The scale

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[326] AB 32 EJ Advisory Committee, Draft Recommendations, NF32, NF33, NF34, NF35, NF37. *ejacrecsrevised.pdf (ca.gov)*.

[327] AB 32 EJ Advisory Committee, Draft Recommendations, NF31. *ejacrecsrevised.pdf (ca.gov)*.

[328] IPCC. 2022. *Climate Change 2022: Mitigation of Climate Change*. *https://www.ipcc.ch/report/sixth-assessment-report-working-group-3/*

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." In line with that report, the Draft 2022 Scoping Plan considers carbon dioxide removal (CDR) as a complement to technologically feasible and cost-effective GHG emissions mitigation, and the size of its role will depend on the degree of success in reducing GHG emissions at the source across the economy.[329] The modeling shows that emissions from the AB 32 GHG Inventory sources will continue to persist even if all fossil related combustion emissions are phased out. These residual emissions must be compensated for to achieve carbon neutrality. Options for CDR include both sequestration in natural and working lands and mechanical approaches like direct air capture. Chapter 2 provides estimates on how much CO_2 removal is possible by our natural and working lands and how much must be removed by mechanical CDR.

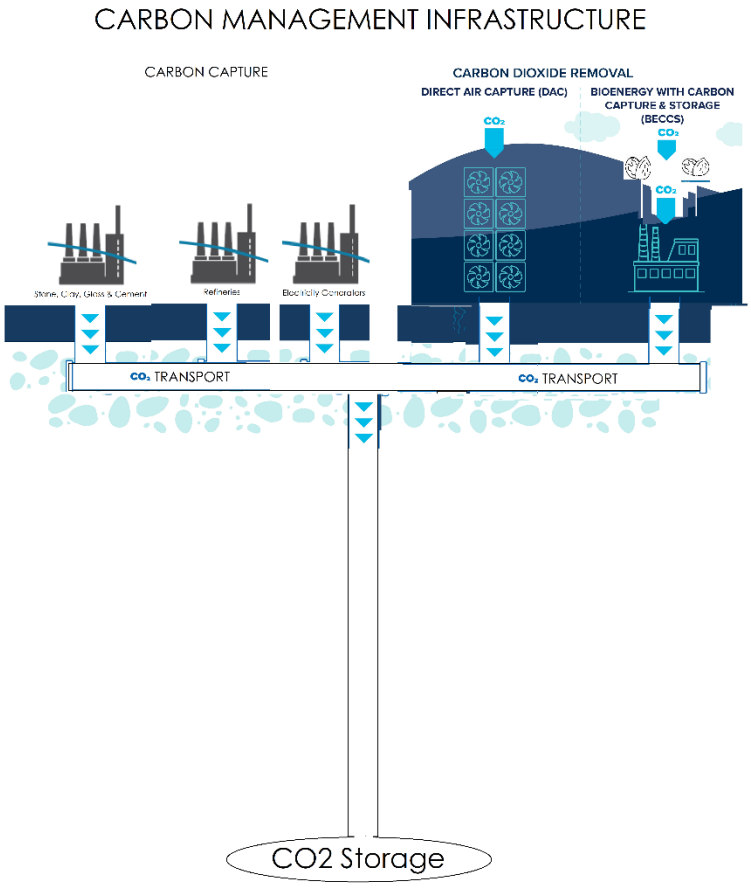
CCS, which is carbon capture from anthropogenic point sources, is described in Chapter 2 and involves capturing carbon from a smokestack of an emitting facility. Direct air capture, on the other hand, captures carbon directly from the atmosphere. Direct air capture technologies, unlike CCS, are not associated with any particular point source.

For this section, *carbon management* refers to the capture, movement, and sequestration of CO_2 through mechanical solutions for both capture at point sources and direct removal from the atmosphere through direct air capture.[330] Enabling policies and regulations across each of these steps are necessary for individual projects, and on a broader scale, for delivering reductions in support of the state's carbon neutrality and long-term carbon-negative goals. Figure 4-10 provides a graphic of the typical carbon management infrastructure.

[329] AB 32 EJ Advisory Committee, Draft Recommendations, F4.4, F4.8. *ejacrecsrevised.pdf (ca.gov)*.

[330] CDR through natural and working lands is discussed in Chapter 2 and later in this chapter.

Figure 4-10: Carbon management infrastructure



Carbon dioxide removal directly from the atmosphere itself refers to a suite of carbon negative technologies that can be used to drawdown ongoing and historical carbon emissions already in the atmosphere. Some CO_2 removal technologies leverage the abilities of both natural photosynthesis and mechanical removal by using biomass wastes as inputs to make low- or zero-carbon energy or fuels, all while capturing and storing produced CO_2.

Captured CO_2 from point sources or from the atmosphere is permanently stored in specialized geologic formations, typically half a mile or more underground. A recent Stanford University study estimated the state's commercial storage potential is nearly 70,000 million metric tons of CO_2, even when excluding oil and gas reservoirs.[331]

[331] Stanford Center for Carbon Storage. Opportunities and Challenges for CCS in California. *https://sccs.stanford.edu/california-projects/opportunities-and-challenges-for-CCS-in-California*.

California is well-positioned because few other places on the West Coast are suitable for geologic storage at scale. To inform discussion around CO_2 removal, CARB held two full-day workshops exploring the types of options for carbon capture and geologic storage and utilization in products.[332,333,334]

The modeling results provided in Chapter 2 demonstrate the targeted need for CCS on large facilities such as refineries and cement. The CCS numbers do not include the potential additional applications for producing hydrogen with renewable natural gas, other manufacturing, electricity, or other bioenergy. If CCS is not deployed, those emissions would be released directly into the atmosphere and instead need to be addressed through CDR to achieve carbon neutrality. Although a study finds California has 76 existing electricity and industrial facilities that are suitable candidates for CCS retrofit,[335] the Draft 2022 Scoping Plan proposes a targeted role for this technology such that it would only be used to address sectors where non-combustion options are not technologically feasible or cost-effective at this time. In future updates to the Scoping Plan, there may be additional options for technologically feasible or cost-effective technologies that may be deployed, which would further reduce the need for CDR except in situations to address historical GHG emissions.

The merits of each CCS or CDR project must be evaluated on a case-by-case basis.[336] This type of infrastructure could support skilled jobs and workforces, including those in traditional fossil energy communities. Other co-benefits could include criteria air pollutant reductions and water production. It will be important to design projects that do not exacerbate community health impacts, include early and ongoing community engagement, and are in compliance with local, state, and federal public health and environmental protection laws. It also should be noted that, as these types of projects are an emerging area of governance, additional coordination and discussion will be needed among the various levels of authorities involved.

Chapter 2 includes a more detailed discussion about the proposed role of carbon dioxide removal in the Draft Scoping Plan.

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[332] CARB. December 11, 2019. Carbon Neutrality Meetings & Workshops. *https://ww2.arb.ca.gov/our-work/programs/carbon-neutrality/carbon-neutrality-meetings-workshops*.

[333] CARB. August 2, 2021 Scoping Plan Meetings & Workshops. *https://ww2.arb.ca.gov/our-work/programs/ab-32-climate-change-scoping-plan/scoping-plan-meetings-workshops*.

[334] *Carbon utilization* refers to the use of captured carbon to produce products such as plastics and concrete.

[335] Glenwright, Kara. 2020. *Roadmap for carbon capture and storage in California.* Precourt Institute for Energy. *https://earth.stanford.edu/news/roadmap-carbon-capture-and-storage-california#gs.ysj78q.*

[336] AB 32 EJ Advisory Committee, Draft Recommendations, F4.6. *ejacrecsrevised.pdf (ca.gov)*.

Sector Transformation

State,[337] national,[338,339] and global decarbonization analyses[340] indicate a significant role for carbon management infrastructure, yet relatively few projects are operational. Around the world, about two dozen large CCS projects are capturing tens of millions of metric tons of CO_2 each year, with about a dozen operating in the United States.[341] The vast majority of capacity is at industrial facilities, such as ethanol and fertilizer plants, that would otherwise vent nearly pure CO_2 into the atmosphere as a by-product of normal, non-combustion processes. Future research, development, and demonstration projects must refine and commercialize capture systems for more complex applications, especially for those with limited decarbonization options. It has only been in the last few years that attention has seriously turned to mechanical CDR. As new information and modeling on climate change have been made available, the science has become clearer that avoiding the most catastrophic impacts of climate change requires both reducing emissions and deploying mechanical CDR.

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.[342] CCS is not a new concept or

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[337] E3. October 2020. Achieving Carbon Neutrality in California Report: Final Presentation. *https://ww2.arb.ca.gov/sites/default/files/2020-10/e3_cn_final_presentation_oct2020_2.pdf*.

[338] World Resources Institute. January 31, 2020. CarbonShot: Federal Policy Options for Carbon Removal in the United States. Working paper. *https://www.wri.org/research/carbonshot-federal-policy-options-carbon-removal-united-states*.

[339] C2ES. No date. Getting to Zero: A U.S. Climate Agenda — Center for Climate and Energy Solutions. *https://www.c2es.org/getting-to-zero-a-u-s-climate-agenda-report/*.

[340] IPCC. Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development. *https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_Chapter2_Low_Res.pdf*. All analyzed pathways limiting warming to 1.5°C with no or limited overshoot use CDR to some extent to neutralize emissions from sources for which no mitigation measures have been identified and, in most cases, also to achieve net negative emissions to return global warming to 1.5°C following a peak (high confidence). The longer the delay in reducing CO_2 emissions toward zero, the larger the likelihood of exceeding 1.5°C, and the heavier the implied reliance on net negative emissions after mid-century to return warming to 1.5°C (high confidence).

[341] Congressional Research Service. 2021. Carbon Capture and Sequestration (CCS) in the United States. R44902. *https://crsreports.congress.gov/product/pdf/R/R44902?msclkid=e45e0012c25911ec8085ca575cb61e82*.

[342] CARB. August 13, 2018. Carbon Capture and Sequestration Protocol under the Low Carbon Fuel Standard. *https://ww2.arb.ca.gov/sites/default/files/2020-03/CCS_Protocol_Under_LCFS_8-13-18_ada.pdf*.

technology. Twenty years of CCS testing show it is a safe and reliable tool.[343] Moreover, there has been a U.S. Department of Energy CCS research program underway for more than two decades. These all form a foundation of information for future efforts. Certified projects must successfully demonstrate adherence to rigorous pre-construction, operational, and site closure standards designed to strengthen environmental performance, as described in CARB's CCS Protocol. The protocol is designed to layer on top of existing federal carbon sequestration regulations designed to protect the environment. The protocol would need to be reevaluated if CCS were to be more broadly applied across sectors beyond transportation fuel production.

Direct air capture and carbon mineralization have high potential capacity for removing carbon, but direct air capture is currently limited by high cost. Carbon mineralization may also have high potential for removing carbon from the atmosphere, but understanding of the technology is still limited.[344] The remaining emissions would need to be addressed through CO_2 removal from the atmosphere. Direct air capture could also be deployed at higher rates to remove legacy GHG emissions from the atmosphere. Chapter 2 contains additional information on the current status of CCS and mechanical CDR projects globally, as well as federal support of such technologies.

Strategies for Achieving Success

- Convene a multi-agency Carbon Capture and Sequestration Group comprised of federal, state, and local agencies to engage with environmental justice advocates, academics, researchers, and community representatives to identify the current status, concerns, and outstanding questions concerning CCS, and develop a process to engage with communities to understand specific concerns and consider guardrails to ensure safe and effective deployment of CCS.[345]
- Iteratively update the CARB CCS Protocol with the best available science and implementation experience.
- Incorporate CCS into other sectors and programs beyond transportation where cost-effective and technologically feasible options are not currently available.
- Evaluate and propose, as appropriate, financing mechanisms and incentives to address market barriers for CCS and CDR.

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[343] National Energy Technology Laboratory. Permanence and Safety of CCS. *https://netl.doe.gov/coal/carbon-storage/faqs/permanence-safety*.

[344] Aines, Roger. No date. Options for Removing CO_2 from California's Air. Lawrence Livermore National Laboratory. *https://ww2.arb.ca.gov/sites/default/files/2021-08/llnl_presentation_sp_engineeredcarbonremoval_august2021.pdf*.

[345] AB 32 EJ Advisory Committee, Draft Recommendations, F4.2, F4.6, F4.7, F4.9, F4.10. *ejacrecsrevised.pdf (ca.gov)*.

- Evaluate and propose, as appropriate, the role for CCS in SB 596.
- Further refine and characterize prime carbon storage sites relative to CCS and CDR needs.
- Support carbon management infrastructure projects through core CEC research, development, and demonstration (RD&D) programs.
- Continue to explore carbon capture applications for producing or leveraging zero-carbon power for reliability needs as part of SB 100.
- Consider carbon capture infrastructure when developing hydrogen roadmaps and strategy, especially for non-electrolysis hydrogen production.
- Clarify pore space ownership and pore space unitization rules and processes as they apply to geologic carbon sequestration.
- Evaluate and streamline permitting barriers to project implementation while protecting public health and the environment.
- Explore options for how local air quality benefits can be achieved when CCS is deployed.
- Explore opportunities for CCS and CDR developers to leverage existing infrastructure, including subsurface infrastructure.
- Explore permitting options to allow for scaling the number of sources at carbon sequestration hubs.

Short-Lived Climate Pollutants (Non-Combustion Gases)

Short-lived climate pollutants (SLCPs) include black carbon (soot), methane (CH_4), and fluorinated gases (F-gases, including hydrofluorocarbons [HFCs]). They are powerful climate forcers and harmful air pollutants that have an outsized impact on climate change in the near term, compared to longer-lived GHGs, such as CO_2. According to the IPCC's *Climate Change 2021: The Physical Science Basis,* in the near-term (i.e., 10- to 20-year time scale) the warming influence of all SLCPs combined will be at least as large as that of CO_2.[346] The United Nations Environment Programme's Global Methane Assessment advises that achieving the least-cost pathways to limit warming to 1.5°C requires global methane emission reductions of 40–45 percent by 2030 alongside substantial simultaneous reductions of all climate forcers, including CO_2 and SLCPs. Action to reduce these powerful emissions sources today will provide immediate benefits—both to human health locally and to reduce warming globally—as the effects of our policies to transition to low carbon energy systems and achieve carbon neutrality further unfold.

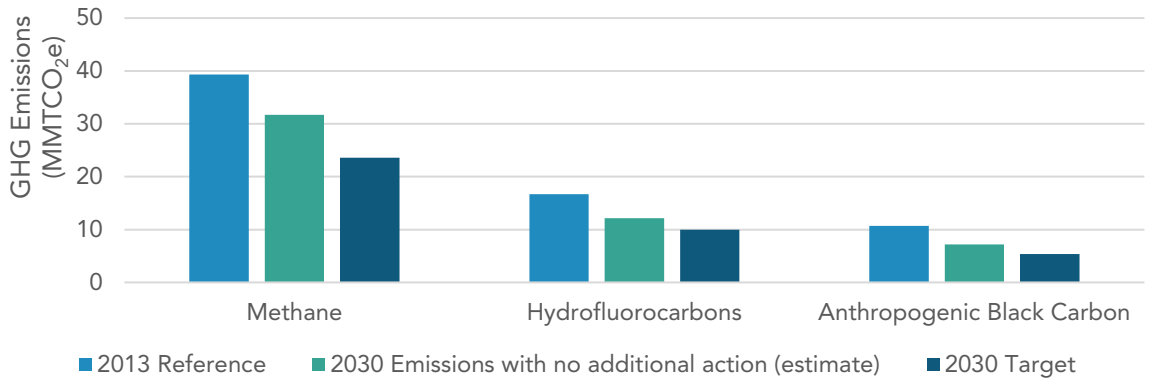
[346] IPCC. 2021. *Climate Change 2021:The Physical Science Basis.* Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. https://www.ipcc.ch/report/ar6/wg1/.

In 2017, the Board approved the comprehensive Short-Lived Climate Pollutant Reduction Strategy (Strategy).[347] This Strategy explained how the state would meet the following SB 1383-established targets:

- 40 percent reduction in total methane emissions[348] (including a separate 40 percent reduction in dairy and livestock emissions)
- 40 percent reduction in hydrofluorocarbon gas emissions
- 50 percent reduction in anthropogenic black carbon emissions
- 50 percent reduction of organic waste disposal from 2014 levels by 2020, and 75 percent by 2025, including recovery of at least 20 percent of edible food for human consumption

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). As directed by the Legislature under SB 1383, state agencies focused on voluntary, incentive-based mechanisms to reduce SLCP emissions in the early years of implementation to overcome technical and market barriers. Under this "carrot-then-stick" strategy, incentives are replaced with requirements as the solutions become increasingly feasible and cost-effective. To meet legislated targets, more aggressive action is needed.

Figure 4-11: Expected progress toward SB 1383 targeted emissions reductions by 2030 through strategies currently in place



While the state's overall GHG emissions have declined by 9 percent over the past decade, SLCP emissions reductions have not kept pace with broader progress toward

[347] CARB. 2017. Short-Lived Climate Pollutant Reduction Strategy. March. https://ww2.arb.ca.gov/sites/default/files/2020-07/final_SLCP_strategy.pdf.

[348] All SB 1383 emissions reductions are mandated to be realized by 2030 and are relative to 2013 levels.

decarbonization. After growing steadily in the preceding decade, methane emissions have remained relatively flat since 2013.

HFCs are the fastest growing source of GHG emissions, primarily driven by their use to replace ozone-depleting substances and an increased demand for cooling and refrigeration.[349] Since 2005, statewide HFC emissions have more than doubled. While the rate of increase has slowed in recent years due to the state's measures, HFC emissions are still on the rise in California, and have grown by over 50 percent since 2010.[350] Globally, as temperatures rise, adoption of cooling technologies (and refrigerants) is increasing rapidly. If no measures are taken, it is estimated that HFCs will account for 9 to 19 percent of the total global GHG emissions by 2050.[351]

Methane

Human sources of methane emissions are estimated to be responsible for up to 25 percent of current warming.[352] Fortunately, methane's short atmospheric lifetime of ~12 years[353] means that emissions reductions will rapidly reduce concentrations in the atmosphere, slowing the pace of temperature rise in this decade. Further, a substantial portion of the targeted reductions can be achieved at low cost and will provide significant human health benefits. For example, the UN's *Global Methane Assessment* (2021)[354] found that over half of the available targeted measures have mitigation costs below $21/MTCO$_2$e, and that each million metric tons of methane reduced would prevent 1,430 premature deaths annually due to ozone pollution caused by methane.

Following the Twenty Sixth Conference of Parties COP26 (the United Nations Convention on Climate Change in 2021), over 110 nations have signed onto the Global Methane

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[349] CARB. 2021. *California Greenhouse Gas Emissions for 2000 to 2019 - Trends of Emissions and Other Indicators.* https://ww3.arb.ca.gov/cc/inventory/pubs/reports/2000_2019/ghg_inventory_trends_00-19.pdf

[350] Ibid.

[351] Velders, G. J., D. W. Fahey, J. S. Daniel, M. McFarland, and S. O. Andersen. 2009. "The large contribution of projected HFC emissions to future climate forcing." *Proceedings of the National Academy of Sciences* 106(27), 10949–10954.

[352] IPCC. 2021. *Climate Change 2021:The Physical Science Basis.* Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press. https://www.ipcc.ch/report/ar6/wg1/.

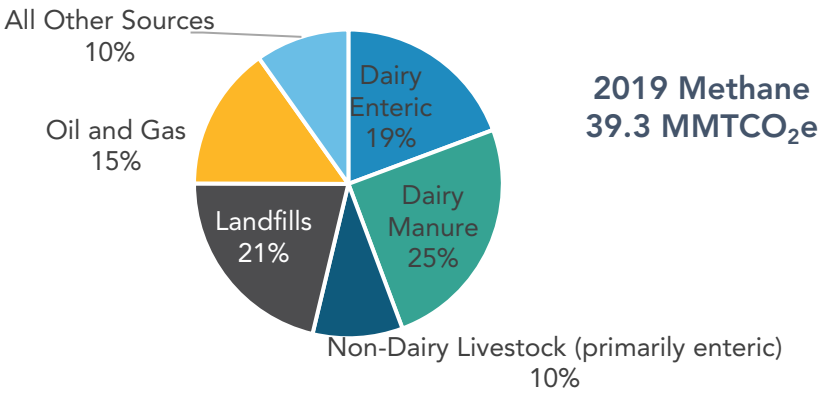
[353] In contrast, the lifetime of CO_2 is hundreds of years. The IPCC Third Assessment Report concluded that no single lifetime can be defined for CO_2 because of the different rates of uptake by different removal processes. According to IPCC Fourth Assessment Report, the majority of an increase in CO_2 will be removed from the atmosphere within decades to a few centuries, while the remaining 20 percent may stay in the atmosphere for many thousands of years.

[354] United Nations. 2021. Global Methane Assessment. https://wedocs.unep.org/bitstream/handle/20.500.11822/35917/GMA_ES.pdf.

Pledge (Pledge)[355] to limit methane emissions by 30 percent relative to 2020 levels. The Pledge covers countries which emit nearly half of all methane and make up 70 percent of global GDP. The UN's *Global Methane Assessment* shows that human-caused methane emissions can be reduced by up to 45 percent this decade, which would avoid nearly 0.3°C of global warming by 2045.

As shown in Figure 4-12, the three largest sources of California's methane emissions are the dairy and livestock industry, landfills, and oil and gas systems.

Figure 4-12: Sources of California methane emissions (2019)



Emissions from dairy and livestock operations come from two main sources—(1) enteric fermentation and (2) manure management operations, especially at dairies that employ open anaerobic lagoons that allow methane to escape into the atmosphere. Landfills, the second largest source of methane emissions, produce methane from the decomposition of organic waste. Although approximately 95 percent of all the waste that has been disposed of in the state has been deposited in a landfill that is equipped with a gas collection and control system, as required by California's Landfill Methane Regulation, a portion of the methane still escapes into the atmosphere. Fugitive methane emissions can be intermittent and highly variable, both seasonally and spatially, particularly at landfills. Research has shown that landfills are complex systems and a wide range of conditions (e.g., atmospheric, operational, biological, chemical, and physical) may contribute to variability in rates of organic waste degradation, methane generation, and capture efficiency. Non-combustion methane emissions from the oil and gas sector are

[355] Global Methane Pledge. *https://www.globalmethanepledge.org/* .

the third largest source of methane emissions in California. Almost three-quarters of the methane emissions from this sector come from leaks and venting affiliated with fossil gas transmission and distribution pipelines and equipment.

Hydrofluorocarbons

HFCs are synthetic GHGs that are powerful climate forcers. They are used mainly as refrigerants or heat transfer fluids in refrigeration, space conditioning, and heat pump equipment. Refrigerants are ubiquitous and are used everywhere from supermarkets, convenience stores, cold storage warehouses and wineries, to vending machines and residential and motor vehicle air-conditioners. Additionally, HFCs are also used as foam-blowing agents, solvents, aerosol-propellants, and fire suppressants. While HFCs remain in the atmosphere for a much shorter time than CO_2, the relative global warming potential (GWP) values of HFCs can be hundreds to thousands of times greater than CO_2. The mix of HFCs currently in use in California, weighted by usage (tonnage), have an average 100-year GWP of 1,700.[356] The average atmospheric lifetime of the mix of HFCs in use is 15 years.[357] Given the short average lifetimes, rapid reductions in HFC emissions can translate into near-term reductions in climate change effects.

As the global temperatures increase, the demand for cooling and refrigerants will continue to grow, as will the use of electric heat pumps to replace conventional fossil gas heating options. Unless addressed, continued use of high-GWP HFCs will perpetuate a feedback loop, where the cooling agents themselves cause additional warming.

In 2016, representatives from 197 nations signed the Kigali Amendment, which amended the existing Montreal Protocol (to reduce ozone-depleting substance production and consumption) to include a global phasedown in the production and consumption of HFCs beginning in 2019.[358] As of February 2022, 129 nations had either accepted, approved, or ratified the Kigali Amendment. In the United States, Congress enacted the federal

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[356] CARB. 2020. I*nitial Statement of Reasons: Public Hearing to Consider the Proposed Amendments to the Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Chillers, Aerosols-Propellants, and Foam End-Uses Regulation.* October 20. https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2020/hfc2020/isor.pdf?_ga=2.164659835.592460318.1646664679-912670513.1542398285.

[357] Zhongming, Z., et al. 2011. *HFCs: A Critical Link in Protecting Climate and the Ozone Layer: A UNEP Synthesis Report.*

[358] United Nations Treaty Collection. Chapter XXVII, Amendment to the Montreal Protocol on Substances that Deplete the Ozone Layer. https://treaties.un.org/Pages/ViewDetails.aspx?src=IND&mtdsg_no=XXVII-2-f&chapter=27&clang=_en.

American Innovation and Manufacturing (AIM) Act in December 2020.[359] The AIM Act authorizes the U.S. EPA to address HFCs in several ways, including a national HFC phasedown that nearly mirrors the schedule of the global phasedown under the Kigali amendment.[360]

Nearly 90 percent of HFC emissions in California come from their use as refrigerants in the commercial, industrial, residential, and transportation sectors. The timescales over which the HFC emissions occur vary, depending on the type of application. Thus, strategies to reduce HFC emissions must be tailored by equipment type. CARB has several measures in place to tackle HFC emissions from the various sources shown in Figure 4-13 below. This includes the Refrigerant Management Program[361] that tracks and manages emissions from large commercial, industrial, and cold storage refrigeration facilities in the state. CARB has adopted regulations to reduce HFC emissions from consumer product aerosol propellants, semiconductor manufacturing, and small cans of automotive refrigerant.[362] In 2018, California also HFC prohibitions via regulation and legislation for several sectors, including stationary refrigeration and foam end uses to backstop the partial vacatur of the federal Significant New Alternatives Policy (SNAP) program.[363] Most recently, in 2020, CARB adopted additional measures that place GWP limits on refrigerants used in refrigeration and air conditioning equipment, which are the largest sources of HFC emissions, and are commonly used in residential, commercial, and industrial buildings. Additionally, CARB adopted a unique pilot program requiring the use of reclaimed refrigerant: the Refrigerant Recovery, Reclaim, and Reuse, or R4 Program. The newly adopted HFC rules for the refrigeration and air conditioning sectors are the first of their kind in the nation. Once again, California is leading the way when it comes to groundbreaking strategies for tackling climate pollution.

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[359] 42 U.S.C § 7675, Pub. L. 116-260, § 103. https://www.epa.gov/sites/default/files/2021-03/documents/aim_act_section_103_of_h.r._133_consolidated_appropriations_act_2021.pdf.

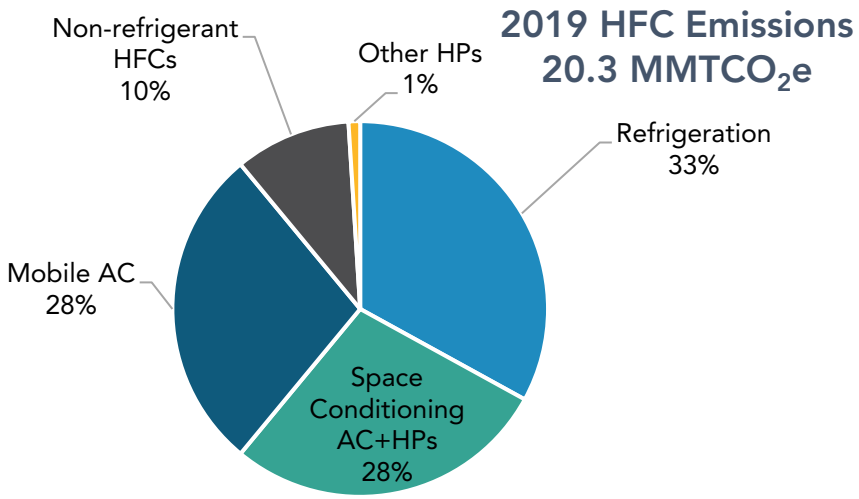
[360] Ibid.

[361] Cal. Code of Regs., tit. 17, §§ 95380, et seq.

[362] Contained in various sections, commencing with Cal. Code of Regs., tit. 13, §§ 1900 et seq.

[363] Cal. Code of Regs., tit. 17, §§ 95371, et seq.; California Cooling Act, Senate Bill 1013 (Lara, Stats. of 2018, Ch. 375, Health & Saf. Code § 39764).

Figure 4-13: Sources of hydrofluorocarbon (HFC) emissions (2019)

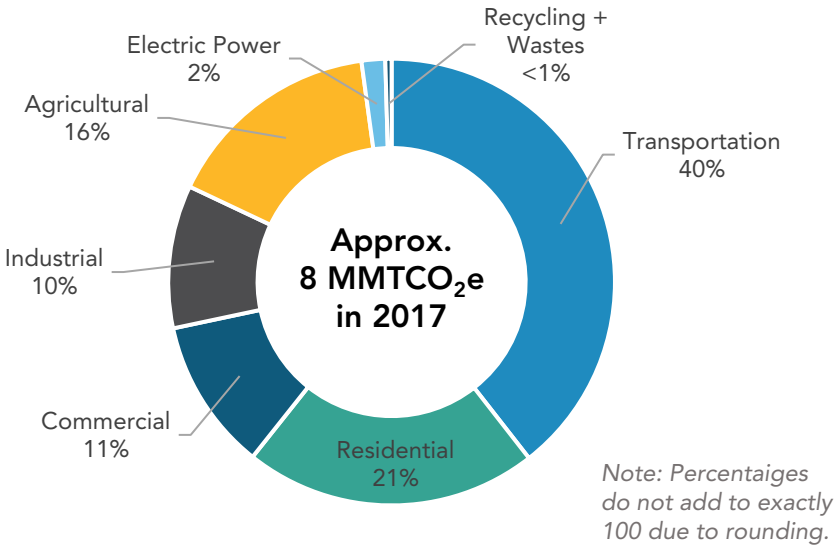


Anthropogenic Black Carbon

Black carbon (BC) is not included in AB 32 or the state's AB 32 GHG inventory that tracks progress toward the state's climate targets; however, it has been identified as a powerful climate forcer and is included California's Short-Lived Climate Pollutant Reduction Strategy. The majority of anthropogenic BC emissions come from transportation, specifically heavy-duty vehicles, and they have decreased since 2013 due to engine certification standards and in-use rules for on-road and off-road fleets, along with clean fuel requirements and incentives including California Climate Investments and LCFS credits. Additionally, fuel combustion for residential, commercial, and industrial applications contribute significantly to overall BC emissions. Approximately 95 percent of residential BC emissions are due to wood combustion; these emissions are being reduced through programs like the Woodsmoke Reduction Program established by SB 563 (Lara, Chapter 671, Statutes of 2017). Alternatives to agricultural burning and policies that phase out agricultural burning will also result in agricultural BC emissions reductions. In 2021 CARB provided a preliminary estimate of 2017 BC emissions (Figure 4-14).[364] This estimate will be finalized as part of a future update to the Short-Lived Climate Pollutant Inventory.

[364] CARB. 2021. 2022 Scoping Plan Update – Short-Lived Climate Pollutants Workshop Presentation, September 8. https://ww2.arb.ca.gov/sites/default/files/2021-09/carb_presentation_sp_slcp_september2021_1.pdf.

Figure 4-14: Sources of anthropogenic black carbon (preliminary 2017 estimates; AR5 100-yr GWP 900)



Sector Transformation

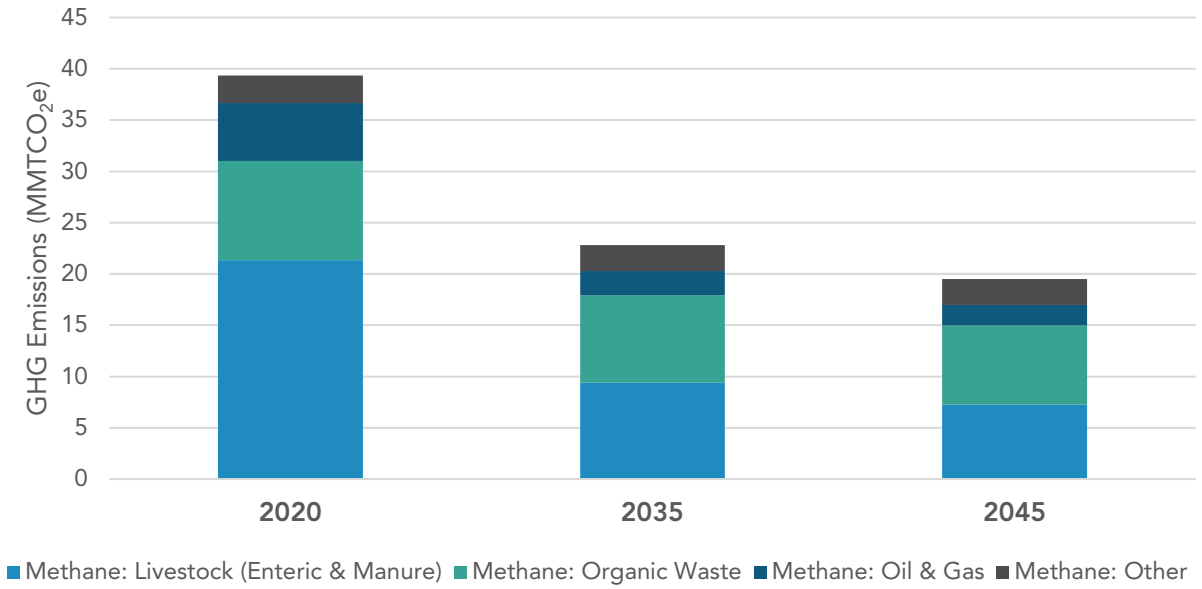
California has long recognized the importance of mitigating non-combustion SLCPs and took several early action measures as part of a comprehensive, ongoing program to reduce in-state GHG emissions under AB 32. The early action measures included CARB's Landfill Methane Regulation,[365] Refrigerant Management Program,[366] and Oil and Gas Methane Regulation.[367]

Methane

The methane abatement strategies currently in place are projected to reduce methane emissions by 20 percent relative to 2013 levels. Achieving the overall methane reduction target of SB 1383 (40 reduction by 2030) translates to a limit of less than 24 $MMTCO_2e$ in 2030 (Figure 4-15). It is anticipated that, since some sectors have fewer strategies that can be implemented to reduce methane in the near-term, other sectors will need to go beyond the 40 percent reduction to meet the target.

[365] Cal. Code of Regs., tit. 17, §§ 95460, et seq.
[366] Cal. Code of Regs., tit. 17, §§ 95380, et seq.
[367] Cal. Code of Regs., tit. 17, §§ 95665-77.

Figure 4-15: Methane emissions in 2020, 2035, and 2045 in the Proposed Scenario[368]



Dairy and Livestock Methane

California is the largest dairy-producing state, home to one in five U.S. dairy cows. To date, methane emissions reductions from the dairy and livestock sector have mainly been driven by a decreasing animal population and the growing adoption of manure management strategies, including anaerobic digesters and conversion to dry manure systems and pasture systems. CARB recently completed a detailed analysis of the emission reductions expected by 2030 and the estimated additional investment needed to reach the dairy and livestock sector methane reduction target. [369]

Assuming no adoption of additional manure management and enteric mitigations strategies beyond the projects that have committed funding, and a continued annual animal population decrease of 0.5 percent per year through 2030, further reductions of approximately 4.4 $MMTCO_2e$ will be needed to achieve the 2030 methane emissions reduction target for the sector set by SB 1383. If the remaining reductions are met through a mix of dairy projects in which half are dairy digesters and half are alternative manure

[368] The *Organic Waste* category includes methane from landfills, wastewater treatment, compost, and anaerobic digestion facilities.

[369] CARB. 2021. Analysis of Progress toward Achieving the 2030 Dairy and Livestock Sector Methane Emissions Target. June. https://ww2.arb.ca.gov/sites/default/files/2021-06/draft-2030-dairy-livestock-ch4-analysis.pdf.

management projects, then it is estimated that at least 420 additional projects will be necessary. Additional emissions reductions beyond this level will likely be necessary to ensure that the overall state methane emissions reduction targets are met.

Despite the considerable methane emissions mitigation potential of enteric strategies like feed additives, little progress has been made, as few products with proven mitigation potential have become commercially available, and unlike manure management strategies, there is a lack of financial incentives for their adoption.

Market conditions favoring farm consolidation and improved production efficiencies have driven reductions in the California and U.S. dairy population over the past decade. [370] These efficiency gains have allowed California to maintain production levels despite the decreasing population. If demand for dairy and beef products remains steady or increases, continued improvements in production efficiency and adoption of effective manure management and enteric mitigation strategies will be important to support dairy and livestock methane emission reductions.

Strategies for Achieving Success

- Install state of the art anaerobic digesters that maximize air and water quality protection, maximize biomethane capture, and direct biomethane to sectors that are hard to decarbonize or as a feedstock for energy.
- Increase alternative manure management projects, including but not limited to conversion to "solid," "dry," or "scrape" manure management; installation of a compost-bedded pack barn; an increase in the time animals spend on pasture; and implementation of solid-liquid separation technology into flush manure management systems.[371]
- Implement enteric fermentation strategies that are cost-effective, scientifically proven, safe for animal and human health, and acceptable to consumers, and do not impact animal productivity. Provide financial incentives for these strategies as needed.[372]

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[370] MacDonald, James M., Jonathan Law, and Roberto Mosheim. 2020. *Consolidation in U.S. Dairy Farming.* ERR-274. July. *https://www.ers.usda.gov/webdocs/publications/98901/err-274.pdf.*

[371] AB 32 EJ Advisory Committee, Draft Recommendations, M22. *ejacrecsrevised.pdf (ca.gov).* M22 recommends that CARB "prioritize (via innovation, investments, etc.) reductions of materials/process emissions versus energy source emissions, depending on which is the greatest contributor of emissions in any particular industry." While offered in the context of the manufacturing sector, the dairy and livestock sector—comprising animal husbandry operations with managed inputs and outputs for commodity production—provides a useful analogue. The actions listed above will reduce methane from the state's largest source of emissions.

[372] AB 32 EJ Advisory Committee, Draft Recommendations, M22. *ejacrecsrevised.pdf (ca.gov)*. (See footnote 335 for further explanation.)

- Accelerate demand for dairy and livestock product substitutes such as plant-based or cell-cultured dairy and livestock products to achieve reductions in animal populations.[373]

Landfill Methane

Achieving the 75 percent organic waste disposal reduction target[374] of SB 1383, and maintaining that level of disposal in subsequent years, would bring annual landfill emissions in 2030 to just below the 2013 baseline. Annual methane emissions will be higher through 2030 than originally anticipated by the strategy because the state did not achieve reductions in organic waste disposal of 50 percent below 2014 levels by 2020. SB 1383 prohibited the organic disposal regulations from taking effect until 2022,[375] and, as a result, emissions have continued to increase.

Due to the multidecadal time frame required to break down landfilled organic material, the emissions reductions from diverting organic material in one year are realized over the course of several decades. For example, one year of waste diversion in 2030 is expected to avoid 8 $MMTCO_2e$ of landfill emissions, cumulatively, over the lifetime of that waste's decomposition.[376] Near-term diversion efforts are critical to avoid locking in future landfill methane emissions.

CalRecycle's 2020 Analysis of Progress Toward the SB 1383 Waste Reduction Goals estimated that 8 million short tons of composting and anerobic digestion capacity will be needed to manage organic wastes, above the existing and new capacity expected to be available by 2025. The 2019 co-digestion capacity analysis from the State Water Resources Control Board estimated that at least 2.4 million tons of digester capacity is available at urban wastewater treatment plants if sufficient incentives or funding for collection, receiving, and processing operations are provided to enable utilization of this capacity. The CPUC approved a decision in February 2022 implementing the biomethane procurement program, which will require investor-owned utilities by 2025 to procure 17.6 billion cubic feet (BCF) of biomethane produced from organic wastes to support the landfill

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[373] AB 32 EJ Advisory Committee, Draft Recommendations, M22. *ejacrecsrevised.pdf (ca.gov)*. (See footnote 335 for further explanation.)

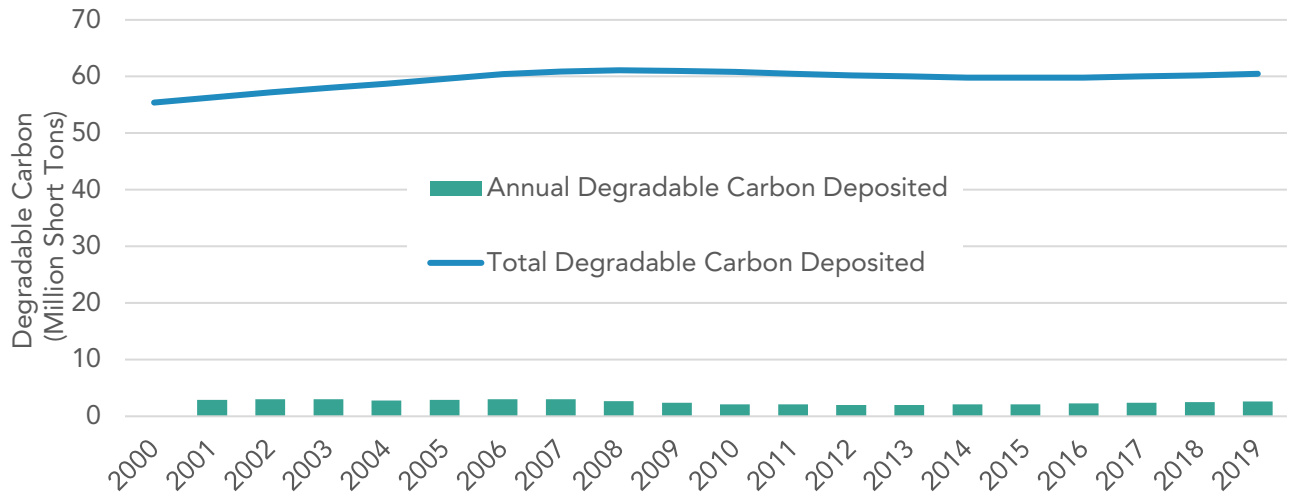
[374] The target is from 2014 levels by 2025.
Public Resources Code, § 42652.5. CalRecycle approved the *SLCP: Organic Waste Reductions* regulations in 2020 and began implementing them in January 2022. These regulations are designed to achieve the 2025 disposal reduction and edible food recovery targets

[376] The life cycle emissions reduction is based on anticipated diversion of 27 million short tons of organic waste from CalRecycle (2020) Analysis of the Progress Toward the SB 1383 Organic Waste Reduction Goals. Under CalRecycle's SLCP regulations, an alternative to landfill disposal must achieve a life cycle GHG reduction of 0.3 $MTCO_2e$ per short ton of waste diverted.

disposal reduction and SLCP target and reduce fossil gas reliance for residential and commercial customers.[377] Additionally, the organic waste stream includes more than one million tons of edible food that could be recovered before it enters the waste stream through food rescue programs that combat hunger in communities throughout California.

While reducing organic waste disposal is the most effective means of achieving reductions in waste sector methane, strategies to reduce emissions from waste already in place in landfills will also play a role in achieving near-term reductions. As Figure 4-16 shows, the total degradable carbon (a measure of the amount of waste with potential to generate methane) that is accumulated from waste deposited in previous years is over 20 times greater than the amount added each year. This illustrates that even if we were able to entirely phase out landfilling of organic waste today, the existing waste in place at landfills would continue to generate methane for decades into the future.

Figure 4-16: Degradable carbon deposited in landfills



Strategies for Achieving Success

- Maximize existing infrastructure and expand it to reduce landfill disposal, with strategies including composting, anaerobic digestion, co-digestion at wastewater treatment plants, and other non-combustion conversion technologies.
- Expand markets for products made from organic waste, including through recognition of the co-benefits of compost, biochar, and other products.[378]

[377] California Public Utilities Commission. 2022. Decision 22-02-025.

[378] AB 32 EJ Advisory Committee, Draft Recommendations, O9. ejacrecsrevised.pdf (ca.gov).

- Recover edible food to combat food insecurity.
- Invest in the infrastructure needed to support growth in organic recycling capacity.
- Utilize existing digesters at wastewater treatment facilities to rapidly expand food waste digestion capacity.
- Direct biomethane captured from landfills and organic waste digesters to sectors that are hard to decarbonize.
- Implement improved technologies and best management practices at composting and digestion operations.[379]
- Reduce emissions from landfills through improvements in operational practices, lower permeability covers, advanced collection systems, and technologies to utilize landfill gas.[380]
- Leverage advances in remote sensing capabilities to quickly pinpoint large methane sources and mitigate leaks, and improve understanding of the factors that lead to better capture efficiency, and explore new technologies and practices that can reliably improve methane control.[381]

Upstream Oil and Gas Methane Reduction

For oil and gas production, processing, and storage, California is currently on track to achieve a 41 percent reduction in methane emissions by 2025 relative to 2013. The additional reductions needed to meet the 2030 target may be achieved by implementing additional regulatory requirements to further reduce intentional venting of fossil gas from equipment. If necessary, additional reductions from transmission and distribution facilities may be achieved by requiring the utilities to increase inspection and repair activities or further reduce emissions from pipeline blowdowns by implementing methods such as using portable compressors, using plugs to isolate sections of pipelines, flaring vented gas, routing gas to fuel gas systems, and installing static seals on compressor rods. Advances in methane detection technologies (e.g., satellites equipped to detect large methane sources) may also help to quickly identify and mitigate methane emissions across the oil and gas sector.[382]

As California transitions away from fossil fuels, in-state oil and gas production will likely decline. This could result in an increase over time in the number of long-term idle and orphan wells in the state. While California has regulations aimed at helping ensure operators manage their idle wells, there could likely be an increase in California's orphan

[379] AB 32 EJ Advisory Committee, Draft Recommendations, M10 and O9. *ejacrecsrevised.pdf (ca.gov)*.
[380] AB 32 EJ Advisory Committee, Draft Recommendations, M10 and O9. *ejacrecsrevised.pdf (ca.gov)*.
[381] AB 32 EJ Advisory Committee, Draft Recommendations, O9. *ejacrecsrevised.pdf (ca.gov)*.
[382] AB 32 EJ Advisory Committee, Draft Recommendations, O9. *ejacrecsrevised.pdf (ca.gov)*.

well population. Plugging all orphan wells, of which there are currently over 5,000, could take decades due to the limited resources California has for orphan well plugging. The benefits from plugging wells include methane emission reductions and job creation; employment gains from well plugging and site remediation activities could help temporarily offset job losses from the oil and gas industry.[383] The California Council on Science and Technology's 2018 report on orphan wells, Orphan Wells in California: An Initial Assessment of the State's Potential Liabilities to Plug and Decommission Orphan Oil and Gas Wells, found that the potential cost to the state of plugging current orphan wells could be approximately $500 million, and the cost of plugging all active and idle wells could total over $9.1 billion. As oil and gas production in California declines due to reduced demand for fossil fuels, additional funding will likely be needed to cover the costs of plugging wells that have no viable operator.

Strategies for Achieving Success

- Mitigate emissions from leaks by regular leak detection and repair (LDAR) surveys at all facilities.[384]
- Replace high emitting equipment with zero emission alternatives wherever feasible.[385]
- Minimize emissions from equipment that must vent fossil gas by design (e.g., fossil gas powered compressors).
- Install vapor collection systems on high emitting equipment.
- Phase out venting and routine flaring of associated gas (gas produced as a by-product during oil production).
- Continuous ambient monitoring at fossil gas underground storage facilities to quickly detect large methane sources.
- Reduce pipeline and compressor blowdown emissions.
- Leverage advances in remote sensing capabilities to quickly pinpoint large methane sources and mitigate leaks.[386]

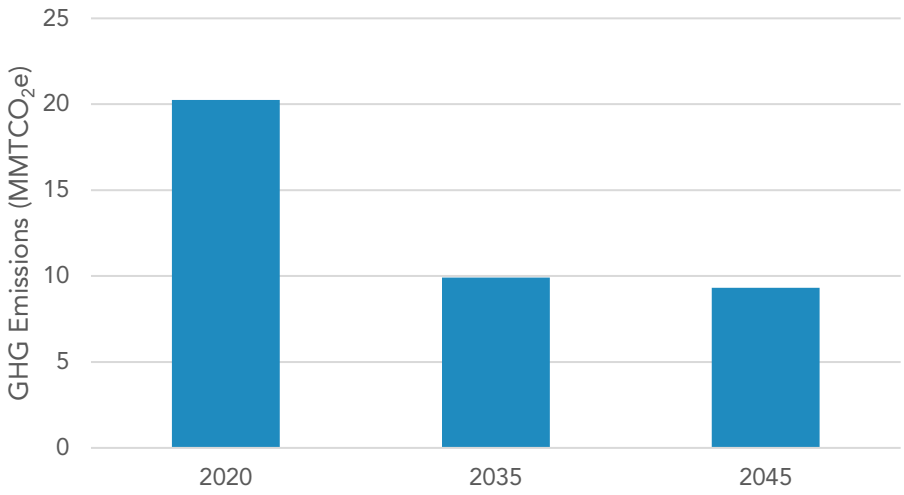
Hydrofluorocarbons

In California, all the HFC measures currently in place will help achieve more than 70 percent of the reductions needed to achieve the 2030 HFC goal and provide very significant emissions reductions by 2045 and beyond. However, new targeted measures will be needed to maintain the pace of reductions, as demand for technologies that

[383] AB 32 EJ Advisory Committee, Draft Recommendations, F3A and F3B. *ejacrecsrevised.pdf (ca.gov)*.
[384] AB 32 EJ Advisory Committee, Draft Recommendations, O9. *ejacrecsrevised.pdf (ca.gov)*.
[385] AB 32 EJ Advisory Committee, Draft Recommendations, P5. *ejacrecsrevised.pdf (ca.gov)*.
[386] AB 32 EJ Advisory Committee, Draft Recommendations, O9. *ejacrecsrevised.pdf (ca.gov)*.

currently predominantly use high-GWP refrigerants is anticipated to grow. Despite decarbonization efforts, high-GWP HFCs are expected to be among the last remaining persistent GHG emission sources, as shown in Figure 4-17.[387]

Figure 4-17: Hydrofluorocarbon emissions in 2020, 2035, and 2045 in the Proposed Scenario



HFC emissions from new and existing sources should be addressed in tandem with building decarbonization efforts to maximize reductions.[388] As buildings are electrified in an effort to decarbonize them, the use of heat pumps for space conditioning, water heaters, and clothes dryers is expected to increase significantly. Heat pumps, while using electricity, not fossil gas, currently rely predominantly on high-GWP refrigerants. Very low- or no-GWP technologies and solutions are either available or emerging for various heat pump technologies, and likely to develop further as international efforts to mitigate HFCs continue. However, most of these technologies are still nascent in the U.S. In addition, some of the alternatives cannot be used until California building codes are updated, which is currently expected at the earliest in 2025 for some technologies, and in the following years for others. The current updates to the building codes will allow the use of many refrigerants with lower GWPs than HFCs currently in use. However, additional building code updates may be needed to expand the choices of ultra-low-GWP alternatives. The adoption of low-GWP refrigerants must occur in parallel with building decarbonization

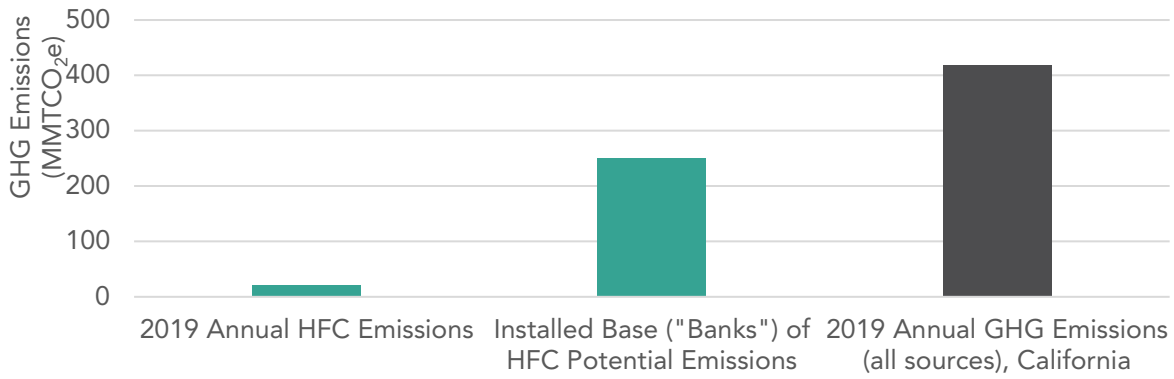
[387] Energy and Environmental Economics, Inc. 2020. *Achieving Carbon Neutrality in California. PATHWAYS Scenarios Developed for the California Air Resources Board*. October. https://ww2.arb.ca.gov/sites/default/files/2020-10/e3_cn_final_report_oct2020_0.pdf.

[388] AB 32 EJ Advisory Committee, Draft Recommendations, NF35. ejacrecsrevised.pdf (ca.gov).

efforts; without such efforts, the vast GHG benefits of the latter will be partially offset, and the proportion of HFC emissions from buildings will continue to grow.

Leaks from existing air conditioning and refrigeration equipment are a major source of statewide and global HFC emissions. Once installed, refrigeration and air conditioning equipment can stay in place for decades, while leaking refrigerants into the atmosphere. This makes it very important that new installed equipment use refrigerants with a GWP as low as possible. The refrigerants inside existing equipment are sometimes collectively referred to as the *installed base* or *banks* of potential HFC emissions. If released spontaneously, the existing HFC banks would equal 60 percent of all annual statewide GHG emissions in California, as illustrated in Figure 4-18.[389]

Figure 4-18: Potential emissions from refrigerants in existing equipment



Strategies for Achieving Success

- Expand the use of very low- or no-GWP technologies in all HFC end-use sectors, including emerging sectors like non-space conditioning heat pumps to maximize the benefits of building decarbonization.[390]
- Convert large HFC emitters such as existing refrigeration systems to the lowest practical GWP technologies.[391]

[389] CARB. 2021. 2022 Scoping Plan Update – Short-Lived Climate Pollutants Workshop Presentation. September 8. https://ww2.arb.ca.gov/sites/default/files/2021-09/carb_presentation_sp_slcp_september2021_1.pdf.
[390] AB 32 EJ Advisory Committee, Draft Recommendations, NF35, M3 and M8. ejacrecsrevised.pdf (ca.gov).
[391] AB 32 EJ Advisory Committee, Draft Recommendations, NF31, M3 and M8. ejacrecsrevised.pdf (ca.gov).

- Prioritize small-scale and independent grocers serving priority populations in addressing existing "banks" of high-GWP refrigerants.[392]
- Improve recovery, reclamation, and reuse of refrigerants by limiting sales of new or virgin high-GWP refrigerants and requiring the use of reclaimed refrigerants where appropriate.[393]
- Assist low-income and disadvantaged communities in obtaining low-GWP space conditioning units to protect vulnerable communities from heat stress and wildfire smoke.[394]
- Accelerate technology transitions in California and the U.S. overall by collaborating with international partners committed to taking action on HFCs under the Kigali Amendment to the Montreal Protocol; this includes addressing barriers to adoption of very low- or no-GWP refrigerant technologies such as high upfront costs, shortage of trained technicians, and lag in updating safety standards and building codes.

Anthropogenic Black Carbon

Significant progress has been made since 2013 to reduce anthropogenic black carbon emissions, primarily from decreased combustion of distillate fuels in the agricultural sector, as well as improvements to provide cleaner, on-road combustion technologies. Under current strategies, anthropogenic black carbon from transportation is expected to be reduced by over 60 percent in 2030. Continued reductions in combustion emissions across all sectors from both the state's climate and air quality programs will also help reduce anthropogenic black carbon emissions going forward.

Strategies for Achieving Success

- Reduce fuel combustion commensurate with state's climate and air quality programs, particularly from reductions in transportation emissions and agricultural equipment emissions.[395]
- Invest in residential woodsmoke reduction.

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[392] AB 32 EJ Advisory Committee, Draft Recommendations, O29 and O30. *ejacrecsrevised.pdf (ca.gov)*.

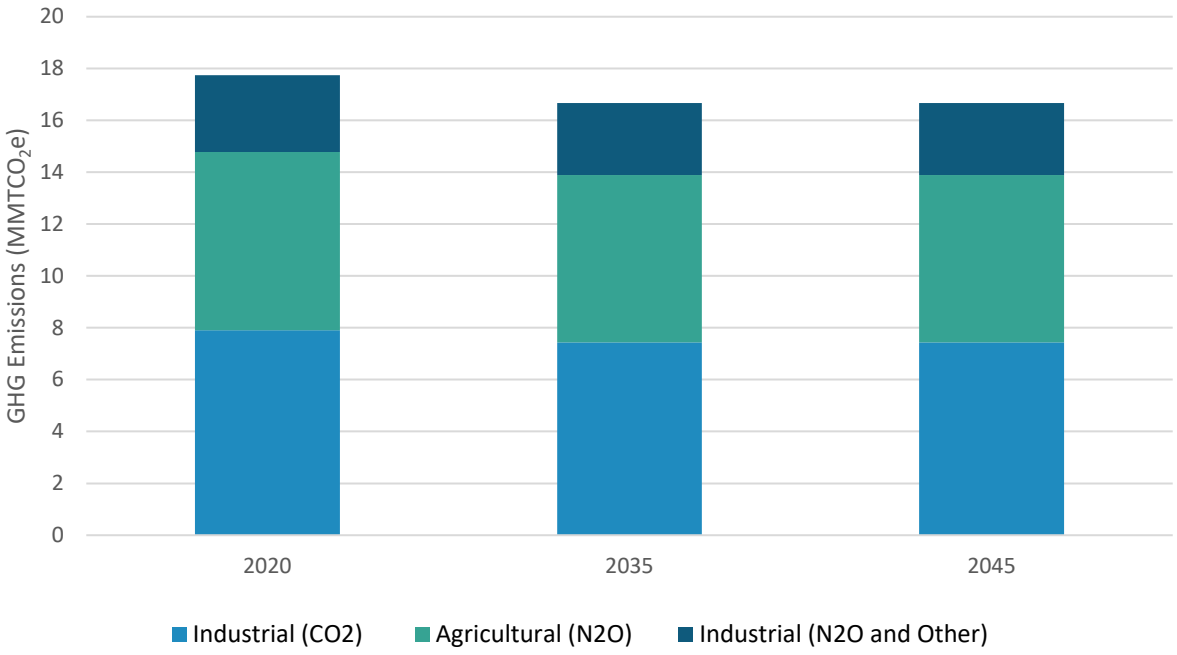
[393] AB 32 EJ Advisory Committee, Draft Recommendations, O6. *ejacrecsrevised.pdf (ca.gov)*.

[394] AB 32 EJ Advisory Committee, Draft Recommendations, NF37, O29, and O30. *ejacrecsrevised.pdf (ca.gov)*.

[395] AB 32 EJ Advisory Committee, Draft Recommendations, F1A and Appendix A (Public Process). "Emissions reductions from energy consumed by California's agricultural sector, including post-harvest processing, use of tractors and other farm equipment, and water import and irrigation."

In addition to SLCP emissions, there are remaining non-combustion emissions that are anticipated to persist in the coming decades, as shown in Figure 4-19. These include CO_2 from industrial processes such as cement manufacturing, oil and gas extraction, and geothermal electric power; N_2O from wastewater treatment, fertilizers, and livestock manure; and other industrial, non-HFC GHG emissions.

Figure 4-19: Remaining non-combustion emissions in 2020, 2035, and 2045 in the Proposed Scenario



Natural and Working Lands

California's natural and working lands cover approximately 90 percent of the state's 105 million acres,[396] and include nature's living systems—forests, grasslands, shrublands, croplands, wetlands, deserts, and the green spaces in urban and built environments. These lands include California Native American tribes' ancestral and cultural lands, parks and green spaces in our cities and communities, and the waters and the iconic landscapes we know and love. California's lands are diverse and provide a multitude of benefits to the people of California, including clean water, clean air,

[396] California Natural Resources Agency. 2022. Natural and Working Lands Climate Smart Strategy. *https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Expanding-Nature-Based-Solutions/CNRA-Report-2022---Final_Accessible_Compressed.pdf*.

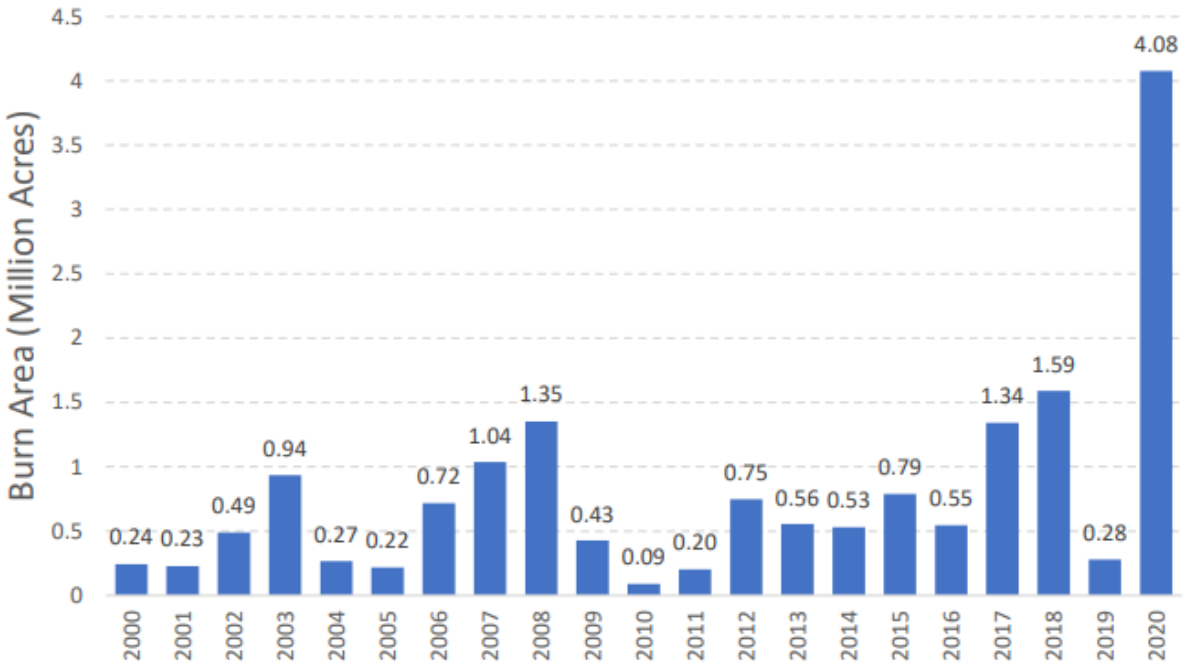
biodiversity, food, recreational opportunities, continuation of traditional tribal ways of life, mental health benefits, and many other benefits.

Our lands are a critical sector in California's fight to achieve carbon neutrality and build resilience to the impacts of climate change. Healthy land can sequester and store atmospheric CO_2 in forests, soils, and wetlands. Healthy lands also can reduce emissions of powerful SLCPs, limit the release of future GHG emissions, protect people and nature from the impacts of climate change, and build our resilience to future climate risks. Unhealthy lands have the opposite effect—they release more GHGs than they store and are more vulnerable to future climate change impacts.

Climate change impacts have become more apparent in recent years and are having significant effects on communities throughout the state. One of these impacts is the much more frequent occurrence of unusually large, high-severity wildfires, which are being driven by climate change and a recent history of fire-exclusion and land management practices that have resulted in forests with high levels of biomass. These recent large and high-severity wildfires have resulted in a significant amount of burned acres and emissions in California (Figure 4-20).[397]

[397] CARB. 2021. Wildfire Emission Estimates for 2020. July. *https://ww2.arb.ca.gov/sites/default/files/2021-07/Wildfire%20Emission%20Estimates%20for%202020%20_Final.pdf*.

Figure 4-20: Acreage of burned wildland vegetation area



These wildfires deviate from the frequent, low-severity fires that previously occurred at natural intervals, around which our forests evolved. As climate change accelerates, these large, uncharacteristic wildfires are likely to become more common and impact a larger and larger portion of our landscapes. Climate change is also expected to have other significant effects on our lands, including more extreme droughts, floods, extreme heat, and the spread of invasive aquatic and terrestrial species, pests, diseases, and parasites. These impacts can lead to negative feedback loops on human and ecological health; for example, increasing spread of invasive species can lead to increases in pesticide use, if not managed through regulation or mitigation, which can pose risks to human health and the environment.

To address these interconnected risks of extreme fire and invasive expansion due to climate stress requires more ecological and holistic approaches to carbon, water, plant and animal species management at the landscape level, and so California's approach to climate action in the natural and working lands sector is not solely focused on maximizing carbon stocks but instead on supporting carbon management that fosters ecosystem health, resilience, provision of overall climate function and other co-benefits.

Natural systems operate on a longer timescale than the energy and industrial sectors, and benefits from climate action on our lands can take decades to accrue, so California recognizes that climate action may lead to less total carbon on the landscape than we currently have in order to ensure ecosystem benefits in the long run. Scaling climate smart land management in California requires taking action now and playing the "long game" by establishing and maintaining consistent, patient approaches and programs. Plants, soils,

and trees operate on decadal time scales, and to achieve climate benefits over time we must act today.

Landscapes

For the first time, the Draft Scoping Plan includes modeling for the natural and working lands sector. The focus of the initial modeling is limited to seven land types, that align with the those in the NWL Climate Smart Strategy,[398] and work will continue to incorporate more landscapes and management practices into the modeling over time. The initial landscapes included in the modeling for the Draft 2022 Scoping Plan are:

- Forests
- Shrublands and Chapparal
- Grasslands
- Croplands
- Wetlands
- Developed Lands
- Sparsely Vegetated Lands

Each of these land types are a key component to the state's approach to increasing climate action in the natural and working lands sector, as called for in Executive Order N-82-20. This EO also directed CARB to update the target for this sector in support of carbon neutrality as part of the 2022 Scoping Plan, and to take into consideration the NWL Climate Smart Strategy. Additionally, in 2021, the Governor signed SB 27[399] (Skinner, Chapter 237, Statutes of 2021) into law. It directed CARB to establish CO_2 removal targets for 2030 and beyond and take into consideration the NWL Climate Smart Strategy. The Governor's Executive Order and SB 27 add to the previous direction from the Legislature and past administrations emphasizing the importance of quantifying land-

[398] California Natural Resources Agency. 2022. *Natural and Working Lands Climate Smart Strategy. Appendix B. https://resources.ca.gov/-/media/CNRA-Website/Files/Initiatives/Expanding-Nature-Based-Solutions/Appendix-B_04132022_ada.pdf*

[399] SB-27 Carbon sequestration: state goals: natural and working lands: registry of projects. *https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB27*.

based carbon both statewide[400], and in programs and policies,[401] setting targets[402] for natural and working lands to support the state's climate objectives, and advancing land management actions[403] that support the health and resiliency of these lands.

An eighth landscape—Blue Carbon (carbon captured and held in coastal vegetation, such as seagrasses)—is also important to consider as we look at long-term climate goals. However, this landscape is not currently covered by IPCC inventory guidelines or included in California's NWL Inventory. California's Ocean Protection Council and San Francisco Estuary Institute are partnering to create a new coastal wetlands, beaches, and watersheds inventory, which will provide additional information. CARB staff will utilize information from this effort and assess other available data to evaluate how this landscape may be integrated into our efforts in the future as more data become available.[404]

Trends of Carbon on Landscapes

CARB currently tracks the carbon stock changes though the Inventory of Ecosystem Carbon in California's Lands[405] (NWL Inventory), which is summarized in Chapter 1. The NWL Inventory is a key tool for tracking changes in carbon stocks across the state, and it will serve as the inventory of record for this sector, tracking sector-wide progress toward the target. The NWL Inventory provides a retrospective snapshot of the status of California's lands, and captures the gains or losses of carbon stocks that occur over time. In addition to tracking carbon stock changes, the NWL Inventory is an important tool for understanding the impacts of our efforts to increase climate action in this sector (such as those identified in this Scoping Plan and the NWL Climate Smart Strategy) on NWL carbon stocks. The Inventory is also used as the foundation for Scoping Plan scenario modeling and target setting.

CARB's inventory shows that these lands were a source of GHG emissions from 2001 to 2011, releasing more carbon than they were storing, and then returned to a slight carbon

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[400] SB 859 Public resources: greenhouse gas emissions and biomass (SB 859, Committee on Budget and Fiscal Review, Chapter 368, Statutes of 2016). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB859.

[401] SB 1386. Resource conservation: working and natural lands. (SB 1386, Chapter 545, Statutes of 2016). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB1386.

[402] CARB. 2017. 2017 Climate Change Scoping Plan Update. Board Resolution 17-46. https://ww2.arb.ca.gov/sites/default/files/barcu/board/res/2017/res17-46.pdf.

[403] Executive Department. State of California. EO B-52-18.

[404] AB 32 EJ Advisory Committee, Draft Recommendations, ejacrecsrevised.pdf (ca.gov), N2.

[405] CARB. *An Inventory of Ecosystem Carbon in California's Natural & Working Lands.* 2018 Edition. nwl_inventory.pdf (ca.gov) Accessed 3/2/2022.

sink from 2012–2014.[406] These trends highlight the interannual and interdecadal variability of lands and their ability to be both a source and a sink of carbon, and the importance of looking at NWL data and trends over multiyear and multidecadal time periods, as opposed to looking only at annual changes. This movement is part of the Earth's carbon cycle, where carbon transfers between the land, ocean, and atmosphere. As part of the carbon cycle, over decades or centuries, fire and plant respiration and decomposition move carbon from the land to the atmosphere while plant growth and other processes move carbon from the atmosphere to the land. Emissions from fossil-fuel combustion are contributing to putting this cycle out of balance. Additionally, some historic land management practices which have resulted in the loss of carbon from the soil are also contributing to the atmospheric rise of CO_2 while simultaneously exacerbating the imbalance of the water cycle, which is influenced by and linked to the carbon cycle. These emissions are also contributing to a feedback loop for California's lands: as CO_2 emissions accumulate in the atmosphere—and California experiences more warming, extreme heat events, and droughts—the risk and intensity of carbon losses also increases, which in turn transfers more carbon from the land to the atmosphere. And because forests and shrublands comprise approximately 85 percent of the carbon stocks in California, management strategies and disturbances in forest and shrubland carbon play an important role in determining whether California's lands are providing either net carbon sequestration or net emissions on an annual basis.

And while we expect the gains and losses of carbon on our lands will fluctuate in the future, what is important is to restore carbon in places where it has been lost and reduce carbon losses and other GHG emissions from our natural and working lands.

Goals and Accelerating Nature-Based Solutions

The state's climate mitigation targets are traditionally identified in individual years, (i.e., mass of GHG emissions in 2020 or 2030), but because NWL fluctuate year to year and NWL carbon sometimes takes decades to accrue, it is important to consider the long-term trends for carbon stocks, emissions, and sequestration when identifying how this sector can contribute to California's pathway to achieving carbon neutrality. Additionally, California's NWL Inventory tracks carbon stocks from the NWL carbon pools in the state, so it is important to identify an NWL target that can be tracked by the NWL Inventory.

As outlined in Chapter 2, California is projected to lose carbon stocks over the coming decades, but the 2022 Scoping Plan update analysis also shows that increasing the pace and scale of climate smart land management in California will reduce the carbon stock

[406] These trends are consistent estimates in the most recent AB 1504 reporting period.

losses and GHG emissions from the NWL sector. In response to EO N-82-20, the proposed targets for NWL are shown in Table 4-1.

Table 4-1: 2022 Scoping plan modeled target for NWL, based on increasing action on NWL

	Total Carbon Stock % Change from 2014
2035	-2
2045	-4

These targets are based on expanding the pace and scale of NWL actions, including the following:

- Increasing forest, shrubland, and grassland management to at least 2.3 million acres a year.
- Increasing climate smart agricultural practices to at least 50,000 acres a year, annually conserving at least 6,000 acres a year of croplands, and increasing organic agriculture to comprise at least 20 percent of cultivated acres in California by 2045.
- Increasing annual investment in urban trees in developed lands by at least 20 percent above historic levels and establishing defensible space on all parcels.
- Restoring at least 60,000 acres, or approximately 15 percent of all Sacramento–San Joaquin River Delta (Delta) wetlands, by 2045.
- Cutting land conversion of deserts and sparsely vegetated landscapes by at least 50 percent annually from current levels.

The actions above represent a significant increase in climate-smart management for NWL from current rates. For forests, shrublands, and grasslands achieving at least 2.3 million acres annually by 2025 would mean an approximate 10x increase in management from current levels. For croplands, increasing climate-smart management to at least 58,000 acres annually would represent an approximate 5x increase in healthy soils practices from current levels and a 2x increase in total acres of organic agriculture by 2045.

If the carbon stock targets above are met, and the management actions above are implemented, the modeling for NWL indicates that California's lands will produce approximately 8 $MMTCO_2e$ of average annual emissions. Additional climate smart management practices and additional landscapes, such as those included in the Climate Smart Strategy, have the potential to increase carbon stocks and reduce GHG emissions from NWL beyond the levels identified in this Scoping Plan.

The purpose of the NWL target and the above outcomes is to provide a numerical guide that can support the state's efforts to accelerate both near-term and long-term climate action on California's lands, prioritizing durable solutions that deliver multiple outcomes. Taking these actions over the coming decades will reduce the potential carbon losses from NWL, reduce GHG emissions from some landscape types (such as croplands and Delta wetlands), and support sequestration of GHGs from NWL between 2025 and 2045. These actions will also deliver significant benefits to Californians beyond advancing our climate goals, such as reducing wildfire emissions and their associated health impacts, increasing habitat for biodiversity, reducing urban heat island effects, reducing harmful pesticide exposure, expanding economic opportunities, and others. Additional information on several economic and health outcomes from the Proposed Scenario is included in Chapters 2 and 3.

Strategies for Achieving Success: Crosscutting Items for all NWL

- Accelerate the pace and scale of climate smart action, consistent with the management levels identified above, as part of a collective effort between federal, state, private, philanthropic, and individual land managers.
- Prioritize and practice equity, including through meaningful community engagement and prioritizing implementation of nature-based solutions that benefit the communities most vulnerable to climate change.
- Advance multi-benefit, collaborative, landscape-level approaches that engage communities and landowners, and incorporate adaptive managements.
- Partner with California Native American tribes to increase co-management and tribal management authority; restore and enhance natural cultural resources, traditional foods, and cultural landscapes; and support tribes' implementing tribal expertise and Traditional Ecological Knowledges and cultural easements.[407]
- Leverage existing and explore new innovative financial and market mechanisms between the public, private, and philanthropic sectors to secure funding of climate smart land management.
- In partnership with communities and the private sector, expand and develop new infrastructure for manufacturing and processing of climate smart agricultural and biomass products.
- Leverage and support technical assistance providers: such as UC Cooperative Extension and California's 98 Resource Conservation Districts, which have track records of providing technical assistance to local landowners and implementing

[407] AB 32 EJ Advisory Committee, Draft Recommendations, N1, N6. ejacrecsrevised.pdf (ca.gov).

agriculture, forestry, natural resource management, and restoration projects across the state.

- Establish and expand mechanisms that ensure NWL are protected from land conversion and parcelization (e.g., conservation easements or Williamson Act).[408] Pair land conservation projects with management plans that increase carbon sequestration, where feasible.
- Increase opportunities for private and philanthropic investments in nature-based climate solutions, utilizing existing voluntary and compliance carbon markets, existing state and local programs, and the California Carbon Sequestration and Climate Resiliency Project Registry established pursuant to SB 27.
- Expand monitoring and tracking of management actions and outcomes consistent with the tracking and monitoring recommendations of the Climate Smart Strategy.

Forests, Shrublands, and Chaparral

At roughly 29 million acres, forests cover 27 percent of California and are primarily found in the northern portion of the state. Shrublands and chaparral cover 31 percent of the state, roughly 33 million acres, and are primarily located in the southern portion of the state, though there is considerable intermixing between the landscape types across all of California. Both types are distinct, with their own ecological dynamics and management strategies, and are modeled within a single model that is calibrated to treat them uniquely.

Together, forests, shrublands, and chaparral support a high biodiversity of plants and animals in addition to high levels of carbon stocks. They provide important air and water quality benefits to all Californians, as well as recreational opportunities and, for forests, harvested wood products for the state. These landscapes are fire-adapted, and historical tribal management of these lands fostered ecosystem health and resilience. Over the past century, these lands have been severely impacted by fire exclusion, including exclusion of indigenous people's management and past management practices, which has resulted in less resilient ecosystems and communities and more destructive wildfires today. This, along with drought induced stress and mortality, has changed these landscapes from a carbon sink to a carbon source. Climate smart management can help make forests more resilient to climate change and less prone to catastrophic wildfire. Climate-smart management in shrublands and chaparral face additional challenges and uncertainty, but can still provide protection for threatened communities and natural resources. This management, if conducted on a regular basis to maintain forest health, can help reduce

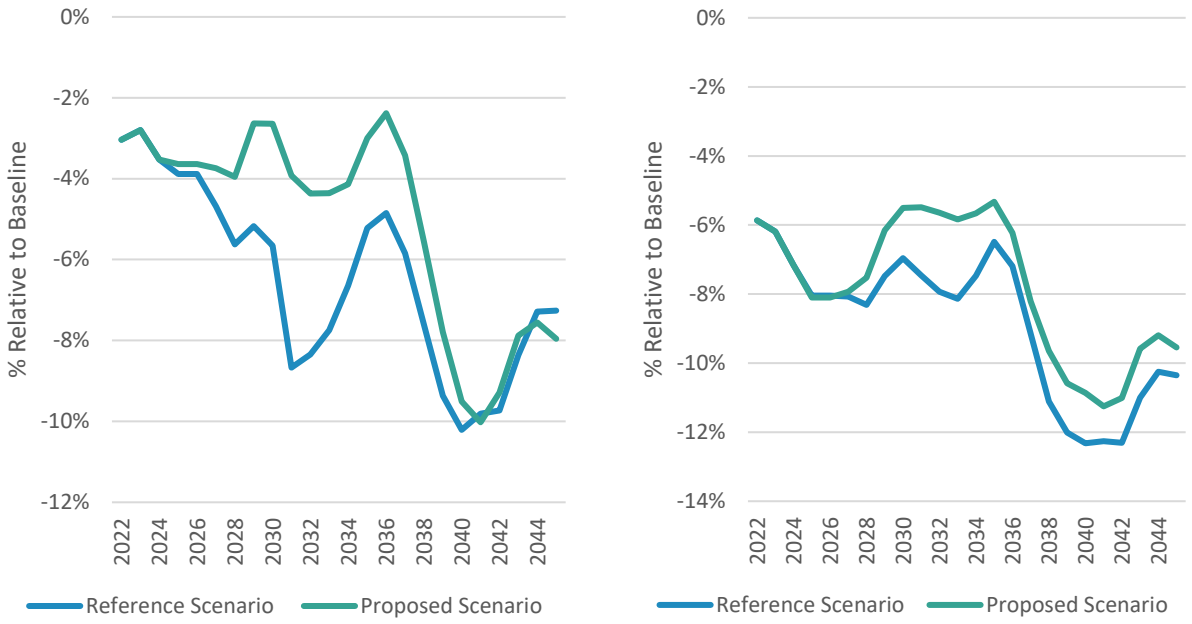
[408] AB 32 EJ Advisory Committee, Draft Recommendations, N5. *ejacrecsrevised.pdf (ca.gov)*.

emissions from forests, shrublands, and chaparral, and help strengthen and maintain the co-benefits that Californians experience from them.

For forests, shrublands, and chapparal there are also a number of additional strategies identified in the Climate Smart Land Strategy—such as active reforestation efforts in areas recovering from severe wildfires, restoration of mountain meadows and riparian forest ecosystems, and promotion of infill development to avoid conversion of natural and working lands. These strategies, when deployed, can provide additional carbon and other environmental benefits from NWL beyond what is provided in the Scoping Plan modeling results.

Under all management levels, forests and shrublands are expected to lose carbon over the next two decades due to climate change and wildfire (Figure 4-21).

Figure 4-21: Forest (left) and shrubland (right) carbon stocks by 2045[409]



While this decrease in carbon stocks may be inevitable, forest management under the Proposed Scenario can help direct where and how carbon loss occurs. By proactively managing forests and shrublands, the loss of carbon from wildfire can be lessened as the risk of high severity fire is decreased, with the removed biomass going toward a more useful purpose such as harvested wood products, bioenergy, or engineered carbon removal. Managing for a diverse and resilient forest landscape also can help forests

[409] AB 32 EJ Advisory Committee, Draft Recommendations, N13. ejacrecsrevised.pdf (ca.gov).

recover more quickly so that when climate change and wildfire impacts occur, forests will be less impacted and can continue to thrive and sequester carbon.

Strategies for Achieving Success

- Accelerate the pace and scale of climate smart forest management to at least 2.3 million acres annually by 2025, in line with the climate smart management strategies identified in the Draft 2022 Scoping Plan, as well as the additional strategies identified in the Climate Smart Strategy and the Wildfire and Forest Resilience Action Plan.[410]
- Establish and expand mechanisms that ensure forests, shrublands, and grasslands are protected from land conversion and that support ongoing, rather than one-time, management actions.
- In collaboration with state and local agencies, accelerate the deployment of long-term carbon storage from waste woody biomass residues resulting from climate smart management, including storage in durable wood products, underground reservoirs, soil amendments, and other mediums.
- Expand infrastructure to facilitate processing of biomass resulting from climate smart management.
- Expand permit streamlining in collaboration with state and local agencies to accelerate implementation of climate smart forest management while protecting natural resources.

Grasslands

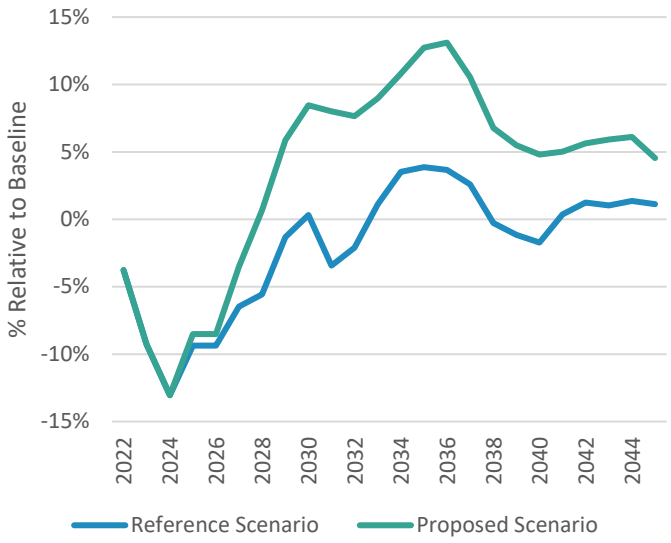
Grasslands cover 9 percent of California, roughly 10 million acres, and are found throughout the state in various landscapes, with concentrations in the foothills surrounding the Sacramento and San Joaquin Valleys. In addition to carbon storage (primarily in the soil), grasslands provide open space, wild habitat, grazing land, and important water filtration and recharge benefits. The protection of grasslands provides an opportunity to reduce sprawl and support complementary VMT reduction strategies. As grasslands are susceptible to invasive species, climate smart strategies can increase grassland resilience to climate change by improving species diversity and maintaining or increasing soil carbon stocks.

Modeling results show that increased fuels treatments and avoided land conversion can increase carbon stocks by 2045, but sequestration rates fluctuate annually. Grasslands

[410] Forest Management Task Force. 2021. California's Wildfire and Forest Resilience Action Plan: Recommendations of the Governor's Forest Management Task Force. https://www.fire.ca.gov/media/ps4p2vck/californiawildfireandforestresilienceactionplan.pdf.

are capable of high carbon sequestration rates but are susceptible to carbon losses from wildfire and land conversion. Soil carbon is the major carbon pool on these lands, and continued future improvement of the monitoring and modeling of soil carbon is needed. Similar to forests and shrubland/chaparral, modeling alternatives that include fuels treatments resulted in greater carbon stocks compared to no management, and had lower wildfire emissions. Unlike forests and shrubland/chaparral, which have a general declining carbon stocks trend, the modeling results (Figure 4-22) show grasslands can maintain or increase carbon stocks with active management of grasslands.

Figure 4-22: Grassland carbon stocks by 2045



Strategies for Achieving Success

- Establish and expand mechanisms that ensure grasslands are protected from land conversion/parcelization and that support ongoing, rather than one-time, management actions that improve carbon sequestration.
- Deploy grassland management strategies, like prescribed grazing, compost application, and other regenerative practices, to support soil carbon sequestration, biodiversity, and other ecological improvements.
- Increase adoption of compost production on farms and application of compost in appropriate grassland settings for improved vegetation and carbon storage, and to deliver waste diversion goals through nature-based solutions.

Croplands

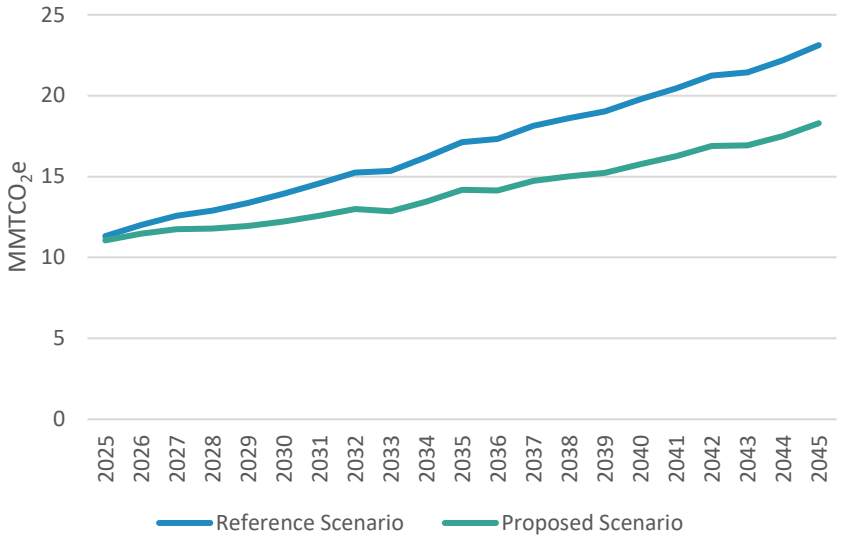
Croplands cover 9 percent of the state, roughly 9.5 million acres, concentrated in the Sacramento and San Joaquin Valleys, with significant additional acreage in the Imperial and Salinas valleys and Ventura region. This land is some of the most productive

agricultural land in the world, and enables California to be a global leader in agriculture. Aside from developed lands, croplands are the most intensively managed landscapes in the state, and are closely tied to society through the food they produce and the constant, direct contact that people have with croplands through the course of management. In addition to food security, croplands provide considerable carbon storage in the soil and, in perennial croplands, in aboveground biomass. Climate smart practices can improve public health; for example, by reducing synthetic fertilizer and pesticide use while helping to maintain or increase the climate resilience of cropland productivity through improved soil conditions and increased pollinator habitat.

There is also significant potential to transform this sector to increase soil carbon storage, reduce GHG emissions (Figure 4-23), and reduce pesticide exposure and health impacts. Moving to an agricultural system that improves soil health and water holding capacity reduces over-application of nitrogen, reduces the use of pesticides and fumigants, and increases biodiversity and pollinator habitat, supporting California's pathway to carbon neutrality while simultaneously improving the lives of those who live and work in the agricultural community. Croplands are intricately tied to people, communities, and their health, and through climate smart practices and cropland conservation, these lands have the potential to contribute more to society than just food. The implementation of climate smart agricultural practices can help California achieve social and environmental benefits, like improving water use efficiency, increasing pollinator habitat, and reducing synthetic fertilizer and pesticide use.[411]

[411] AB 32 EJ Advisory Committee, Draft Recommendations, N3, N4, N5. *ejacrecsrevised.pdf (ca.gov)*.

Figure 4-23: Cumulative CO_2e emissions from annual croplands in 2045[412]



CARB acknowledges the complex nature of croplands, cross-sector relationships, and the need to build on this analysis to further our understanding of cropland dynamics. The NWL Climate Smart Strategy identifies several additional strategies for croplands, such as the promotion of climate smart irrigation systems, increasing groundwater recharge, repurposing fallowed croplands, organic waste utilization, and scaling up integrated pest management. When deployed, these can provide additional carbon and other environmental and social benefits that were not included in the cropland modeling results. In addition, many more aspects of cropland management need to be explored for potential climate benefits, such as water and nutrient use management, pest control methods, crop rotations, and other management practices. The impacts of climate change on water availability, annual/perennial crop growth, and future carbon sequestration trends are uncertain, and recent policies such as the Sustainable Groundwater Management Act may also influence cropland management in unforeseen ways. Nonetheless, it is clear that greater climate smart practice implementation can prepare California for the future and yield tangible benefits for the state.

Strategies for Achieving Success

- Accelerate the pace and scale of healthy soils practices to 50,000 acres annually by 2025, annually conserve at least 6,000 acres of annual crops, and increase organic agriculture to 20 percent of all cultivated acres by 2045.

[412] AB 32 EJ Advisory Committee, Draft Recommendations, N11. ejacrecsrevised.pdf (ca.gov).

- Deploy additional climate smart agricultural strategies for croplands identified in the Climate Smart Strategy (e.g., improved nitrogen use efficiency, whole-orchard recycling, riparian restoration, on-farm energy generation, and others) and utilize the recommendations included in CDFA's Farmer and Rancher-Led Climate Change Solutions[413] report to accelerate deployment of healthy soils practices, organic farming, and other climate smart agriculture practices.
- Establish or expand financial mechanisms that support ongoing deployment of healthy soils practices and organic agriculture.[414]
- Implement DPR's Sustainable Pest Management Work Group recommendations[415] to accelerate a systemwide transition to safer, more sustainable pest management.[416]
- Support strategies that achieve co-benefits of safer, more sustainable pest management practices and the health and preservation of ecosystems.
- Conduct research on the intersection of pesticides, soil health, GHGs, and pest resiliency via a multiagency effort with DPR, CDFA, and CARB.[417]
- Conduct outreach and education to develop and facilitate the increased adoption of safer, more sustainable pest management practices and tools, reduce the use of harmful pesticides, promote healthy soils, improve water and air quality, and reduce public health impacts.
- In collaboration with state and local agencies, accelerate the deployment of alternatives to agricultural burning that increase long-term carbon storage from waste agricultural biomass, including storage in durable wood products, underground reservoirs, soil amendments, and other mediums.
- Work across state agencies to reduce regulatory and permitting barriers around some healthy soils practices (e.g., composting), where appropriate.
- Utilize innovative agriculture energy use and carbon monitoring and planning tools to reduce on-farm GHG emissions from energy and fertilizer application or increase carbon storage, as well as to promote on-farm energy production opportunities.

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[413] California Department of Food and Agriculture. 2021. Farmer and Rancher Led Climate Change Solutions. *https://www.cdfa.ca.gov/oefi/climate/docs/cdfa_farmer_and_rancher-led_climate_solutions_meetings_summary.pdf*.

[414] AB 32 EJ Advisory Committee, Draft Recommendations, N5. *ejacrecsrevised.pdf (ca.gov)*.

[415] The work group will be releasing its draft recommendations in May/June 2022. The Administration's plan for implementing the work group's recommendations will follow the release of work group's anticipated final recommendations in fall 2022.

[416] AB 32 EJ Advisory Committee, Draft Recommendations, N3, N4, N5. *ejacrecsrevised.pdf (ca.gov)*.

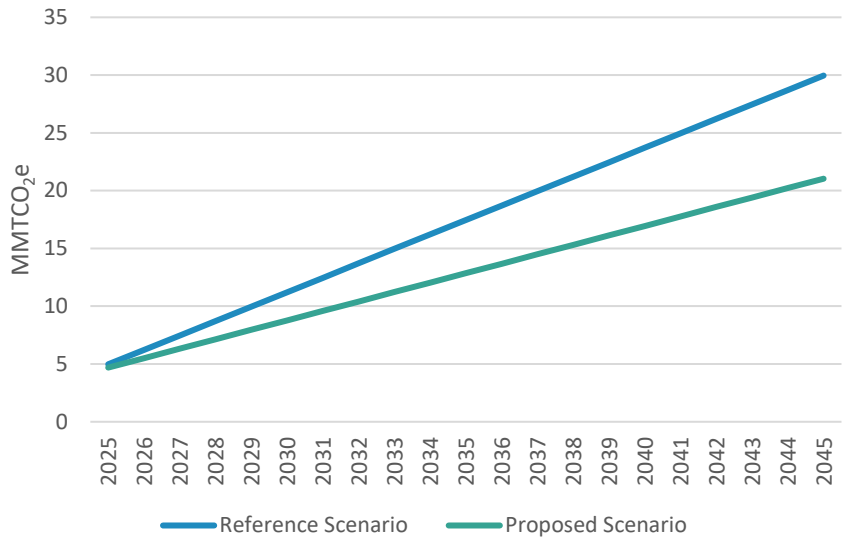
[417] AB 32 EJ Advisory Committee, Draft Recommendations, N3, N4, N5. *ejacrecsrevised.pdf (ca.gov)*.

Wetlands

Wetlands cover 2 percent of the state, roughly 1.7 million acres, and include inland and coastal wetlands, such as vernal pools, peatlands, mountain meadows, salt marshes, and mudflats. These lands are essential to California's communities as they serve as hotspots for biodiversity, contain considerable carbon in the soil, are critical to the state's water supply, and protect upland areas from flooding due to sea level rise and storms. Wetlands have been severely degraded through reclamation, diking, draining, and dredging practices in the past, resulting in the emissions of the carbon stored in the soils and the loss of ecosystem benefits. Climate smart strategies to restore and protect all the types of wetlands can reduce emissions while simultaneously improving the climate resilience of surrounding areas and improving the water quality and yield for the state. Restored wetlands also can reduce pressure on California's aging water infrastructure. These benefits beyond emissions reductions will help in the future, as climate change is predicted to negatively affect water supply.

Avoided conversion and restoration of wetlands reduces CO_2 and CH_4 emissions from wetlands, with GHG reductions scaling with implementation rates (Figure 4-24). Expansion of conservation and restoration efforts will generate benefits such as the conservation of biodiversity, improved water quality and supply, and reduced flood risk. There are a number of additional wetland strategies identified in the Climate Smart Strategy, such as protecting and restoring all of the various types of wetlands to enhance natural functions and prepare for future climate change impacts like sea level rise.

Figure 4-24: Cumulative CO_2e emissions from Delta wetlands by 2045



Strategies for Achieving Success

- Restore 60,000 acres of Delta wetlands annually by 2045 to reduce methane emissions from wetlands and reverse the resulting subsidence.
- Deploy additional wetland protection, restoration, and enhancement activities identified in the Climate Smart Strategy, including both inland and coastal wetlands.
- Identify and prioritize wetland restoration efforts around climate vulnerable communities.
- Leverage other funding and institutions to support wetland restoration projects, including land trusts, local funding (e.g., San Francisco Measure AA), federal funding, and private and philanthropic funding to support wetlands restoration projects.
- Work across state agencies to reduce regulatory and permitting barriers around Delta restoration projects, where appropriate.

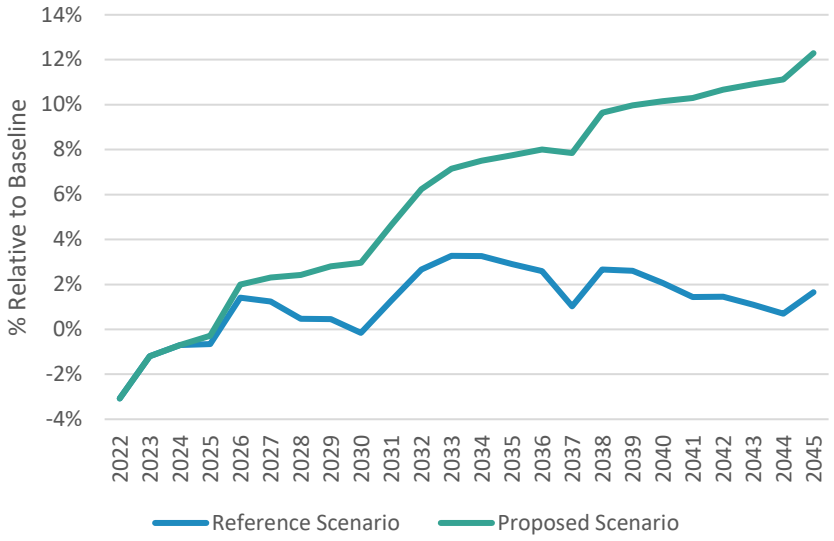
Developed Lands

Developed lands cover 6 percent of the state (roughly 6.8 million acres) and include urban, suburban, and rural areas, as well as transportation and supporting infrastructure throughout California. This area encapsulates the land where the vast majority of Californians reside and call home. The vegetation within cities and communities, and along infrastructure, are all part of developed lands. This vegetation provides numerous benefits to surrounding areas, including carbon storage, air and water filtration, reduced urban heat island effect, access to nature, aesthetics, and mental health, among others. These areas are susceptible to climate change as well, and climate smart strategies to protect and expand the urban forests, landscaping, green spaces, parks, and associated vegetation can increase their climate resilience and the benefits Californians derive from them. These strategies also have a significant opportunity to benefit disadvantaged communities, which may not have equitable access to these practices or the benefits they provide.[418]

Urban forests have a significant potential to sequester carbon (Figure 4-25). They are vastly different from wildland forests, as they require investments to maintain and irrigate. This results in the need for a significant increase in investment to increase urban forest carbon. As urban forests become denser and management difficulty increases, the carbon stock returns on investment diminish, making it expensive to maximize carbon in urban forests. Water availability and irrigation efficiency is also an important consideration for increasing urban forest cover. As water becomes scarcer, the prioritization of irrigating trees over lawns or gardens may be required to achieve increases in urban forest carbon.

[418] AB 32 EJ Advisory Committee, Draft Recommendations, N8. *ejacrecsrevised.pdf (ca.gov)*.

Figure 4-25: Carbon stocks in urban forests by 2045



Within wildland-urban interface (WUI) areas, defensible space can protect urban and rural communities from wildfire. Analysis results show that 48 percent of parcels are currently fully compliant with defensible space requirements. This highlights how much work needs to be done to protect communities and homes. Defensible space results in a decrease in carbon stocks, as expected when reducing fuels for wildfire.

For developed lands there are a number of additional strategies identified in the Climate Smart Land Strategy, such as infrastructure greening, improving urban habitat connectivity, promoting green space, enhancing public safety by reducing infrastructure fire risks, utilizing integrated pest management, improving water use management, and many others. These practices present a significant opportunity to protect or enhance several co-benefits that directly improve the lives of people, such as reducing the urban heat island effect, providing shade, reducing stress levels, and improving recreational opportunities, among others.

Strategies for Achieving Success

- Increase urban forestry investment annually by 20 percent, relative to BAU.
- Increase public awareness of urban forests benefits and, where appropriate, prioritizing irrigation of trees over lawns.
- Provide technical assistance and resources to disadvantaged communities to implement community greening projects to provide equitable access to the benefits of greening projects.[419]
- Work with state and local agencies to expand technical assistance for and enforcement of the defensible space requirements of PRC 4291 to reduce wildfire risk to homes and structures.

Sparsely Vegetated Lands

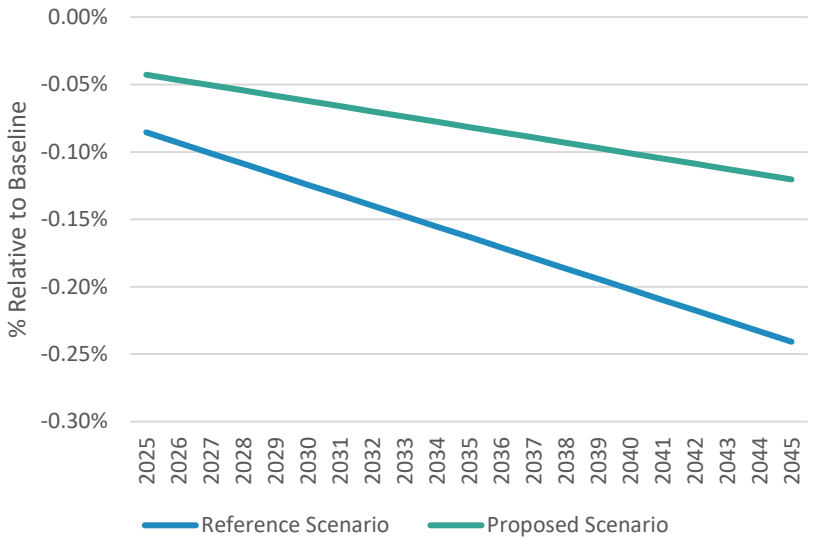
Sparsely vegetated lands cover 10 percent of the state, roughly 10.2 million acres, primarily in the east and southern parts of California. These lands include deserts, beaches, dunes, bare rock, and areas covered in ice and snow (e.g., higher mountain elevations). The limited carbon storage of these lands varies from bare rock and mineral soil to more vegetated areas, though severe climate limits the amount of biomass. Nonetheless, sparsely vegetated lands are important for open space and provide rare and unique habitats for endemic species and a diversity of wildlife. These lands present important recreational opportunities for Californians and serve as important protective

[419] AB 32 EJ Advisory Committee, Draft Recommendations, N8. *ejacrecsrevised.pdf (ca.gov)*.

buffers in coastal and low-lying areas. Land use change threatens these lands, and conservation efforts are important for protecting these unique areas of California.

Avoided conversion of sparsely vegetated lands reduces the organic carbon lost from the soil, which is the major carbon pool in this land type (Figure 4-26). In identifying the outcomes for sparsely vegetated lands, CARB modeled avoided land conversion to another land use. There are a number of additional strategies identified in the Climate Smart Land Strategy for sparsely vegetated lands, such as restoring native species, applying cultural fire where appropriate, and protecting shoreline and beach habitats from climate change impacts like sea level rise.

Figure 4-26: Carbon stocks in sparsely vegetated lands by 2045



Strategies for Achieving Success

- Establish and expand mechanisms that ensure sparsely vegetated lands are protected from land conversion, prioritizing those areas most vulnerable to climate change and loss.

Chapter 5: Challenge Accepted

This chapter provides an overview of the next steps and partnerships that will be needed to successfully implement the 2022 Scoping Plan update once it is approved by the Board. The path forward is not dependent on one agency, one state, or even one country. It will take action on a global level to address the threat climate change poses. But, the work begins at home.[420] The state can lead by engaging Californians and demonstrating how action at the state, regional, and local levels of government, as well as action at community and individual levels, can contribute to addressing the challenge before us. We must build partnerships with academic institutions, private industry, and others to support and accelerate the transition to carbon neutrality. Ultimately, the success of the 2022 Scoping Plan update will be measured by our ability to implement the actions modeled in the Proposed Scenario at all levels of government and society. This will depend on a mix of legislative action, regulatory program development, incentives, institutional support, workforce and business development, education and outreach, community engagement, and research and development and deployment. Optimizing this mix will help to ensure that clean energy and other climate mitigation strategies are clear, winning alternatives in the marketplace and in communities—to promote equity, drive innovation, and encourage consumer adoption. Bold institutional action will catalyze continued research and push private investment to create jobs and bring innovative ideas to reality.

State-level Action

Achieving the targets described in the Final 2022 Scoping Plan will require continued commitment to and successful implementation of existing policies and programs and identification of new policy tools and technical solutions to go further, faster. California's Legislature and state agencies will continue to collaborate to achieve the state's climate, clean air, social equity, and broader economic and environmental protection goals. It will be necessary to maintain and strengthen this collaborative effort, and to draw upon the assistance of regional and local governments, communities, academic institutions, and the private sector to achieve the state's near-term and longer-term emission reduction goals and a more equitable future for all Californians.

[420] This "polycentric" approach to climate challenges, engaging many levels of government, was articulated in leading papers by Nobel laureate Elinor Ostrom. See, for example, Ostrom, E. 2014. "A Polycentric Approach to Coping with Climate Change." *Annals of Economics and Finance* 15-1, 97–134.

Regulations and Programmatic Development

Meeting the AB 32 2020 GHG emissions reduction target four years earlier than mandated demonstrated that developing mitigation strategies through a public process, where all stakeholders have a voice, leads to effective actions that address climate change and yields a series of additional economic and environmental co-benefits to the state. Following adoption of the 2022 Scoping Plan update, state agencies will continue to update and implement new and existing programs to align with the outcomes in the final plan. Community and stakeholder engagement will be a critical part of this work. Several state agencies, including CARB, CEC, the California State Transportation Agency (CalSTA), CPUC, and others will need to be part of various subsequent rulemaking processes. Each of these agencies' leadership and technical staff will engage with the public through public meetings, written and oral comment, and other methods of engagement. This work will be informed by evaluations of health, air quality, environmental, equity, and economic benefits and impacts of regulations, including an assessment of the societal cost of carbon, as required under AB 197.

Incentive Programs

As described in Chapter 1, incentive programs are one of the most important tools the state has in advancing our low carbon future, especially for climate vulnerable communities. The programs ensure clean technology and energy is accessible and are critical to closing ongoing opportunity gaps. These programs also leverage private-sector investment and build sustainable, growing markets for clean and efficient technologies, and they are particularly necessary to support GHG emission reduction strategies for priority sectors, sources, and technologies. Clean technologies are often already the best and lowest cost option over their lifetimes but incentive funding is critical to ensure that they are broadly available, especially in climate vulnerable communities. Incentives also build on California's long track record of driving innovative technology developments, and creating new industries, with targeted investment.

Many state funding programs are designed to achieve multiple objectives simultaneously: reduce emissions from GHGs, criteria pollutants, and toxic air contaminants; manage natural and working lands for carbon sequestration; and address health and opportunity gaps in disadvantaged communities. California's incentive programs focused on jump-starting the transition to a zero emission transportation future are a good example of this "stacked" approach. The state is investing billions of dollars through programs such as the On-Road Heavy-Duty Voucher Incentive Program and Clean Cars 4 All in order to replace the light- and heavy-duty vehicles most responsible for the state's GHG emissions and poor air quality, all while bolstering the nascent ZEV market. Further strategies aid in developing new technologies, in ramping up access for all, and in shifting to cleaner modes of transport; for instance, by supporting investments in walkable, bikeable

communities and transit, as well as in vehicles. This funding strategy is, of course, paired with the regulatory approach described above.

Local Action

Local action by cities can support and amplify efforts to reduce GHGs. For example, the City of Oakland requires all new construction to be all-electric and is currently working on electrifying existing buildings.[421] In addition, starting in 2023, the City of Sacramento will require all new buildings under three stories to be all-electric, and extends the mandate to all new construction by 2026 with some limited exemptions. The City of Sacramento also requires levels of EV charging infrastructure in new construction starting in 2023 higher than the minimum state requirements and provides parking incentives for zero-emission carsharing and EV charging.[422] Local governments asserting this type of leadership are critical partners in supporting state-level measures to contain the growth of GHG emissions associated with the transportation system and the built environment.

It is clear that California must accommodate population and economic growth in a far more sustainable and equitable manner than in the past. Good climate policy can and should create affordable and pleasant places to live, with effective transport and clean air for all—a future in which local governments and communities are central partners. Local governments have the primary authority to plan, zone, approve, and permit how and where land is developed to accommodate population growth, economic growth, and the changing needs of their jurisdictions. They also make critical decisions on how and when to deploy transportation infrastructure, and can choose to support transit, walking, and bicycling, and neighborhoods that do not force people into cars. Local governments also have the option to adopt building ordinances that exceed statewide building code requirements, and play a critical role in facilitating the rollout of ZEV infrastructure. As a result, local government decisions play a critical role in supporting state-level measures to contain the growth of GHG emissions associated with the transportation system and the built environment—the two largest GHG emissions sectors over which local governments have authority.

Local governments are also frequently the source of innovative and practical climate solutions that can be replicated in other areas. Their efforts to reduce GHG emissions within their jurisdictions are vital to achieving the state's near-term air quality and long-term climate goals. Local governments must continue to take affirmative action to build the projects and expend the funds needed to further the state's collective path toward

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[421] City of Oakland. Building Electrification. *https://www.oaklandca.gov/projects/building-electrification*.

[422] City of Sacramento. Electrification of New Construction. *http://www.cityofsacramento.org/SacElectrificationOrdinance*.

equitable emissions reductions. As such, aligning local jurisdiction action with state-level priorities to tackle climate change and the outcomes called for the in the Draft 2022 Scoping Plan, once approved, is critical. Local governments can implement climate strategies that can effectively engage residents by addressing local conditions and issues that also deliver local economic benefits.

Local Climate Action Planning and Permitting

California encourages local jurisdictions to take ambitious, coordinated climate action at the community scale; action that is consistent with, and supportive of, the state's climate goals.[423] There is much local jurisdictions can do to enable statewide priorities, such as taking local action to help the state develop the housing, transport systems, and other tools we all need. Indeed, state tools—such as the Cap-and-Trade Program or zero-emission vehicle programs—do not substitute for these local efforts. Multiple legal tools are open to local jurisdictions to support this approach, including a climate action plan (CAP), sustainability plan, or inclusion of a plan for reduction of GHG emissions and climate actions within a jurisdiction's general plan. Any of these can help align zoning, permitting, and other local tools with climate action.

Once adopted, the GHG emissions reductions plans detailed in CAPs can provide local governments with a valuable tool for coordinated climate planning in their community. When a local CAP complies with CEQA requirements, individual projects that comply with the CAP are allowed to streamline the project-specific GHG analysis.[424,425] Effectively, local governments that adopt a CEQA-CAP enable project developers to use this streamlined approach. This saves time and resources and provides more consistent expectations for how GHG reduction measures are applied across projects in the jurisdiction. While the state encourages local governments to follow this approach, we acknowledge not all jurisdictions have the resources to develop a CAP that meets the CEQA requirements.

In addition to being required for a local CAP to comply with CEQA, local GHG reduction targets have long been recommended as part of the process of developing a climate

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[423] This plan provides more detailed guidance and tools to local governments in Appendix D (Local Actions).

[424] California Code of Regulations § 15183.5. Tiering and Streamlining the Analysis of Greenhouse Gas Emissions. *https://govt.westlaw.com/calregs/Document/I872A68805F7511DFBF66AC2936A1B85A?viewType=FullText&originationContext=documenttoc&transitionType=StatuteNavigator&contextData=(sc.Default)*

[425] California Governor's Office of Planning and Research. n.d. "General Plan Guidelines - Chapter 8 Climate Change."

action plan.[426] One challenge local jurisdictions have faced is how to evaluate and adopt quantitative, locally appropriate goals that align with statewide goals. An effective response to this challenge is to focus on goals that can help implement overall state priorities—enabling the key transformations California needs.

There are many ways that local governments can make key contributions to this transformation, depending on the characteristics of their jurisdiction and community. For example, some jurisdictions will inherently have more land capacity to remove and store carbon, whether through natural and working lands or by other means. Other jurisdictions will be host to GHG-emitting facilities that serve necessary functions and will take time to transition to clean technology (e.g., municipal wastewater treatment plants, landfills, and energy generation and transmission facilities). It is important to recognize that we will need to build new energy production and distribution infrastructure, and repurpose existing ones, for clean technology and energy before we are able to phase down existing fossil sources. There will also be a need to handle the significant amount of biomass resulting from sustainable forest management for wildfire prevention, agricultural waste, and landfill diversion.

Regional efforts can support change too: energy and transportation systems that serve Californians do not stop at jurisdictional boundaries, and some local decisions can have ramifications for other communities. For instance, Metropolitan Planning Organizations (MPOs) can help integrate local efforts by planning consistent with the Scoping Plan and Climate Action Plan for Transportation Infrastructure, including by removing polluting roadway capacity expansions from project pipelines and instead focusing on climate-friendly solutions. These varied capabilities and needs should be taken into account in setting targets for local climate plans. For instance, although net zero targets can often be valuable and achievable, and mitigation is important, targets need to be considered in the larger context of these goals. This all means any GHG targets on a local scale should take into consideration the actions and outcomes included in the Final 2022 Scoping Plan. Jurisdictions considering “net zero” targets should carefully consider the implications such targets may have on emissions in neighboring communities and the ability of the state to meet our collective targets.

Jurisdictions without formal CAPs also have important opportunities within this context. These jurisdictions can still take actions that effectively translate key state plans, goals, and targets, including those articulated in this Scoping Plan for local action. For instance, state ZEV targets can be forwarded by local efforts to promote broad and equitable access to charging and fueling. Similarly, local jurisdictions can enable reduced

[426] ICLEI. 2010. Quick Start Guide for Setting a Greenhouse Gas Reduction Target. https://californiaseec.org/wp-content/uploads/2015/12/ICLEI_Quick_Start_Guide_Milestone_2.pdf.

dependence on single-occupancy vehicles by supporting dense infill housing and transit, among other actions. Such actions can be reflected in particular project plans, in general plans, or through other local policies. Regional partnerships among these jurisdictions can also help unlock resources and provide for more effective overall action.

Unlocking CEQA Mitigation for Local Success

The California Environmental Quality Act also provides important tools. Although many climate-friendly local government actions already fall into categories which may not require a full CEQA analysis, thanks to streamlining or other tools, and other considerations (such as affordable infill housing) are clearly consistent with state climate goals, CEQA analyses may still sometimes be required. CEQA can be a powerful and useful tool to engage the public, identify additional opportunities to support climate efforts, and localize change. It is important that lead agencies look for ways to use CEQA to support these core purposes, ensuring that these processes do not become sources of delay but instead unlock more opportunities. Mitigation measures applied in the communities impacted by projects subject to CEQA have the added benefit of improving health, social, and economic resiliency as climate impacts worsen.

One of these important tools is CEQA mitigation—which can be used to further drive local action consistent with state climate goals. When a lead agency determines that a proposed project would emit significant GHG emissions or conflict with state climate goals, the lead agency must impose feasible design features and mitigation measures to minimize the impact. Lead agencies should prioritize on-site design features[427] and GHG mitigation measures that reduce GHG emissions, such as methods to reduce VMT and support building decarbonization, access to shared mobility services or transit, and EV charging. After exhausting all the on-site GHG mitigation measures, CARB recommends prioritizing local, off-site GHG mitigation measures, including both direct investment and voluntary GHG reduction or sequestration projects, in the neighborhoods impacted by the project. This could include, for example, development of a neighborhood green space, investment in street trees or expansion of transit services. Implementing GHG mitigation measures in the project's vicinity would allow the project proponent and the lead agency to work directly with the affected community to identify and prioritize the mitigation measures that meet their needs while minimizing multiple environmental and societal impacts.

Once all potential on-site and local off-site GHG mitigation measures have been incorporated to the extent feasible, other voluntary offsets issued by a reputable voluntary

[427] California Code of Regulations, § 15126.4(c)(2) and (3).

carbon registry (as listed on CARB's website[428]) may be appropriate. Additional in-state mitigation also may be available in the upcoming SB 27[429] (Skinner, Chapter 237, Statues of 2021) registry, which will serve as a database of projects in the state that drive climate action on natural and working lands. Lead agencies should use substantial evidence to demonstrate that the project proponent explored and prioritized investing in feasible, local mitigation prior to moving mitigation to a geography located farther away from the project.

Communities and Environmental Justice

As noted in Board Resolution 20-33,[430] it is incumbent on CARB to function as an agent of responsible social change, especially when it is clear that environmental injustices continue to persist for low-income communities and communities of color.

State law defines *environmental justice* as the fair treatment of all people of all races, cultures, and incomes with respect to the development, adoption, implementation, and enforcement of environmental laws, regulations, and policies.[431] Government Alliance for Race and Equity (GARE)[432] defines *racial equity* as when race can no longer be used to predict life outcomes and outcomes for all groups are improved.

For the 2022 Scoping Plan update, once approved, to be successful, it must address environmental justice and advance racial equity. Implementation of the plan needs to address the needs of those communities that are disproportionately burdened by climate impacts and continue to face significant health and opportunity gaps. Now, we need to ensure our actions allow these communities to not only have a seat at the table, but also inform and shape the policies to ensure their communities thrive.

In alignment with AB 32, and to ensure environmental justice and racial equity were integrated into the Draft 2022 Scoping Plan, CARB reconvened the AB 32 Environmental Justice Advisory Committee (EJ Advisory Committee) to advise CARB on the

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[428] CARB. 2022. *Offset Project Registries.* https://ww2.arb.ca.gov/our-work/programs/compliance-offset-program/offset-project-registries.

[429] SB-27 Carbon sequestration: state goals: natural and working lands: registry of projects. (SB 27, Skinner, Chapter 237, Statutes of 2021). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB27.

[430] CARB. 2020. Resolution 20-33: A Commitment to Racial Equity and Social Justice. October 22. https://ww2.arb.ca.gov/sites/default/files/barcu/board/res/2020/res20-33.pdf.

[431] Gov. Code, § 65040.12, subd. (e).

[432] Local and Regional Government Alliance on Race and Equity. 2015. *Advancing Racial Equity and Transforming Government: A Resource Guide to Put Ideas into Action.* Page 9. https://racialequityalliance.org/wp-content/uploads/2015/02/GARE-Resource_Guide.pdf.

development of the Draft 2022 Scoping Plan. Since reconvening in May 2021, the EJ Advisory Committee has engaged in the following activities:

- In October 2021, the EJ Advisory Committee sent a letter to the Governor requesting a timeline extension for the Scoping Plan process. In response to the EJ Advisory Committee's letter, CARB modified the 2022 Scoping Plan update process433 and committed to an active engagement with the EJ Advisory Committee following the approval of the Scoping Plan. The EJ Advisory Committee also presented to the CARB Board[434] at its October Board meeting, reiterating its request for a timeline extension, as well as sharing additional concerns about process.
- In December 2021, the EJ Advisory Committee shared its responses to Scenario Input Questions,[435] as well as a narrative document outlining their concerns[436] around the process, the need for evaluation, and the need for a tribal representative. In response to the EJ Advisory Committee Scenario Input Questions, CARB incorporated the EJ Advisory Committee responses into the Scenario Assumptions document,[437] and modeled results from PATHWAYS.[438] In response to the EJ Advisory Committee's concerns, CARB worked diligently to appoint a tribal representative[439] in February 2022, and to outline additional

[433] Randolph, L. M. 2021. LMR October 19 response to Environmental Justice Advisory Committee Letter. *https://ww2.arb.ca.gov/sites/default/files/2021-10/LMR%20October%2019%20response%20to%20EJAC%20Letter%20Final.pdf*.

[434] Argüello, M. D., K. Hamilton, S. Taylor, and P. Torres. 2021. EJAC Co-Chair Informational Presentation to CARB Board. October 28. *https://ww2.arb.ca.gov/sites/default/files/barcu/board/books/2021/102821/21-11-4pres.pdf*.

[435] EJ Advisory Committee. 2021. EJAC Final Responses to CARB Scenario Inputs. December 2. *https://ww2.arb.ca.gov/sites/default/files/2021-12/EJAC%20Final%20Responses%20to%20CARB%20Scenario%20Inputs_12_2_21.pdf*.

[436] EJ Advisory Committee. 2021. EJAC Responses to Scenario Input Questions. EJAC narrative document regarding scenario input recommendations. December 1. *https://ww2.arb.ca.gov/sites/default/files/2021-12/EJAC%20Narrative%20Document%20re%20Scenario%20Input%20Recommendations%2012_1_2021.pdf*.

[437] CARB. 2021. PATHWAYS Scenario Modeling. *https://ww2.arb.ca.gov/sites/default/files/2021-12/Revised_2022SP_ScenarioAssumptions_15Dec.pdf*.

[438] E3. 2022. CARB Draft Scoping Plan AB32 Source Emissions Initial Modeling Results. March 15. *https://ww2.arb.ca.gov/sites/default/files/2022-03/SP22-Model-Results-E3-ppt.pdf*.

[439] CARB. AB32 EJAC Committee Meeting, February 28, 2022 CARB Update. *https://ww2.arb.ca.gov/sites/default/files/2022-02/CARB%20EJAC022822presentation.pdf*.

opportunities for the EJ Advisory Committee to engage in the Scoping Plan process.[440]

- In March 2022, the EJ Advisory Committee presented at the joint EJ Advisory Committee / CARB Board meeting[441] and walked through their preliminary draft recommendations to inform the Draft Scoping Plan. In April, the EJ Advisory Committee shared its revised preliminary draft recommendations[442] to inform the Draft 2022 Scoping Plan. To the extent possible, CARB has incorporated and cited these recommendations through this Draft 2022 Scoping Plan.

In addition to the activities listed above, Central Valley EJ Advisory Committee members hosted a successful community engagement workshop in San Joaquin Valley in February 2022 with over one hundred attendees. The EJ Advisory Committee will continue to coordinate community outreach efforts throughout the development of the Scoping Plan to ensure the voices of those communities most burdened by climate impacts are reflected in the plan. The EJ Advisory Committee will continue to play a vital role in the Scoping Plan and its implementation to ensure environmental justice and racial equity are prioritized in our effort to address the climate challenge before us.

To the extent possible, the EJ Advisory Committee's recommendations were integrated throughout the draft plan and directly cited to ensure that this plan addresses environmental justice and does not leave communities behind.

As the plan continues to be refined through ongoing engagement efforts and discussions with the EJ Advisory Committee, there will be a need to better understand how to address EJ Advisory Committee recommendations on the following topics:

- Actions under the jurisdiction of other agencies: there are certain EJ Advisory Committee recommendations that are outside of CARB's jurisdiction. As the EJ Advisory Committee continues to convene, it would helpful to understand the role that CARB can play as it relates to EJ Advisory Committee's recommendations for actions outside CARB's jurisdiction and coordinates with sister agencies.
- Actions that require legislative direction: there are certain EJ Advisory Committee recommendations that would require legislative action. As the EJ Advisory Committee continues to convene, it will be helpful to understand how CARB can

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[440] Fletcher, C. 2021. CARB Response to EJAC Narrative. CARB. December 15. *https://ww2.arb.ca.gov/sites/default/files/2021-12/CARB%20response%20to%20EJAC%20Narrative.pdf*.
[441] EJ Advisory Committee. 2022. EJAC Presentation: Preliminary Draft Recommendations. March 10. *https://ww2.arb.ca.gov/sites/default/files/barcu/board/books/2022/031022/ejacpres.pdf*.
[442] EJ Advisory Committee. 2022. EJAC Presentation: Preliminary Draft Recommendations. March 10. *https://ww2.arb.ca.gov/sites/default/files/barcu/board/books/2022/031022/ejacpres.pdf*.

work with the EJ Advisory Committee to share these recommendations with the appropriate members of the Legislature.

- Actions directly tied to implementation activities: The Draft Scoping Plan is not an implementation document; it is a plan to chart a course to continue to reduce GHG emissions and achieve carbon neutrality. Once the Scoping Plan is approved, there will be follow up action at CARB as well as other agencies. In these follow-up efforts, there will be a role for ongoing EJ Advisory Committee engagement.

CARB proposes to work with the EJ Advisory Committee to better understand how to move forward on EJ Advisory Committee recommendations that fall into the topics listed above and any other recommendations that were not included in this draft plan. It is also important to note that there are numerous recommendations where CARB shares the goals of the EJ Advisory Committee and can assist in implementation steps once the Scoping Plan is final. Examples include the following:

- CARB shares the goal of prioritizing non-fossil energy generation and supports non-fossil projects and opportunities to locate behind-the-meter clean resources in communities of concern in programs such as the Solar on Multi-Family Homes program.
- CARB will engage with agencies and academic institutions to further workforce development.
- Many other recommendations related to financial support for various energy projects, such as microgrids, are within the purview of the CPUC or local public owned utilities. Similarly, utility scale projects are within the jurisdiction of other agencies. However, CARB supports strategies identified in the recommendations such as offshore wind to reduce the reliance on fossil fuel generation.
- CARB is supportive of rooftop solar, although it is not within CARB's jurisdiction to determine how incentives for those projects are structured.
- CARB is supportive of strong energy decarbonization goals, recognizing that increased reliance on electrification in transportation and other sectors will create significant demand for electricity and therefore ensuring reliability of a decarbonized grid is a critical need for the state.
- In the transportation sector, CARB is supportive of the EJ Advisory Committee's recommendations to maintain aggressive zero emission vehicle goals consistent with its statutory mandate to ensure regulations are technologically feasible and in alignment with Governor Newsom's ZEV Executive Order (EO N-79-20). CARB looks forward to continued engagement on rulemakings that will implement these goals.
- As noted elsewhere in this draft plan, CARB is supportive of the Caltrans California Transportation Plan 2050 and the California Climate Action Plan for Transportation Infrastructure.

- CARB is supportive of additional public support for transit. CARB is supportive of locating EV charging in low-income communities and communities of color.
- CARB is supportive of prioritizing funding incentives for transit and heavy- and medium-duty vehicles, although CARB does believe there is an important role for incentives that support adoption of light-duty vehicles for the time being. CARB will also be opening a rulemaking on the Low Carbon Fuel Standard to ensure it continues to support clean fuels that will displace petroleum fuels and will consider the EJ Advisory Committee recommendations on this program.
- In the industrial sector, in addition to the strategies discussed more fully in this Draft 2022 Scoping Plan, CARB continues to work with the Legislature, local agencies, and air districts to support, implement, and enforce effective reductions in emissions of GHGs and air pollutants in stationary sources. Only the air districts have the authority to directly issue permits addressing a facility's criteria pollutant and toxics emissions levels. These levels are set after careful permit review, under district regulation and statute. However, AB 617 directs and authorizes CARB to take several actions to improve data reporting from facilities, air quality monitoring, and pollution reduction planning for communities affected by a high cumulative exposure burden. CARB will continue to implement AB 617 and look for ways to strengthen the Community Air Protection Program.
- Considerations around the phaseout of oil and gas extraction and refining, and the role of carbon capture are discussed more thoroughly in Chapter 2.

As CARB continues to engage with the EJ Advisory Committee—in addition to the EJ Advisory recommendations that have been integrated throughout this plan—below are the following commitments that CARB is making to ensure that environmental justice is integrated in this plan and its implementation:

- Building decarbonization is a pillar of the Scoping Plan and CARB commits to working closely with state and local agencies to implement the EJ Advisory Committee recommendations that call for prioritization for residents in low-income communities and communities of color in this transition.
- CARB commits to sharing the EJ Advisory Committee's recommendations with the CEC, CPUC, and other agencies administering funds to support building decarbonization, and to work closely with those agencies as they engage in public processes to further building decarbonization.
- CARB has committed to review the Cap-and-Trade program and determine what potential legislative or regulatory amendments could be necessary to ensure the program the program continues to deliver GHG reductions needed to achieve the statutory climate goals. In that process, CARB will consider the recommendations

of the EJ Advisory Committee[443] and Independent Emissions Market Advisory Committee,[444] as well as others.

Critically, the EJ Advisory Committee makes numerous recommendations centered around tracking progress of the various strategies in the Scoping Plan. Currently, progress is tracked and reported in numerous ways, including the annual GHG inventory and reports to the Legislature. Part of the ongoing work of implementation, however, will include consideration of ways to provide more data and information to the public, such as rates of deployment of clean energy and technology. CARB will also continue to collaborate with CDPH and OEHHA on health metrics to track cumulative benefits of air pollution and climate programs, especially in low-income communities and communities of color.

As noted earlier in this document, the EJ Advisory Committee will continue to play a vital role in the Scoping Plan and its implementation to ensure environmental justice and racial equity are prioritized in our effort to address the climate challenge before us. This includes the creation of a permanent EJ Advisory Committee to advise CARB on the development of the Scoping Plan and any other pertinent matters in implementing AB 32. This permanent EJ Advisory Committee will help to ensure integration of environmental justice in implementation efforts as it relates to AB 32, and also help CARB as we work toward a future where race is no longer a predictor for life outcomes.

Academic Institutions and the Private Sector

Academic institutions produce and present the latest science on both the impacts of, and actions to reduce, climate change damages. They are also leading the way by

[443] California Legislative Information. Bill Text - AB-32 Air pollution: greenhouse gases: California Global Warming Solutions Act of 2006. (AB 32, Nuñez, Chapter 488, Statutes of 2006). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200520060AB32.

[444] California Legislative Information. Bill Text - AB-398 California Global Warming Solutions Act of 2006: market-based compliance mechanisms: fire prevention fees: sales and use tax manufacturing exemption. (AB 398, Eduardo Garcia, Chapter 135, Statutes of 2017). https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201720180AB398.

establishing their own climate goals and GHG emissions reductions targets.[445,446,447] They are incubators for innovation and knowledge in clean energy and technology and play an important role in adding to the wealth of robust information to inform policies and programs. Academic institutions have the ability to fill knowledge gaps and push us toward new frontiers. As we move forward, we will continue to see these institutions as partners and resources to help look for ways to accelerate and introduce actions to reduce GHG emissions and remove and store carbon. As such, it will be important to maintain and enhance relationships with academic institutions, including community colleges. Community colleges are more likely to have a large proportion of first generation students or students that come from low-income communities or communities of color. The perspective of this diverse student body will be critical to inform discussions on climate change damages and mitigation efforts. This student body is also a future workforce, and courses to teach the skills for a sustainable economy are a chance to close historical opportunity gaps. Importantly, many of the students at community colleges are local residents and community members. This engagement provides another way to invest in communities across our state.

As noted in Chapter 1, public and private partnerships will be important as we move forward in the great energy transition. But the private sector is also important in the context of research and development and deployment. Many of these companies have the resources and expertise to build and produce the clean technology and energy we will need. It was through the efforts of several private companies (Bell, Exxon, Telecom Australia) that the photovoltaic solar panels in use today were developed.[448] Similarly, it was companies such as General Electric and Texas Instruments that contributed to the development of hydrogen fuel cells.[449] This Scoping Plan update includes the known and emerging clean technologies and fuels available today. The private sector spirit of

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[445] University of California. Our Commitment. *https://www.universityofcalifornia.edu/initiative/carbon-neutrality-initiative/our-commitment*.

[446] California State University. Energy & Sustainability. *https://www.calstate.edu/csu-system/doing-business-with-the-csu/capital-planning-design-construction/operations-center/Pages/energy-sustainability.aspx#:~:text=As%20a%20result%20CSU%E2%80%99s%20climate%20action%20is%20focused,neutrality%20no%20later%20than%202045%20for%20all%20emissions.?msclkid=165feeddc4ef11ec901f67f2e9bb56e7*.

[447] California Community Colleges Chancellor's Office. Climate Action and Sustainability *https://www.cccco.edu/About-Us/Chancellors-Office/Divisions/College-Finance-and-Facilities-Planning/Facilities-Planning/Climate-Action-and-Sustainability?msclkid=4a72350ec4f511ecaf292c6b14ac9a4f*.

[448] Californiasolarcenter.org. Passive Solar History. *http://californiasolarcenter.org/old-pages-with-inbound-links/history-pv/*.

[449] Fuel Cell Store. History of Fuel Cells. *https://www.fuelcellstore.com/blog-section/history-of-fuel-cells?msclkid=04a19450c50211ec8d20f2afff4039fe*.

invention, improvement, and innovation must continue to deliver new tools in the fight against climate change.

Individuals

The Draft Scoping Plan not only projects ambitious availability of clean technology and energy, but also includes aggressive assumptions about consumer adoption of ZEVs, heat pumps, and other energy efficiency practices, among others. When it comes to climate change mitigation, the sum of the parts matters. Only when we add up the impacts of the choices we make do we understand the true impact on GHG emissions. We can choose to drive a car, take a bus, bike, or walk. We can choose to install a heat pump or buy an electric cooktop. Together, we get to pick the future we want. We can start or transform businesses that create clean jobs, innovate new technologies, or introduce new systems. We can engage with fellow workers to support durable paths for labor in a clean economy. And we can choose to engage with our community and our governments to advocate for change, call out challenges, and propose solutions. Our choices will help determine California's climate future. Down one path is a future of climate impacts that will continue to worsen and further increase disparities across communities. Down the other is a future that avoids the worst impacts of climate change, improves air quality—especially for the most burdened communities—and fosters new economic and job opportunities to support a sustainable economy.

Importantly, we must acknowledge that historical decisions have resulted in health and opportunity gaps for residents in low-income communities and communities of color. Not everyone has the resources or access to make these choices—to buy a ZEV, install a heat pump, or use public transit to get to work. It is here that government can help. Government can fund programs and structure policies to provide consumers with more choice and to support them in adopting cleaner technology options. Whether through affordable energy rates or assistance in purchasing zero emission vehicles and appliances, we can use the transition to a carbon neutral economy as an opportunity to close some of these persisting opportunity gaps. By acting now, we can change our planet's fate and build a more resilient, healthier, and equitable future for all Californians.