The Air We Breathe, Part 3

By John Benson

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1. Introduction

This the third part of this series. This part was made necessary via the primary source-document for Parts 2 and 3 being too long to summarize in a single paper, this this is the second paper summarizing the document referenced here.[1]

Part 2 is described and linked below.

The Air We Breathe, Part 2:

https://energycentral.com/c/ec/air-we-breathe-part-2

Part 2 of this paper describes high level goals

Part 3 (today's post) includes:

- Scenarios used to evaluate possible plans and the selected Scoping Plan Scenario.
- Action Plans for each Sector in the Scoping Plan Scenario
- Carbon Removal and Sequestration Methods and Roles

2. Scenarios

A number of scenarios were considered in an early draft of this Plan. Thus the non-consecutive numbering below. Note that the "*Scoping Plan Scenario,"* immediately below was the selected scenario to be used in the Scoping Plan.

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

Scoping Plan Scenario (modeling scenario Alternative 3 from the Draft): carbon neutrality by 2045, deploy a broad portfolio of existing and emerging fossil fuel alternatives and clean technologies, and align with statutes, Executive Orders, Board direction, and direction from the governor.

Alternative 1: carbon neutrality by 2035, nearly complete phase-out of all combustion, limited reliance on carbon capture and sequestration and engineered carbon removal, and 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 Scoping Plan Scenario, and a higher reliance on CO_2 removal.

[1] California Air Resources Control Board, 2022 Scoping Plan for Achieving Carbon Neutrality, November 16, 2022, https://ww2.arb.ca.gov/sites/default/files/2022-11/2022-sp.pdf

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 compliance options 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?*

2.1. Scenarios for Natural and Working Lands (NWL)

Author's comment: Although NWL are an important part of our long-term GHG and air pollution management practices, natural lands have been damaged by climate change, and working lands must prioritize production and income in the short range. Thus we must first assure the health of these lands, and then evolve to using them for CO_2 and pollution management as their health and economic value are assured.

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 Scoping Plan Scenario is the preferred choice because it prioritizes sustainable land management to sequester carbon over the long term, GHG and air pollution reductions, ecosystem health and resilience, and implementation and technological feasibility and cost-effectiveness. The Scoping Plan Scenario reduces catastrophic 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 Scoping Plan Scenario takes into consideration the priority landscapes and nature-based strategies identified in California's Climate Smart Strategy[2] and reflects the state's priorities to manage lands in ways that support the multiple benefits they provide. The Scoping Plan Scenario, as well as each of the alternative NWL scenarios, were informed by input from other agencies, the public, and the environmental justice (EJ) Advisory Committee. Additional landscapes and land

[2] CNRA. 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

management activities will be added and evaluated in future Scoping Plan updates and in response to AB 1757.

Each of the NWL scenarios have several similarities, including the following:

- *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. These include:

- *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 burning or thinning for forests, grasslands, and shrublands.*

The summary below provides an overview of the alternatives designed and considered for the NWL sectors in this Scoping Plan. Full details of each scenario considered can be found in the Draft 2022 Scoping Plan Update.

- *Scoping Plan Scenario (NWL Alternative 3 from the Draft): 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 catastrophic wildfires in forests, shrublands, and grasslands*

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 Governor Newsom's Executive Order N-82-20 (e.g., California's Climate Smart Strategy and Pathways to 30x30). As part of this Scoping Plan, 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…

3. Scoping Plan Scenario

Note this subsection focuses on the primary Scoping Plan Scenario (modeling scenario Alternative 3 from the Draft), as identified in the beginning of section 2.

The Scoping Plan Scenario achieves GHG emission reductions that exceed the 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 AB 32 GHG Inventory sources away from fossil fuel combustion affect each economic sector. Actions that lead to improved carbon stocks affect each landscape.

3.1. 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*[3]
- *The two transportation carbon neutrality studies required by AB 74*[4]
- *The Mobile Source Strategy*[5]
- *SB 100 60 percent Renewables Portfolio Standard*
- *A Low Carbon Fuel Standard carbon intensity reduction target of 20 percent*

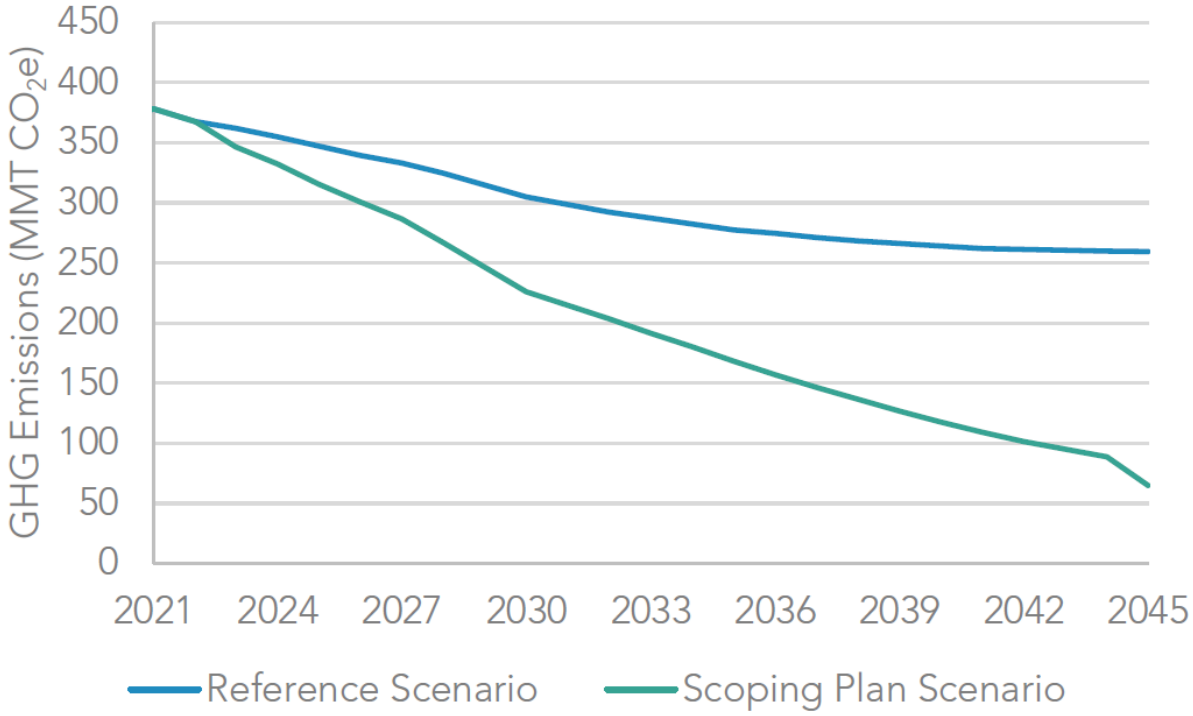
[3] California Energy Commission (CEC). 2020. 2019 Integrated Energy Policy Report. https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2019-integrated-energy-policy-report

[4] Brown et al. 2021. Driving California's Transportation Emissions. https://escholarship.org/uc/item/3np3p2t0 and Deschenes et al. 2021. Enhancing equity. https://zenodo.org/record/4707966#.Yl72RNrMKUn

[5] CARB. 2021. 2020 Mobile Source Strategy. https://ww2.arb.ca.gov/sites/default/files/2021-12/2020_Mobile_Source_Strategy.pdf

Policies that are under study or design, such the Advanced Clean Fleets regulation, are not included. The Reference Scenario reflects current trends and expected performance of policies identified in the 2017 Scoping Plan—some of which are performing better (such as the 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 Scoping Plan Scenario.

Figure 2-1: Reference and Scoping Plan Scenario GHG emissions[6]



The Scoping Plan Scenario is summarized in Table 2-1. 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, although it is not comprehensive of all existing new authorities for directing or supporting the actions described. Each action is expected to both reduce GHGs and help improve air quality, primarily by transitioning away from combustion of fossil fuels. The Scoping Plan Scenario achieves the AB 1279 target of 85 percent below 1990 levels by 2045 and identifies a need to accelerate the 2030 target to 48 percent below 1990 levels.

Author's comment: The following tables were real monsters, and were difficult to format and fit into this paper's pages, but they define many planned actions and direction that will impact the overall goal (first row below).

[6] The drop in emissions in 2045 reflects both the need to achieve an 85% reduction below 1990 levels in anthropogenic emissions per AB 1279 and Governor Newsom's request for a 100 MMT CO2e carbon removal and capture target in 2045. This was modeled by extending CCS to electric sector emissions.

Table 2-1: Actions for the Scoping Plan Scenario: AB 32 GHG Inventory sectors

Sector	**Action**	**Statutes, Executive Orders, Other Direction, Outcome**
GHG Emissions Reductions Relative to the SB 32 Target[7]	*40% below 1990 levels by 2030*	*SB 32: Reduce statewide GHG emissions.*[8] *AB 197: direct emissions reductions for sources covered by the AB 32 Inventory*[9]
Smart Growth / Vehicle Miles Traveled (VMT)	*VMT per capita reduced 25% below 2019 levels by 2030, and 30% below 2019 levels by 2045*	*SB 375: Reduce demand for fossil transportation fuels and GHGs, and improve air quality.*[10] *In response to Board direction and EJ Advisory Committee recommendations*
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.*[11] *AB 197: direct emissions reductions for sources covered by the AB 32 Inventory* *2035 target aligns with the EJ Advisory Committee recommendation.*
Truck ZEVs	*100% of medium-duty (MDV)/HDV sales are ZEV by 2040 (AB 74 University of California Institute of Transportation Studies [ITS] report)*	*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	*20% 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* *In response to Governor Newsom's July 2022 letter to CARB Chair Liane Randolph*[12]

[7] While the SB 32 GHG emissions reduction target is not an Action that is analyzed independently, it is included in this table for reference.
[8] SB-32 Energy: general plan: building decarbonization requirements.(2021-2022), https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=202120220SB32
[9] AB-197 Housing.(2021-2022), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB197
Also, 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.
[10] SB-375 Transportation planning: travel demand models: sustainable communities strategy: environmental review.(2007-2008), https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=200720080SB375
[11] 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
[12] Gavin Newsom, Governor of California, July 2022 letter to CARB Chair Liane Randolph, https://www.gov.ca.gov/wp-content/uploads/2022/07/07.22.2022-Governors-Letter-to-CARB.pdf?emrc=1054d6

Sector	***Action***	***Statutes, Executive Orders, Other Direction, 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.* *AB 197: direct emissions reductions for sources covered by the AB 32 Inventory*
Port Operations	*100% of cargo handling equipment is zero-emission by 2037.* *100% of drayage trucks are zero emission by 2035.*	*Executive Order N-79-20:* *Reduce demand for petroleum fuels and 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, beginning in 2028*[13] *Production reduced in line with petroleum demand.*	*Reduce GHGs and improve air quality.* *AB 197: direct emissions reductions for sources covered by the AB 32 Inventory*
Oil and Gas Extraction	*Reduce oil and gas extraction operations in line with petroleum demand by 2045.*	*Reduce GHGs and improve air quality.* *AB 197: direct emissions reductions for sources covered by the AB 32 Inventory*
Electricity Generation	*Sector GHG target of 38 million metric tons of carbon dioxide equivalent (MMTCO2e) in 2030 and 30 MMTCO2e in 2035* *Retail sales load coverage*[14] *20 gigawatts (GW) of offshore wind by 2045* *Meet increased demand for electrification without new fossil gas-fired resources.*	*SB 350 and SB 100: Reduce GHGs and improve air quality.*[15] *AB 197: direct emissions reductions for sources covered by the AB 32 Inventory* *In response to Governor Newsom's July 2022 letter, Board direction, and EJ Advisory Committee recommendation*
New Residential and Commercial Buildings	*All electric appliances beginning 2026 (residential) and 2029 (commercial), contributing to 6 million heat pumps installed statewide by 2030*	*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* *In response to Governor Newsom's July 2022 letter*

[13] CCS = carbon capture and sequestration.
[14] SB 100 speaks only to retail sales and state agency procurement of electricity. The 2021 SB 100 Joint Agency Report reflects the agency authors' understanding that other loads—wholesale or non-retail sales and losses from storage and transmission and distribution lines—are not subject to the law.
[15] SB-350 Clean Energy and Pollution Reduction Act of 2015.(2015-2016), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB350
Also SB-100 California Renewables Portfolio Standard Program: emissions of greenhouse gases.(2017-2018), https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB100

Sector	***Action***	***Statutes, Executive Orders, Other Direction, 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.* *AB 197: direct emissions reductions for sources covered by the AB 32 Inventory*
Port Operations	*100% of cargo handling equipment is zero-emission by 2037.* *100% of drayage trucks are zero emission by 2035.*	*Executive Order N-79-20:* *Reduce demand for petroleum fuels and GHGs, and improve 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 such that by 2030 there are 3 million all-electric and electric-ready homes—and by 2035, 7 million homes—as well as contributing to 6 million heat pumps installed by 2030.*	*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* *In response to Governor Newsom's July 2022 letter*
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, contributing to 6 million heat pumps installed statewide by 2030.*	*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* *In response to Governor Newsom's July 2022 letter*
Food Products	*7.5% of 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% of energy demand electrified by 2030 and 75% electrified 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, Other Direction, Outcome***
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, and Cement	*CCS on 40% of operations by 2035 and on all facilities by 2045* *Process emissions reduced through alternative materials and CCS*	*SB 596: Reduce demand for fossil energy, process emissions, 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 for petroleum fuels and 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*
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 is 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*

Sector	***Action***	***Statutes, Executive Orders, Other Direction, Outcome***
Low Carbon Fuels for Buildings and Industry	*In 2030s biomethane135 blended in pipeline* *Renewable hydrogen blended in fossil 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*
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 GWP Potential Emissions	*Low GWP refrigerants introduced as building electrification increases, mitigating HFC emissions*[16]	*SB 1383: Reduce short-lived climate pollutants.*

Table 2-2 below summarizes the Scoping Plan Scenario. The table also includes references to relevant statutes and Executive Orders where available.

[16] GWP = global warming potential

Table 2-2: Actions for the Scoping Plan Scenario: NWL sectors

Sector	***Action***	***Statutes, Executive Orders, Other Direction, Outcome***
Natural and Working Lands	*Conserve 30% of the state's NWL 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.*[17] *AB 1757: Establish targets for carbon sequestration and nature-based climate solutions.*[18] *SB 1386: NWL are an important strategy in meeting GHG reduction goals.*[19]
Forests and Shrublands	*At least 2.3 million acres*[20] *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 (Skinner, Chapter 534, Statutes of 2010): CARB to recognize the role forests play in carbon sequestration and climate mitigation.*[21]

Author's comment: Note that under "*Developed Lands*" below, there will be a substantial investment in urban forestry. This is necessary to help reduce the impact of urban warming through the heat-island effect.

[17] Gavin Newsom, Executive Order N-82-20, Oct 7, 2020, https://www.gov.ca.gov/wp-content/uploads/2020/10/10.07.2020-EO-N-82-20-.pdf , Also: SB-27 Carbon sequestration: state goals: natural and working lands: registry of projects.(2021-2022), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220SB27

[18] AB-1757 California Global Warming Solutions Act of 2006: climate goal: natural and working lands.(2021-2022)

[19] SB-1386 Resource conservation: working and natural lands.(2015-2016), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=201520160SB1386

[20] The 2.3 million acre target is what the Scoping Plan modeling shows would be needed to realize the carbon stock target called for in this Scoping Plan by 2045.

[21] AB-1504 Forest resources: carbon sequestration.(2009-2010), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=200920100AB1504

Sector	***Action***	***Statutes, Executive Orders, Other Direction, Outcome***
Grasslands	*At least 2.3 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.*	*Help to achieve climate targets, improve air quality, and reduce health costs.*
Croplands	*Implement climate smart practices for annual and perennial crops on ~80,000 acres annually. Land easements/ conservation on annual crops at ~5,500 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: Recognizes the ability of healthy soils practices to reduce GHG emissions from agricultural lands.*[22] *Target increased in response to Governor Newsom's direction to prioritize sustainable land management.*
Developed Lands	*Increase urban forestry investment by 200% 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.* *AB 2251 (Calderon, Chapter 186, Statutes of 2022): Increase urban tree canopy 10% by 2035.*[23] *Target increased in response to AB 2251 and Governor Newsom's direction on CO2 removal targets in his July 2022 letter.*
Wetlands	*Restore 60,000 acres of Delta wetlands*[24]	*Reduce the rate of land conversion to more GHG-intensive land uses.*
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.*

[22] SB-859 Agricultural policy.(2005-2006), https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=200520060SB859

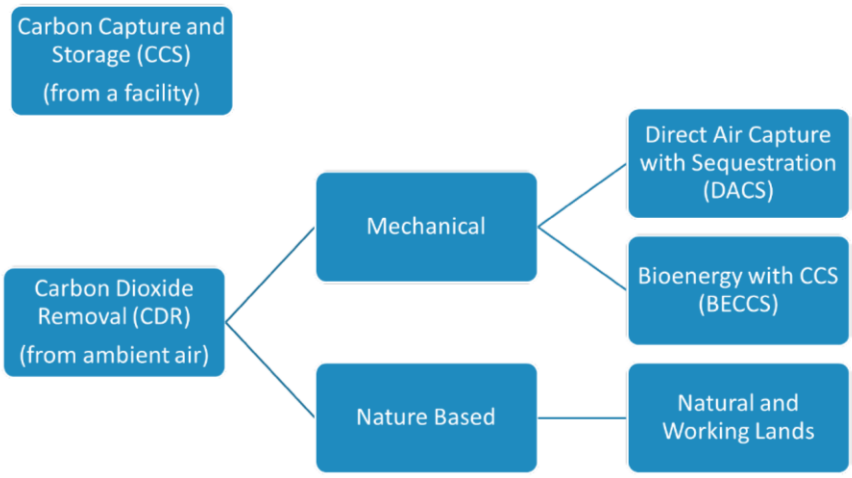
[23] AB-2251 Urban forestry: statewide strategic plan.(2021-2022), https://leginfo.legislature.ca.gov/faces/billNavClient.xhtml?bill_id=202120220AB2251

[24] "Delta" refers to the Sacramento and San Joaquin River's Delta. This feeds into the San Francisco / San Pablo Bay from the northeast. Traditionally the islands in the Delta have been drained and used for forming, but they have started being restored to natural wetlands. Other low-lying bay-front and ocean-front lands are also being restored to natural wetlands.

4. 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, and the modeling clearly shows there is no path to carbon neutrality without carbon removal and sequestration. Governor Newsom also recognized the importance of CO_2 removal strategies and directed CARB to establish CO_2 removal and carbon capture targets of 20 $MMTCO_2$ and 100 $MMTCO_2$ by 2030 and 2045, respectively, as well as signing 2022 legislation on carbon removal and sequestration, including: AB 1279, SB 905, SB 1137, and AB 1757. Carbon removal and sequestration can take different forms. Figure 2-2 below illustrates the types of carbon removal and sequestration included in this Scoping Plan. There are numerous other carbon removal options undergoing research, development, and pilot deployment. As these options mature and new approaches emerge, they can be considered in future Scoping Plan updates.

Figure 2-2: Forms of carbon removal and sequestration considered in this Scoping Plan



4.1. The Role of CCS

Carbon capture and sequestration (CCS) will be a necessary tool to reduce GHG emissions and mitigate climate change while minimizing leakage and minimizing emissions where no technological alternatives may exist. 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.[25] At this time, no CCS projects have been implemented or have generated any credits under that protocol. However, CCS projects have been implemented elsewhere since the 1970s, largely on coal-fired power plants, with over two dozen projects operational around the world. Over 100 are at the stages of advanced or early development and are expanding beyond coal-fired plants to fossil gas, fuel production, and electricity generation facilities.[26] CCS projects are in development for addressing emissions from fuel, gas, energy production, and chemical production. As of November 2019, more than half of global large-scale CCS facilities (representing approximately 22 MMTCO$_2$/yr in capacity[27]) were in the U.S., mostly as a result of sustained governmental support for these technologies.[28] This support includes the federal 45Q tax credit for CCS and research and deployment grants from federal agencies. 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$_2$.[29]

In this Scoping Plan, CCS is included to address emissions from limited sectors, including electricity generation, cement production facilities, and refineries, to ensure anthropogenic emissions are reduced by at least 85 percent below 1990 levels in 2045, as directed in AB 1279. While the modeling outputs show CCS not being applied to the electricity sector until 2045, CCS could be implemented earlier on the electricity sector with a similar ramp up over time as that for refineries and cement plants. An earlier application of CCS in the electricity sector would yield additional reductions in years prior to 2045. In addition, CCS can support hydrogen production until such time as there is sufficient renewable power for electrolysis and an abundant water source…

4.1.1. The Role for Direct Air Capture

Even if anthropogenic emissions are reduced to at least 85 percent below 1990 levels by 2045 as called for by AB 1279, there will still be residual emissions in the AB 32 GHG Inventory sectors in 2045 that must be addressed in order to achieve the California's carbon neutrality target. Figure 2-5 includes the emissions by sector for the AB 32 GHG Inventory Sectors in 2022, 2030, and 2045 for the Scoping Plan Scenario.

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[25] CARB. 2022. Carbon Capture & Sequestration. https://ww2.arb.ca.gov/our-work/programs/carbon-capture-sequestration

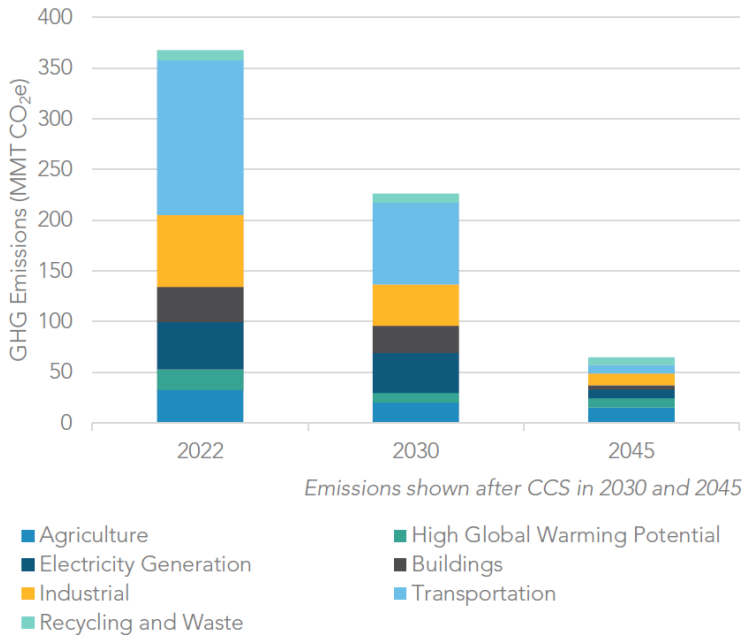
[26] Global CCS Institute. 2021. Global Status of CCS 2021. https://www.globalccsinstitute.com/wp-content/uploads/2021/11/Global-Status-of-CCS-2021-Global-CCS-Institute-1121.pdf

[27] 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

[28] 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

[29] For comparison purposes, California's emitted 418.2 million metric tons of CO2e in 2019. Also see Lawrence Livermore National Laboratory. 2020. Getting to Neutral: Options for Negative Carbon Emissions in California. Revision 1. https://gs.llnl.gov/sites/gs/files/2021-08/getting_to_neutral.pdf

Figure 2-5: Residual emissions in 2022, 2030, and 2045 for the Scoping Plan Scenario[155]



To achieve carbon neutrality, mechanical carbon dioxide removal (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. These 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.[30] As is the case with CCS, mechanical CDR technologies will need governmental or other incentive support to overcome technology and market barriers. In the United States, the U.S. Department of Energy announced financing specifically for DAC in March 2020 and March 2021. [31] Additionally, almost $9 billion in CCS support was included in the $ 1 trillion Infrastructure Investment and Jobs Act of 2021. This includes funding to establish four DAC hubs. The Inflation Reduction Act of 2022160 increases the value of the 45Q tax

[30] The National Academies Press. 2018. "Direct Air Capture and Mineral Carbonation Approaches…:" Proceedings of a Workshop, 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

[31] 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
Also 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

credit to USD 85 per metric ton of CO_2 captured and stored in geologic formations from some industrial applications and USD 180 per metric ton for DAC with storage in geologic formations. In 2021, there were approximately 19 DAC facilities globally…

4.2. CCS Targets

Recognizing the importance of CO_2 removal, Governor Newsom and the Legislature identified the need for targets to send policy and regulatory signals to pilot, deploy, and scale action for those efforts. Governor Newsom requested that CARB set a CO_2 removal and capture target of 20 MMT for 2030 and 100 MMT for 2045, first prioritizing sequestration in NWL. And while this Scoping Plan prioritizes and recommends significant increased climate-smart action on all NWL to support carbon neutrality and healthy and resilient lands, the modeling indicates that, across all NWL, lands will be a net source of emissions when accounting for both carbon sequestration and GHG (CO_2, CH_4, and N_2O) emissions from lands.

Some landscapes, however, are projected to have a net increase in carbon stocks under the Scoping Plan Scenario between 2025 and 2045 relative to the reference case, indicating that NWL actions can help California achieve Governor Newsom's CO_2 removal targets. Carbon stocks in urban forests and grasslands are projected to increase relative to historical levels from implementation of the 2022 Scoping Plan. To support the governor's CO_2 removal targets, CARB estimates that lands would contribute an average of 1.5 MMT of CO_2 removals each year between 2025 and 2045. Any carbon sequestration contributions from lands need to reflect both long-term storage and an overall net increase in carbon stocks over time to ensure these NWL actions are contributing toward California's achievement and maintenance of carbon neutrality …

For the AB 32 GHG Inventory sectors, the Scoping Plan Scenario modeling indicates that the scenario would meet or exceed the 2030 SB 32 target through GHG reduction policies without the need for CDR. CDR will, however, be necessary to increase ambition for an accelerated 2030 target and in increasing amounts over the following decades to achieve carbon neutrality by 2045.[32] 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 to provide some CO_2 removal quickly while mechanical CDR is scaled up between now and 2045. Table 2-3 provides estimates of CO_2 removal and capture needed in 2030 and 2045.

[32] The modeled scenarios assume that residual emissions will be compensated using DAC technologies by including the direct cost in terms of dollars 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 this Scoping Plan.

Table 2-3: GHG emissions and removals to achieve carbon neutrality and meet the removal targets in 2030 and 2045.	***2030 ($MMTCO_2e$)***	***2045 ($MMTCO_2e$)***
GHG Emissions	*233*	*72*
AB 32 GHG Inventory Sector Emissions	*226*	*65*
Net NWL GHG Emissions Across All Landscapes (annual average from 2025–2045)	*7*	*7*
Carbon Capture and Sequestration (CCS): Avoided GHG Emissions from Industry and Electric Sectors	*(13)*	*(25)*
Carbon Dioxide Removal (CDR) including natural and working lands carbon sequestration, Direct Air Capture, and Bioenergy with CCS (BECCS).	*(7)*	*(75)*
Net Emissions (GHG Emissions + CDR)	*226*	*(3)*

Final author's comment: The primary reference for the above (reference 1 on the first page) added many details to the above descriptions and those in Part 2. However, since I needed to keep the expansion of this series to 2 parts, I decided to exclude this. If you would like to explore this material, go through the link in reference 1, and start reading on Page 96.