Appendix C
Technical Methodology for Quantifying GHGs, Co-pollutants, and Costs

March 2026

Bay Area Regional Climate Action Plan

Measure Quantification Technical Reference Appendix to the Bay Area Regional Climate Action Plan

November 24, 2025

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Executive Summary

As part of the development of the 2025 Bay Area Regional Climate Action Plan (BARCAP), the Air District engaged ICF Incorporated, LLC (ICF) to conduct technical analyses to support the planning process. This report presents the methodologies, assumptions, and results of the analysis conducted to evaluate the greenhouse gas (GHG), co-pollutants, and cost impacts of the BARCAP measures.

The baseline for calculating estimated emission reductions from BARCAP measures is the Air District's future projections of the GHG inventory. The future projections estimate GHG emissions through 2050 and are based on the California 2022 Scoping Plan for Achieving Carbon Neutrality (Scoping Plan) Reference Scenario, with adjustments made to reflect emission changes expected from implementation of the Air District's Rules 9-4 and 9-6.[1] The state's Advanced Clean Cars II (ACCII) regulation and the Metropolitan Transportation Commission/Association of Bay Area Governments (MTC/ABAG) Plan Bay Area 2050+ are accounted for separately from the quantification of measures in the transportation sector. The 2022 Scoping Plan Reference Case includes SB100 power sector targets through 2030. Additionally, an estimate of GHG sequestration and emissions were developed for the natural and working lands (NWL) sector.

The Air District's future projections reflect reductions in GHG emissions based on a variety of factors, including expected decreases in certain activities, expected increases in technological efficiencies, and already-in-effect state and Air District policies, regulations, and programs. Across all sectors, the future projections of the BARCAP GHG Emissions Inventory show a 35% reduction in GHG emissions from 2022 to 2045.[2] Total gross GHG emissions were 54.1 million metric tons of carbon dioxide equivalent (MMTCO2e) in 2022. The largest emitting sector is transportation, followed by industry, buildings, and power. Agriculture and waste each contribute less than 5% to the GHG inventory. See Appendix A of the BARCAP for a full overview of the BARCAP GHG Inventory and Projections.

Ten measures were assessed across the buildings, transportation, waste, power, and NWL sectors. With implementation of these measures, GHG emissions decrease 40% from 2022 to 2045, with the transportation sector measures driving the largest GHG reductions. Cumulatively, they lead to an additional reduction in GHG emissions by approximately 50 $MMTCO_2e$ from 2025 through 2045. The measures focus on feasible, actionable, and widely supported strategies, many of which also complement work at the state level or remove barriers and scale projects at the local level. While they contribute significantly towards the GHG reduction targets for 2030 and 2045, they do not achieve them by themselves. Rather, the BARCAP measures are designed to help achieve the targets by working in concert with state and local actions, many of which are enabled by BARCAP measures. Table 1 shows the cumulative GHG reductions by measure.

Table 1. Cumulative GHG Reductions by Measure, 2025 - 2045

Measure	$MMTCO_2e$
B1	1.52
B2	0.09
B3	NE

T1	4.99
T2	6.84
T3	9.87
T4	NE
W1	(0.14)
W2	NE
W3	NE
P1	3.28
P2	NE
NWL1	NE
NWL2	12.22
NWL3	0.12
NWL4	11.29
Total	**50.07**

Note: NE – Not Estimated. Measures B3, T4, W2, W3, P2, and NWL1 were not estimated since they are primarily supporting measures.

In some cases, measures included in the BARCAP address GHG emissions that were not included in the GHG inventory for future emission projections. For example, measure P-1 in Table 1 includes the emission reductions associated with the installation of behind-the-meter (BTM) solar. These emission reductions result from replacing grid electricity, some of which could be generated outside of the BARCAP region, with electricity generated by solar panels on site. However, the BARCAP inventory and future projections only include GHG emissions that are generated within the region.

Further, the BARCAP region is part of the interconnected CAISO electricity system, which includes electricity that is both imported into and exported out of the region. As a result, changes in electricity supply and demand within the BARCAP region – such as increased BTM solar generation or demand from electric vehicle (EV) charging – may not directly reduce natural gas-powered electricity generation within the region. Natural gas power plants in the BARCAP region may also serve broader CAISO demand and may export electricity outside the region. Conversely, power plants located outside the region can provide electricity that is consumed within the region. Therefore, to estimate avoided GHG emissions from power plants, GHG emission reductions for measure P-1 are evaluated based on the overall consumption of electricity occurring within the region, regardless of where the electricity was generated.

Both the upfront cost of implementing measures in this plan, and any savings achieved due to decreased energy costs, were modeled and presented in terms of net present value (NPV). NPV is calculated in real dollars (2025$) using a 3% discount rate. The estimated costs to implement measures range from over $22 million for Measure B2 to over $1.4 billion for Measure T1. Implementation costs are included in GHG and Cost Quantification Methodology descriptions for each measure in this report.

Costs are estimated from a societal framing and generally include capital costs, such as upfront equipment costs, and operating costs and savings, such as impacts on fuel and electricity bills, related to measure activities. Program administration and related costs incurred during implementation of the measures are not explicitly quantified in the societal framing approach. For measure W-1 because there are no operational or capital costs the societal framing was not appropriate, and therefore program administration and related programmatic costs were used to estimate the cost to implement. Cost estimates do not consider the value of other benefits, including reduction in criteria air pollutants, improvements in public health, water quality, quality of life, and other difficult to quantify factors. Also, perhaps most importantly, the estimates do not assign dollar values for carbon removed.

Two measures, P-1 and T-2, show a net cost savings from 2025 – 2045. The net cost savings are due to initial upfront costs of implementation being offset over the longer term by savings. For example, measure P-1 shows a net cost savings of approximately $16 billion from 2025 – 2045. The overall cost savings are derived from estimated electricity bill savings resulting from on-site generation of electricity and current and projected electricity rates in the region. More details on the costs and savings associated with P-1 are shown in Table 40.

In addition to GHG emissions, emissions of criteria air pollutants and their precursors (CAPs) and toxic air contaminants (TACs) from sources covered by measures may harm public health and the environment. Like the GHG inventory, tracking these co-pollutants (CAPs and TACs) in an inventory over time provides an understanding of what pollutants are being released, how much, and their key sources.

In addition to reducing GHG emissions, the proposed measures simultaneously reduce emissions of certain co-pollutants. Cumulative reductions of co-pollutant emissions from 2025 through 2045 across the BARCAP region include: 246,000 MT of carbon monoxide (CO), 11,000 MT (metric tons) of nitrogen oxides (NO_x), 630 MT of particulate matter 10 (PM_{10}), and 120 MT of sulfur dioxide (SO_2), as shown in Table 51. The majority of these emission reductions result from reduced tailpipe emissions in the transportation sector due to increased zero-emission vehicle adoption. However, these vehicles still contribute to PM emissions through road dust and tire wear/brake wear emissions throughout the BARCAP region.

GHG and Cost Quantification Methodology, Assumptions, and Results

B-1: Support implementation of the Air District’s zero NO_x building appliances rules by addressing key challenges

Measure description: Support an equitable and affordable transition to healthy, zero NO_x water and space heating for buildings in the region by addressing key implementation challenges of the Air District’s appliance rules, which go into effect for small gas residential water heaters in 2027 and gas furnaces in 2029. Actions are informed by the Air District’s Implementation Working Group in addition to BARCAP stakeholder engagement.

Methodology for Estimating GHG Reductions

GHG emission reductions from Measure B-1 were quantified by assessing the extent to which targeted education and outreach programs can accelerate the adoption of zero NO_x appliances relative to the future projections of the GHG inventory. Changes in scope 2 emissions associated with the increases in electricity use from the implementation of this measure were excluded from this analysis.

First, the existing stock of residential gas water heaters and furnaces in the BARCAP region was estimated using data from NREL's ResStock dataset and the BayREN Existing Buildings Dashboard (Table 2). The building stock was segmented to develop separate stock turnover models for residential space heating systems, small residential water heating systems, and large residential water heating systems. Average equipment lifetimes outlined in Table 3 were applied to model the cumulative stock and annual turnover rates from 2025 through 2050. For consistency, key inputs to this model were validated and aligned with assumptions from previous reports published by the Air District.

To establish the baseline scenario, data sources from Table 2 and Table 3 were used to forecast baseline adoption of heat pump technologies prior to the compliance dates included in the Air District's zero NO_x rules. Beginning in 2027 for small gas water heaters, 2029 for gas furnaces, and 2031 for large water heating systems, heat pump technologies were assumed to replace all gas systems reaching the end of their useful life, in accordance with the Air District's zero NO_x appliance rules. Adoption curves and emission trajectories were then calibrated to align with forecasted residential natural gas combustion from the Air District's projections.

Emission reductions from Measure B-1 were evaluated along two pathways, depending on whether interventions occur before or after the Air District's zero NO_x appliance rules compliance dates.

- Prior to the start of the zero NO_x rules compliance dates, customers retain the option to replace systems with like-for-like gas equipment. In this context, emission reductions from Measure B-1 are achieved by incentivizing the early replacement of NO_x-emitting equipment with zero NO_x heat pump systems. By accelerating the transition to zero NO_x options ahead of equipment burnout, pre-rule replacements avoid emissions that would otherwise have occurred from the continued operation of gas appliances over their remaining lifetime.
- After the zero NO_x rules compliance dates, the baseline assumes that natural gas furnaces and water heaters are replaced with heat pumps at the end of their useful life. Under Measure B-1, targeted outreach and education are expected to accelerate retirements of natural gas appliances with an average estimated remaining useful life of five years. The targeted outreach and education interventions were assumed to result in the early replacement of roughly 5 percent of the eligible equipment stock each year.

Stock turnover models were used to estimate annual energy consumption by fuel type and technology. Emission impacts were calculated from avoided natural gas combustion and refrigerant leakage. All heat pumps installed after 2025 were assumed to use low-GWP refrigerants R-32 or R-454B in line with US EPA's Hydrofluorocarbon (HFC) Technology

Transitions rule under the American Innovation and Manufacturing (AIM) Act.[3] For HVAC heat pumps, no incremental leakage was assumed for homes already equipped with central AC systems.

Assumptions

- The average effective useful life (EUL) of a residential gas furnace was assumed to be 18 years, and the EUL of a gas water heater was assumed to be 13 years, consistent with Air District assumptions.
- The remaining useful life (RUL) of equipment replaced early is assumed to be five years, based on averages and industry standard practice reported in Connecticut's Measure Life Study (see Tables 2 and 3 below).
- Outreach and education efforts under Measure B-1 are assumed to drive the early replacement of five percent of each eligible equipment cohort per year.
- All heat pump systems installed after 2025 are assumed to use low-GWP refrigerants R-32 or R-454B, in line with the Technology Transitions regulations covered under the EPA's AIM Act. Regulations covered under the AIM Act require that, beginning in 2025, HVAC equipment must be manufactured using refrigerant having a GWP of no more than 700.
- For HVAC heat pumps, no incremental refrigerant leakage is assumed for households that already have central air conditioning systems. These households represent approximately 42% of the baseline housing stock, based on BayREN's Existing Buildings Study (See Table 2). Values of refrigerant charge, annual leakage rate, end-of-life leakage rate and refrigerant global warming potential (GWP), all come from California's High Global Warming Potential Gases Emission Inventory (See Table 2). Leakage rate assumptions are shown in Table 3.

Limitations

- Modeled energy savings represent averages and may not fully capture variability across building types, vintages, and occupant behaviors. Uncertainty is greater for multifamily buildings due to diverse system types and shared loads. Energy savings and costs for large heat pump water heaters are especially uncertain given the limited availability of performance and cost data.
- The assumption that outreach and education efforts under Measure B-1 will drive the early replacement of five percent of each eligible equipment cohort per year is not grounded in comparable studies or prior programs, as this type of intervention has not been widely tested at scale or in the context of a zero NO_x appliance standard.
- Upfront cost estimates for heat pumps are drawn from the TECH Clean California cost dataset[4], as reported in the Air District's report on Installation Costs for Zero NO_x Space and Water Heating Appliances, as well as data from Community Choice Aggregators (CCAs), Publicly Owned Utilities (POUs) and municipal incentive programs (see Table 6). While these estimates include the cost of panel upgrades, they may understate future costs if early adopters were more likely to live in homes with sufficient electrical capacity and thus faced lower upgrade expenses. In the TECH Clean dataset, only 4% of single-family homes undergoing space heating upgrades reported panel upgrade costs. By comparison, a 2024 UCLA study found that 32% of single-family homes in California have electrical panels of intermediate capacity (100 amps) and would likely require load management or panel optimization.[5]

Data Sources

Table 2. Data Sources for Measure B-1 GHG Quantification

Data Source	Application
NREL's ResStock Dataset 2024.2	Bay Area housing stock characteristics, including share of single-family and multifamily units, fuel mix for space heating and water heating, and average energy consumption from gas space heating and water heating appliances
NREL's ResStock Dataset 2024.1 Measure Packages	Average change in gas and electricity consumption resulting from heat pump replacements
BayREN Existing Buildings Dashboard	Number of single-family and multifamily units
Air District's GHG Inventory Projections	Baseline emission projections for residential natural gas
Air District Draft Environmental Impact Report for the Proposed Amendments to Building Appliance Rules	EUL for gas furnaces and water heaters
Connecticut Measure Life Study	Average RUL at early replacement
California's High Global Warming Potential Gases Emission Inventory	Refrigerant charge size, leakage rate, refrigerant type, and refrigerant global warming potential
BayREN Existing Buildings Study Building Characteristics Report	Share of homes with existing central AC systems
EPA's HFC Technology Transitions Regulations	Information on GWP requirements for new HVAC systems installed starting in 2025.
California's High Global Warming Potential Gases Emission Inventory	Values of refrigerant charge, annual leakage rate, end-of-life leakage rate, refrigerant type, and refrigerant GWP

Table 3. Key Modeling Assumptions for Measure B1

Key Assumptions	Value
Baseline Gas Furnace Lifetime	18 years
Baseline Gas Water Heater Lifetime	13 years
RUL at Early Replacement	5 years
Share of Homes with Existing AC	54%
HP HVAC Refrigerant Operational Leakage Rate	5.3%
HP Water Heater Refrigerant Operational Leakage Rate	1.0%
HP HVAC Refrigerant End-of-life Leakage Rate	80%
HP Water Heater Refrigerant End-of-life Leakage Rate	100%

GHG Quantification Results

Table 4. Annual Reduction in Scope I GHG Emissions from Measure B-1 (MMTCO₂e)

Source	2025	2030	2035	2040	2045
Avoided Natural Gas Combustion	.0126	.0757	.1123	.0735	.0581
Refrigerant Leakage	(.0003)	(.0017)	(.0024)	(.0059)	(.0083)
Net Emissions	.0124	.0741	.1099	.0675	.0498

Table 5. Annual Reduction in Energy Consumption from Measure B-1

Source	2025	2030	2035	2040	2045
Natural Gas (MMBTU)	238,657	1,431,944	2,122,201	1,389,427	1,098,528
Electricity (MWh)	(15,444)	(92,666)	(142,542)	(106,664)	(87,968)

Measure Cost Approach

Two types of customer costs were evaluated: upfront installation costs and long-term impacts on utility bills. Costs related to program administration or ongoing equipment maintenance were not included. Incentives were also excluded due to uncertainty regarding the availability, value, and duration of federal, state, and local funding sources. All estimates are presented in 2025 real dollars, with additional results for early replacements expressed in net present value (NPV) using a 3% real discount rate.

Upfront costs for NO_x-emitting appliances, zero NO_x appliances, and AC systems were sourced from the Air District's Implementation Working Group (IWG) 2024 Report on Installation Costs for Zero-NO_x Space and Water Heating Appliances. These estimates (shown in columns 1-3 of Table 6) were initially developed using cost data from the TECH Clean California dataset [6] and include installation, appliance, and labor expenses, as well as electrical panel upsizing where applicable (defined as an increase in capacity of at least 50 amps). These appliance cost estimates provide the starting point for the two early replacement cost calculations described below.

Table 6. Upfront Cost Inputs for Early Replacements

Appliance and Housing Type		Appliance Costs			Early Replacement Costs	
		1. NO_x Emitting	*2. Central AC[1]*	*3. Zero-NO_x*	*A. Pre-Rule Incremental Cost[2]*	*B. Post-Rule Timing Cost (NPV)[3]*
Space Heater[2]	Single Family	$10,731	$3,437	$19,640	$8,909	$2,774
Space Heater[2]	Multifamily	$10,731	$3,437	$20,676	$9,945	$2,921
Water Heater	Single Family	$5,231	$3,437	$7,071	$1,840	$999
Water Heater (Small)	Multifamily	$5,231	$0	$8,309	$3,078	$1,174
Water Heater (Large)[4]	Multifamily	$5,231	$0	$10,289	$4,020	$1,454

[1] *Incremental costs for space heating systems incorporate a weighted average cost for AC systems, reflecting the assumption that AC costs ($8,106 per unit) will be avoided in 42% of homes with existing central AC.*
[2] *Zero NO_x space heating costs were calculated as the average of ducted and non-ducted systems.*
[3] *Zero NO_x water heating costs were calculated as the average of tanked and tankless systems.*
[4]*Additional data from BAMBE program staff were used to refine cost estimates for large water heaters.*

The method for estimating upfront costs from early replacements differs depending on whether installations occurred before or after the zero NO_x rules take effect.

A) **Pre-rule period**: Before the compliance dates, households can still replace equipment with a like-for-like gas system. In this period, the upfront cost impact reflects the additional amount a household would pay to choose a zero NO_x appliance instead of a new NO_x emitting appliance. This comparison is made by subtracting the cost of the NO_x emitting appliance (columns 1-2 of Table 6) from the cost of the zero NO_x appliance (column 3 of Table 6). The resulting pre-rule incremental cost is in column A of Table 6. For space heating appliances, this comparison also accounts for avoided AC costs. 42% of homes have existing central AC and therefore avoid the $8,106 cost of purchasing a new AC system. To reflect this, a weighted average AC cost is applied (column 2 of Table 6).

B) **Post-rule period**: After the compliance dates, all replacement systems were assumed to be zero NO_x appliances. In this period, the calculations rely on a net present value framework (NPV), where the cost impact reflects the cost of replacing equipment earlier than necessary, rather than the cost of choosing one technology over another. Instead of comparing heat pumps to gas systems, the analysis compares the cost of purchasing a heat pump early versus the cost of purchasing the same heat pump five years later. These post-rule timing costs (column B of Table 6) capture only the time value of money. They are calculated by discounting the cost of the zero NO_x appliance (column 3 of Table 6) five years into the future using a 3% annual discount rate. These upfront costs appear only in the NPV results in Table 9. When expressed in real 2025 dollars, the timing cost is $0, so they do not appear in Table 8. An example of this calculation is described in Box 1.

Bill impacts were estimated based on projected changes in natural gas and electricity consumption and corresponding utility rate forecasts. For this analysis, it was assumed that early adopters of zero NO_x appliances were more likely to be higher income households that do not qualify for CARE given the high upfront costs of zero NO_x appliances. Accordingly, baseline electricity and natural gas rates were drawn from the most recent available residential rate schedules for PG&E non-CARE customers.

The CARE program provides income-qualified households in California with a 30-35% discount on electricity bills and a 20% discount on natural gas bills. Because CARE customers receive a larger discount on electricity, their bill increases from electrification are projected to be significantly lower than those of non-CARE customers.

Future rates through 2045 were projected using historical trends in PG&E prices. A key limitation of this analysis is that the relative cost effectiveness of electrification is highly sensitive to utility rate trajectories, which are subject to considerable uncertainty due to market conditions, regulatory policies, and infrastructure investment needs. In this analysis, electricity rates are assumed to increase faster than natural gas rates based on historical trends, resulting in high long-term operating costs for electrified homes and larger bill impacts over time. Additional details on cost assumptions and data sources are provided below.

Cost Assumptions

- Upfront costs include installation, appliance, and labor expenses, as well as electrical panel upsizing where applicable.
- In homes with existing central AC, incremental costs for heat pump HVAC systems reflect the avoided cost of replacing air conditioning equipment.
- Baseline electricity prices were based on the average regional non-CARE residential rate under PG&E's base plan in June 2024.
- Baseline natural gas prices were based on PG&E's non-CARE residential rate from February 2025.
- Electricity prices were assumed to escalate at 6.18% annually and natural gas delivery charges were assumed to escalate at 5.3% annually. Escalation rates were derived from E3's analysis of historical PG&E trends and converted to nominal values, assuming a 2% annual inflation rate.
- Net present value was calculated using a 3% real discount rate. These costs are shown in Table 8.

Box 1. Example HPWH Upfront Costs from the Pre-Rule and Post-Rule Periods

To help illustrate the estimated cost calculations for measure B-1, the pre-rule period and post-rule period scenarios are described in plain language in the examples below. Cost modeling used the two concepts of Incremental Costs and Timing Costs both pre and post rule scaled to the full implementation of the measure to enumerate costs.

A) Pre-Rule Period: Incremental Costs

It's 2026, and Maria's gas water heater is getting old. Wanting to be proactive and avoid the hassle of a surprise breakdown, she decides to replace it early. At this point, the zero NO_x rules have not yet gone into effect for small water heaters, so purchases of new gas systems are still allowed. When Maria shops around, she receives two quotes:

- A new gas water heater: $5,231
- A new heat pump water heater (HPWH): $7,071

The HPWH costs more upfront, so the incremental cost is the difference between the two: $1,840. Maria decides to move ahead with the HPWH and takes advantage of available rebates (not included in calculation).

B) Post-Rule Period: Timing Costs (NPV)

It's 2030, and the zero NO_x rules have now taken effect. Maria's neighbor, David, also has an older gas water heater. After seeing Maria successfully switch to a HPWH, David starts thinking about replacing his own unit. His water heater hasn't had any major issue and likely has about five years of life left. Because the rules are now in effect, any replacement David buys must be a zero NO_x system (assumed to be a HPWH). David faces two choices:

- Buy a HPWH now ($7,071) to replace his water heater early
- Buy a HPWH five years later when his water heater actually breaks down

If David replaces it early, he ends up buying the HPWH five years sooner than he otherwise would. Although he is buying the same appliance in both scenarios, buying it earlier introduces a new kind of cost: the cost of moving the purchase forward in time. Under the NPV framework, money spent in the future is worth less than money spent today, due to the time value of money. David could have used that money for something else in the meantime, like earning interest or paying down debt. To reflect this "opportunity cost," the future cost of the heat pump is discounted using a 3% annual discount rate: $\$7,071 \times (0.97^5) \approx \$6,070$.

This means that by waiting five years the new hot water heater would "cost" David about $6,070 in today's dollars. By replacing the water heater early requires him to spend the full $7,071 today. The difference ($1,001) is the timing cost of replacing the appliance early.

It is important to note that the early replacement of NO_x-emitting appliances generates the additive GHG emission reductions that are attributed to measure B-1.

Box 2. Key Differences in Key Data Inputs and Assumptions: Implementation Working Group report and BARCAP Analysis

A detailed analysis on Installation Costs for Zero-NO_x Space and Water Heating Appliances and associated bill impacts was conducted as part of the Air District's Implementation Working Group (IWG) process. While many of the same input assumptions were used across both efforts, several key findings from the IWG report are not reflected here due to differences in assumptions and scope. In particular, the IWG's findings show that many households — especially low and moderate income (LMI) households — can benefit from large rebates and bill savings, particularly if they qualify for discounted utility rates through CARE. By contrast, this analysis focuses on the subset of customers most likely to pursue voluntary early replacement. These customers are assumed to be higher-income households given the high upfront costs typically involved. As a result, households modeled in this analysis do not receive CARE discounts or rebates, which leads to higher upfront and operating costs than those shown in the IWG analysis. Other key differences are summarized below:

IWG Cost Assessment	Measure B-1 Cost Assessment
Finds that incentives can average $3,400–$13,900 per household, with the largest rebates going to LMI customers.	Rebates are excluded due to uncertainty surrounding long-term funding and the assumed income profile of customers, leading to higher upfront costs.
Evaluates bill impacts under both CARE and non-CARE rates and finds that most CARE customers see net bill savings.	Assumes all customers use non-CARE rates, resulting in high bill increases after electrification.
Segments customers by electricity usage and shows that high-usage households and those who switch to E-ELEC rates typically experience bill savings from electrification.	Does not account for usage-tier and rate-plan switching. Applies a single average electricity rate (simplified approach), which contributes to higher bill increases.
Assesses bill impacts using current or near-term utility rates.	Projects bill impacts over a longer time horizon using utility rates that increase over time. Under these assumptions, electricity rates are expected to rise more quickly than natural gas rates, resulting in substantially higher bill increases

Cost Data Sources

Table 7. Data Sources for Measure B-1 Cost Quantification

Data Source	Application
Air District Report on Installation Costs for Zero-NO_x Space and Water Heating Appliances (2024)	Installation costs for NO_x-emitting and zero NO_x HVAC and water heating appliances
E3 Report on Benefit-Cost Analysis of Targeted Electrification and Gas Decommissioning in California (2023)	Escalation rate for gas and electricity, derived from historical PG&E data
CPUC California Electric Rate Comparison	Residential electricity rates by county (PG&E Base Plan)
PG&E Rate Schedule for Natural Gas	Residential natural gas rates
US Bureau of Labor Statistics Consumer Price Index	Inflation adjustments (CPI)

Results

Cumulative costs incurred from 2025-2045 are shown in the tables below. As explained in Box 2, these results rely on a simplified set of assumptions and do not capture all cost components modeled in the IWG report.

Table 8 presents cumulative costs in real 2025 dollars. The upfront costs shown here include only pre-rule replacements (see example A in Box 1). These early replacements phase out after 2030, as the final stage of the zero NO_x rules takes effect for large HPWHs in 2031. Most of the net costs in Table 8 come from higher utility bills, driven by the higher price of electricity relative to natural gas. As described in Box 2, these bill impacts are based on a rate simplified analysis and do not account for several features of rate structures that can reduce bills for some customers.

Table 9 presents cumulative costs in NPV terms. Upfront costs are higher in Table 9 because they also include post-rule timing costs (see example B in Box 1). In contrast, bill impacts are lower in NPV terms because bill increases occur over a long period, and costs that occur further in the future are discounted, making them worth less in today's dollars.

Table 8. Measure B-1 Cumulative Costs from 2025-2045 (Million Real 2025 Dollars)

Category	Net Cost
Upfront Costs	$270
Bill Impacts	$558
Net Costs	**$828**

Table 9. Measure B-1 Cumulative Costs from 2025-2045, Net Present Value (Million Real 2025 Dollars)

Category	Net Cost
Upfront Costs	$518
Bill Impacts	$372
Net Costs	**$890**

B-2: Advance decarbonization and public health goals by integrating electrification incentives with home repair and weatherization services and other non-energy programs targeted toward low-income and disadvantaged communities.

Measure description: Perform holistic building retrofits that include energy efficiency, electrification, and home repair and remediation by braiding together and augmenting funding, services, and other assistance from existing programs. Focus retrofits in the BARCAP region's low-income and frontline communities. This measure builds on the Air District's Bay Area Healthy Homes Initiative program, and the initial buildings-focused program concept first articulated in the CPRG Priority Climate Action Plan (called the "Bay Area Clean Homes Initiative," or "BACHI"). The implementation of this measure is highly dependent on seeking and obtaining other funding sources to implement (per B-2.1). BayREN and the Air District are committed to leading this exploration in partnership with other key organizations as noted below.

Methodology for Estimating GHG Reductions

To estimate GHG emission reductions from Measure B-2, a whole-home retrofit program concept that integrates and augments funding, services, and technical assistance from existing state, federal, and local programs was developed. The approach builds on BayREN's EASE and BAMBE programs and assumes that additional resources will be leveraged from California's Equitable Building Decarbonization Direct Install program, Energy Savings Assistance, TECH Clean California rebates, Golden State rebates, USDA's Home Repair program, HEERA, HOMES Pay for Performance, and incentives from utilities and community choice aggregators. As with B-1 changes in scope 2 emissions associated with the increases in electricity use from the implementation of this measure were excluded from this analysis.

Table 10 summarizes measures included in the whole-home retrofit. All participating homes were assumed to electrify both HVAC and water heating systems, and to complete air sealing and insulation upgrades. Cooking electrification, smart thermostat, and lighting upgrades were assumed to occur in a subset of homes, based on baseline saturation levels reported in BayREN's Existing Buildings Study, ResStock, and the California Public Utility Commission's Impact Evaluation of Smart Thermostats.

Table 10. Measure B-2 Whole-Home Retrofit Measures

Measure	Base Case	Upgrade Case
Heat Pump HVAC	Gas furnace	Heat pump HVAC
Heat Pump Water Heater	Gas water heater	Heat pump water heater
Cooking Range Electrification	Gas range	50/50 mix of electric resistance and induction ranges
Lighting	100% fluorescent lighting (compact fluorescent lamps)	100% LED lighting (general service filament-LED lamps)
Smart Thermostat	Manual thermostat	Smart thermostat

Measure	Base Case	Upgrade Case
Air Sealing & Insulation	Base insulation	Attic floor insulation (R-49) and air leakage reduction (30% whole-home reduction in AC

ResStock and BayREN's Existing Buildings Study were used to characterize baseline energy use for single-family and multifamily homes and to estimate achievable savings from retrofit measures. To account for the Air District's zero NO_x appliance standards, energy savings and emission reductions were calculated separately for space heating, water heating, and other measures included in the whole-home retrofit. For HVAC and water heating electrification, calculations followed the methodology used in Measure B-1. Prior to the standards taking effect, savings were credited to early adoption of heat pumps, which displaced the full remaining lifetime of gas appliances. After the standards take effect, gas replacements are no longer permitted in the baseline scenario. In this period post rule compliance dates, savings were credited only for early retirements, assumed to occur when equipment had about five years of remaining useful life.

Because both B1 and B2 offer some of the same opportunities for emissions reductions through the early retirement of NO_x-emitting appliances, there is the possibility for overlap in how these reductions are being counted. However, in the context of the Bay Area's housing stock (over 2.7 million households), the modeled annual installations under B-1 (~14,000) and B-2 (~900) represent a small fraction of the total equipment stock, so instances of double counting are assumed to be relatively small.

For each measure completed through the whole-home retrofit, annual energy savings, avoided emissions from reduced natural gas consumption, and emissions from refrigerant leakage associated with the installation of new heat pumps were estimated. All heat pumps installed after 2025 were assumed to use low-GWP refrigerants in compliance with AIM Act regulations. No incremental refrigerant leakage was assumed for HVAC heat pumps installed in homes already equipped with central air conditioning.

Assumptions

- The modeled program was assumed to operate from 2026 through 2030, serving approximately 900 homes each year, based on input provided by the Air District. Of these, 75% were assumed to be single-family homes and 25% in multifamily homes.
- All participating homes were assumed to electrify both HVAC and water heating systems, and to complete air sealing and insulation upgrades. Cooking electrification, smart thermostat, and lighting upgrades were assumed to occur in a subset of homes, based on baseline saturation levels reported in BayREN's Existing Buildings Study, ResStock, and the California Public Utility Commission's Impact Evaluation of Smart Thermostats
- The average EUL of a residential gas furnace is assumed to be 18 years, while the EUL of a gas water heater is assumed to be 13 years, consistent with Air District assumptions.
- The RUL of equipment replaced early is assumed to be five years, based on values and industry standard practice reported in Connecticut's Measure Life Study.

- All heat pump systems installed after 2025 were assumed to use low-GWP refrigerants R-32 and R-454B to comply with the HFC Technology Transitions rule covered under the AIM Act.
- No incremental refrigerant leakage from HVAC heat pumps was assumed for homes already equipped with central air conditioning. These homes represent approximately 42% of the baseline housing stock according to BayREN's Existing Buildings Study.
- The target audience for this program is assumed to be moderate-income residents. No participants were assumed to receive discounted utility rates through the CARE program.

Limitations

- The feasibility of this program is highly dependent on the availability of state, federal, and local incentives, as well as other funding sources. Achieving the modeled participation levels will also require local staff time and resources. Both the value and duration of these funding sources remain uncertain.
- Modeled energy savings represent averages and may not capture the full variability across building types, vintages, and occupant behaviors. Savings from weatherization measures, in particular, can vary widely depending on the baseline condition of the home. Multifamily buildings also present additional uncertainty given the diversity of system types and shared loads.
- Upfront cost estimates for heat pumps include average panel upgrade costs from the TECH Clean dataset, as reported in the Air District's Installation Costs for Zero NO_x Space and Water Heating Appliances report. However, these estimates may understate future costs if early adopters were more likely to live in homes with sufficient electrical capacity and thus faced lower upgrade expenses. As electrification expands, a larger proportion of households will likely require panel upgrades.

Data Sources

Table 11. Data Sources for Measure B-2 GHG Quantification

Data Source	Application
NREL's ResStock Dataset 2024.2	Bay area housing stock characteristics, including share of SF/MF units and energy consumption from space heating and water heating appliances
Air District Draft Environmental Impact Report for the Proposed Amendments to Building Appliance Rules	EUL for gas furnaces and water heaters
California TRM, Massachusetts TRM	EUL for cooking equipment, lighting, thermostats, and insulation
Connecticut Measure Life Study	Average RUL at early replacement
California's High Global Warming Potential Gases Emission Inventory	Values of refrigerant charge, annual leakage rate, end-of-life leakage rate, and refrigerant GWP
BayREN Existing Buildings Study Building Characteristics Report	Share of homes with existing AC systems

Data Source	Application
CPUC Impact Evaluation of Smart Thermostats - Residential Sector - Program Year 2019	Share of homes with existing smart thermostats

GHG Quantification Results

Table 12. Annual Reduction in Scope I GHG Emissions from Measure B-2 (MMTCO$_2$e)

Source	2025	2030	2035	2040	2045
Avoided Natural Gas Combustion	-	.0089	.0041	.0033	.0011
Refrigerant Leakage	-	(.0002)	(.0001)	(.0005)	(.0005)
Net Emissions	-	.0086	.0040	.0028	.0005

Table 13. Annual Reduction in Energy Consumption from Measure B-2

Source	2025	2030	2035	2040	2045
Natural Gas (MMBTU)	-	166,711	76,346	62,778	19,775
Electricity (MWh)	-	(7,380)	(1,604)	(904)	342

Measure Cost Approach

The range of costs that building owners and occupants may incur when participating in a whole-home retrofit were evaluated. Costs were estimated in 2025 real dollars, and a 3 percent real discount rate was applied to calculate net present value. The analysis considered two primary components: upfront costs and bill impacts. Costs associated with program administration and ongoing equipment maintenance were not included.

Upfront costs encompass installation, appliance, and labor expenses, as well as panel upsizing costs where applicable. Incentives were excluded from the analysis due to uncertainty regarding the availability, value, and duration of federal, state, and local funding sources. For HVAC and water heating measures, incremental upfront costs were defined differently depending on whether installations occurred before or after the zero NO_x rules took effect:

- In the period prior to rule compliance dates, incremental cost was defined as the additional expense of installing a heat pump relative to the cost of replacing the unit with a like-for-like gas system at burnout.
- In the period post rule compliance dates, incremental cost was defined as the present-value difference between purchasing a heat pump early and purchasing the heat pump five years later, when the equipment reaches the end of its useful life. This approach captures the opportunity cost of spending money earlier and accounts for the consumer discount rate.

Bill impacts were estimated based on changes in natural gas use and electricity consumption. No participants were assumed to receive discounted utility rates through the CARE program, as the target audience for this program is moderate-income households. Baseline utility rates for electricity and natural gas were drawn from PG&E residential rate schedules. Electricity rates were assumed to escalate at 6.18 percent annually, while natural gas delivery rates were assumed to escalate at 5.3 percent annually.

Cost Assumptions

- Upfront costs include installation, appliance, and labor expenses, as well as panel upsizing costs where required.
- In homes with existing central AC, incremental costs for heat pump HVACs include the cost of avoided AC systems.
- Baseline electricity prices were based on the average regional non-CARE residential rate under PG&E's base plan in June 2024.
- Baseline natural gas prices were based on PG&E's non-CARE residential rate from February 2025.
- Electricity prices were assumed to escalate at 6.18% annually, and natural gas delivery charges are assumed to escalate at 5.3% annually, based on E3's analysis of historical PG&E rates.
- Net present value was calculated using a 3% real discount rate.

Cost Data Sources

Table 14. Cost Data Sources for Measure B-2 Cost Quantification

Data Source	Application
Air District Report on Installation Costs for Zero-NO_x Space and Water Heating Appliances (2024)	Upfront costs for HVAC and water heating appliances
NREL Residential Measures Database	Upfront costs for smart thermostats
RMI Green Upgrade Calculator	Upfront costs for cooking appliances
EIA Technology Forecast Updates Residential and Commercial buildings Appendix C (2023)	Upfront costs for lighting
Bay Area Residential Decarbonization Industry and Workforce Overview (2024)	Upfront costs for insulation and air sealing
E3 Report on Benefit-Cost Analysis of Targeted Electrification and Gas Decommissioning in California (2023)	Escalation rate for gas and electricity, derived from historical PG&E data
CPUC California Electric Rate Comparison	Residential electricity rates by county (PG&E Base Plan)
PG&E Rate Schedule for Natural Gas	Residential natural gas rates
US Bureau of Labor Statistics Consumer Price Index	Inflation adjustments (CPI)

Results

Table 15. Measure B-2 Cumulative Costs from 2025-2045 (Million Real 2025 Dollars)

Category	Net Cost
Upfront Costs	$ 51
Bill Impacts	$ (29)

Category	Net Cost
Net Costs	**$ 22**

Table 16. Measure B-2 Cumulative Costs from 2025-2045, Net Present Value (Million Real 2025 Dollars)

Category	Net Cost
Upfront Costs	$ 55
Bill Impacts	$ (20)
Net Costs	**$ 35**

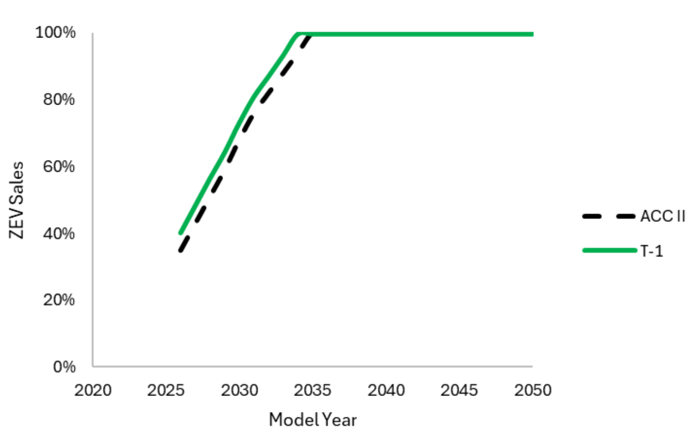
T-1: Accelerate Light-Duty EV Adoption

Measure description: Support the acceleration of light-duty electric vehicle (EV) adoptions through expanded incentives for EVs, coordinated planning for EV charging locations and installation of EV chargers to meet expected demand across the BARCAP region, and expanded support for low-income residents, frontline communities, and local governments in adopting EVs.

Methodology for Estimating GHG Reductions

California's ACC II regulation, which mandates a phased transition to zero-emission vehicles (ZEVs) with the goal of achieving 100% ZEV sales for new light-duty vehicles by 2035, is the state's approach for electrifying the light-duty vehicle market. Emission reductions from this regulation are not included in the quantification of this measure. Additionally, emission reductions that would result from the implementation of vehicle miles traveled (VMT) reducing strategies in MTC/ABAG's Plan Bay Area 2050+ are not included in the quantification of this measure. This measure evaluates the impact of accelerating the transition beyond the ACC II baseline by assuming a 6% increase in light-duty ZEV sales relative to the trajectory established by ACC II. This enhanced adoption scenario results in achieving 100% light-duty ZEV sales by model year 2034—one year earlier than the ACC II target (see Figure 1). Consistent with other measures, changes in scope 2 emissions associated with the increases in electricity use from the implementation on this measure were excluded from this analysis.

Figure 3. LDV ZEV Sales by Year



To quantify the emissions impact of this accelerated pathway, the EMFAC2021 model was used to update the electric VMT fraction for each model year. This allowed for a more precise projection of the reduction in internal combustion engine (ICE) VMT, which directly correlates to decreased fuel consumption and associated greenhouse gas (GHG) emissions. EMFAC2021 model was used to update electric VMT (eVMT) fraction for each model year and project the percentage reduction in ICE VMT and therefore, the fuel consumption and associated GHG emissions. The resulting percentage reduction was then applied to the light-duty vehicle emissions in the inventory to estimate the emissions after T-1 adoption.

Limitations

- The effectiveness of accelerated EV adoption depends heavily on timely and widespread deployment of charging infrastructure. Delays or gaps in infrastructure could limit actual EV usage and reduce expected emissions benefits.
- GHG emissions reduction estimates do not account for the emissions increase resulting from additional electricity consumption and only focus on direct tailpipe GHG emissions reductions from vehicles.

Data Sources

Table 17. Data Sources for Measure T-1 GHG Quantification

Data Source	Application
EMFAC2021 Model	BARCAP region Light-duty Vehicles Miles Traveled and Energy Consumption for Years 2025 - 2050
Advanced Clean Cars II	Projecting 6% Increased Light-duty EV Sales Compared to ACC II

Assumptions

- ZEVs exist in the vehicle fleet for the same length of time as ICEVs.
- ZEV activity/use is identical to an ICEV.
- The plug-in hybrid vehicles (PHEV) sales were assumed to grow as high as 22% following the recommended percentage[7].
- In model year 2026, a 50/50 split between blended and non-blended PHEVs is assumed. This distribution gradually shifts toward full adoption of non-blended PHEVs, reaching 100% non-blended PHEV penetration by model year 2036.
- The eVMT fraction of PHEV—representing the proportion of total miles traveled using electric power—is projected to improve over time due. For passenger cars, the eVMT fraction of PHEV increases from 60% in 2026 to 79% by 2036. For light-duty trucks, the fraction rises from 54% in 2026 to 74% in 2036.

GHG Quantification Results

Table 18. Annual Reduction in Scope I GHG Emissions from Measure T-1 (MMTCO$_2$e)

Source	2025	2030	2035	2040	2045
GHG Emissions Reduction from Fuel Combustion	-	0.14	0.27	0.35	0.40

Measure Cost Approach

- Capital costs associated with light-duty vehicle electrification were estimated by multiplying the projected number of new vehicle purchases in each model year by the average purchase price per vehicle. These costs were differentiated by vehicle class (e.g., passenger car, SUV, pickup) and engine type (e.g., internal combustion engine, battery electric vehicle, plug-in hybrid). The average cost per vehicle reflects the additional upfront cost of electric vehicles compared to conventional vehicles, accounting for technology improvements and cost declines over time.

- Electric vehicle supply equipment (EVSE) costs were estimated assuming one level 2 charger per plug-in electric vehicle.
- All capital costs were assumed to occur at the time of vehicle sale, consistent with adoption curves and equipment lifetime assumptions.
- Fuel costs were calculated by multiplying the projected annual fuel consumption for each fuel type (e.g., gasoline, diesel) by the corresponding projected cost per unit of fuel, derived from EIA's Annual Energy Outlook 2025. Electricity prices were calculated using unit prices from PG&E residential time-of-use service for plug-in electric vehicles.
- Vehicle sales and energy consumption are derived from EMFAC 2021.
- Vehicle maintenance costs were estimated by multiplying the VMT for each vehicle and engine type by an average maintenance cost per mile ($/mi). These per-mile costs were specific to each powertrain type and reflect differences in maintenance needs between electric and conventional vehicles, such as reduced brake wear and fewer moving parts in electric drivetrains. These per-mile costs were derived from Argonne National Laboratory's AFLEET[8] tool.
- Reported cost estimates represent the net change in total costs between the zero-emission adoption scenario and the reference case scenario.

Cost Data Sources

Table 19. Cost Data Sources for Measure T-1 Cost Quantification

Metric	Data Sources
Vehicle capital costs	ICF's projection of vehicle capital cost by type and fuel using AFLEET (Alternative Fuel Life-Cycle Environmental and Economic Transportation)
Projected fuel prices	EIA's Annual Energy Outlook 2025, Table 3
Electricity prices	PG&E residential time-of-use service for plug-in electric vehicles
Vehicle maintenance cost	AFLEET (Alternative Fuel Life-Cycle Environmental and Economic Transportation)

Results

Table 20. Measure T-1 Cumulative Costs 2025-2045 (Million Real 2025 dollars)

Category	Net Costs
Vehicle Cost	$2,871
EVSE Cost	$1,612
Fuel Cost	$(1,395)
Maintenance Cost	$(1,619)
Net Costs	**$1,468**

Key Takeaway

On average, approximately 278,000 light-duty vehicles are sold each year in the BARCAP region. Applying the 6% increase target means that the district would need to incentivize about 16,700 new ZEVs annually. If the district provided an incentive of $2,500 per vehicle, the annual cost would be about $40 million. Over a 25-year period, this amounts to approximately $1 billion in spending to achieve the reductions envisioned under the T1 measure by 2050. To put this in perspective, the Clean Cars for All program in the Bay Area has replaced roughly 5,000 vehicles over about 10 years (through June 30, 2025). By comparison, the T-1 measure would require replacing more than three times that number, 16,700 vehicles, in just a single year. This underscores the significant scale-up in program funding and implementation capacity that would be required to meet the T-1 goals.

T-2: Accelerate Medium- and Heavy-Duty Vehicle and Equipment Decarbonization

Measure description: Accelerate zero-emission medium- and heavy-duty vehicles and equipment adoption through expanded incentives, coordinated deployment of EV chargers and fueling infrastructure to meet expected demand across the BARCAP region, while incorporating the needs of low-income and frontline communities.

Methodology for Estimating GHG Reductions

To quantify emissions reductions from accelerated ZEV adoption in medium- and heavy-duty (MHD) vehicle sector, a scenario-based approach was developed using the EMFAC2021 model. This approach was built upon the baseline assumptions embedded in EMFAC2021. Specifically, a 5% increase in annual electric truck sales for each model year was forecasted, compared to projected sales per that year, and following the same adoption trend. This adjustment was used to estimate the resulting increase in the electric VMT fraction across the MHD fleet and associated reduction in GHG emissions and fuel consumption. Consistent with other measures, changes in scope 2 emissions associated with the increases in electricity use from the implementation on this measure were excluded from this analysis.

Assumptions

- ZEVs exist in the vehicle fleet for the same length of time as ICEVs.
- ZEV activity/use is identical to an ICEV.

Limitations

- As with LDV electrification limitations, ZEV adoption coincides with EV charger adoption and accessibility. If electric vehicle purchases are incentivized but ZEV charging and fueling infrastructure is not enhanced, actual ZEV adoption may be lower than projected. The opposite is also true – if ZEV charging and fueling infrastructure is made more widespread but ZEV purchases are not incentivized, actual ZEV adoption may be lower than projected.
- GHG emissions reduction estimates do not account for the emissions increase resulting from additional electricity consumption and only focus on direct tailpipe GHG emissions reductions from vehicles.

Data Sources

Table 21. Data Sources for Measure T-2 GHG Quantification

Data Source	Application
EMFAC2021 Model	Bay Area AQMD's Medium- and Heavy-duty Vehicles Miles Traveled and Energy Consumption for Years 2025 – 2045

GHG Quantification Results

Table 22. Annual Reduction in Scope I GHG Emissions from Measure T-2 ($MMTCO_2e$)

Source	2025	2030	2035	2040	2045
GHG Emissions Reduction from Fuel Combustion	-	0.10	0.29	0.54	0.73

Measure Cost Approach

- Capital costs associated with MHDV electrification were estimated by multiplying the projected number of new vehicle purchases in each model year by the average purchase price per vehicle. These costs were differentiated by vehicle class (e.g., Single Unit Long-haul Truck) and engine type (e.g., internal combustion engine, battery electric vehicle). The average cost per vehicle reflects the additional upfront cost of electric vehicles compared to conventional vehicles, accounting for technology improvements and cost declines over time.
- Electric vehicle supply equipment (EVSE) cost was estimated assuming one 50 kW charger per electric vehicle in Class 2b-3 and Class 4-8 Vocational. One 150 kW charger was assumed for Class 7-8 Tractor.
- Fuel costs were calculated by multiplying the projected annual fuel consumption for each fuel type (e.g., gasoline, diesel) by the corresponding projected cost per unit of fuel, derived from EIA's Annual Energy Outlook 2025. Electricity prices were calculated using unit prices from PG&E business electric vehicles schedule.
- Fuel consumption is based on EMFAC 2021.
- Vehicle maintenance costs were estimated by multiplying the VMT for each vehicle and engine type by an average maintenance cost per mile ($/mi). These per-mile costs were specific to each powertrain type and reflect differences in maintenance needs between electric and conventional vehicles, such as reduced brake wear and fewer moving parts in electric drivetrains. These per-mile costs were derived from Argonne National Laboratory's AFLEET tool.
- Reported cost estimates represent the net change in total costs between the zero-emission adoption scenario and the reference case scenario.

Cost Data Sources

Table 23. Cost Data Sources for Measure T-2 Cost Quantification

Metric	Data Sources
Vehicle capital costs	ICF's projection of vehicle capital cost by type and fuel using AFLEET (Alternative Fuel Life-Cycle Environmental and Economic Transportation)
Projected fuel prices	EIA's Annual Energy Outlook 2025, Table 3
Electricity prices	PG&E business electric vehicles schedule
Vehicle maintenance cost	AFLEET (Alternative Fuel Life-Cycle Environmental and Economic Transportation)

Results

Table 24. Measure T-2 Cumulative Costs 2025-2045 (Million Real 2025 dollars)

Category	Net Costs
Vehicle Cost	$387
EVSE Cost	$688
Fuel Cost	$(1,186)
Maintenance Cost	$(133)
Net Costs	**$(244)**

T-3: Accelerate Decarbonization of Goods Movement

Measure description: Pilot and implement policies that accelerate decarbonization of goods movement and deliveries of goods and reduce emissions that result from increased e-commerce.

Methodology for Estimating GHG Reductions

This measure consists of two key components aimed at reducing GHG emissions from medium- and heavy-duty vehicles and off-road equipment:

Electrifying Last-Mile Deliveries: To quantify the potential impact of electrifying last-mile delivery operations, the trip data from the National Renewable Energy Laboratory's (NREL) FleetDNA database were analyzed. The analysis revealed that 34% of total VMT made by medium- and heavy-duty vehicles (classes 3-8) are generated by trips under an average of ten miles in length. Assuming electrifying all these trips and accounting for the potential interaction with T-2, this measure is estimated to reduce fuel consumption of medium- and heavy-duty vehicles by 28% in 2050.

Warehouse Indirect Source Rule: This measure is targeting emissions from associated truck and equipment activity in large warehouses. Since measure T-2 is already accounting for increased electrification of MDH trucks, this measure focuses on transport refrigeration activity, with a 50% electrification of transport refrigeration units (TRUs) assumed by 2050. The Offroad Emissions Inventory database was used to estimate diesel consumption and adjust the existing sales to reflect 50% electrification by 2050.

These two electrification scenarios and their associated reductions in ICE VMT were used to project changes in GHG emissions from MHDV, as well as TRUs.

Assumptions

- All short-distance delivery trips are electrified by 2050. Annual rate of electrification adoption is assumed to follow the same trend as MHD ZEV sales (increasing until 2035 and uniform after 2035 until 2050).
- 50% of TRUs are electrified by 2050. Annual rate of electrification adoption is assumed to be an increasing linear trend from 5% eTRU sale in 2026 to 50% eTRU sale in 2050.

Limitations

- Electrification depends on timely and widespread deployment of charging infrastructure.

- FleetDNA data may not fully capture the diversity of delivery operations across different regions, fleet sizes, and business models.
- GHG emissions reduction estimates do not account for the emissions increase resulting from additional electricity consumption.

Data Sources

Table 25. Data Sources for Measure T-3 GHG Quantification

Data Source	Application
FleetDNA Database	Last-mile Delivery Operations Characteristics
EMFAC2021 Model	Bay Area AQMD's Medium- and Heavy-duty Vehicles Miles Traveled and Energy Consumption for Years 2025 – 2045
Off-Road Emissions Inventory	Bay Area AQMD's Transport Refrigeration Units (TRUs) Activity for Years 2025 – 2045

GHG Quantification Results

Table 26. Annual Reduction in Scope I GHG Emissions from Measure T-3 ($MMTCO_2e$)

Source	2025	2030	2035	2040	2045
GHG Emissions Reduction from T-3	-	0.12	0.44	0.79	1.05

Measure Cost Approach

Electrifying Last-Mile Deliveries: Approach follows the same method as T-2.

Warehouse Indirect Source Rule: The assumptions made to estimate costs associated with electrifying TRUs are based on CARB's cost documentation[9].

- Capital costs associated with TRU electrification were estimated by multiplying the projected number of new purchases in each model year by the average purchase price per TRU.
- Charger hardware and installation cost was estimated assuming one level 2 charger per eTRU.
- Fuel costs were calculated by multiplying the projected annual fuel consumption for diesel by the corresponding projected cost per unit of diesel, derived from EIA's Annual Energy Outlook 2025. Electricity prices were calculated using unit prices from PG&E business electric vehicles schedule.
- Fuel consumption is based on Off-Road Emissions Inventory.
- TRU maintenance costs were estimated by multiplying the operating hours by an average maintenance cost per hour ($/hr). These per-hour costs were specific to each powertrain type and reflect differences in maintenance needs between electric and diesel TRUs.
- Reported cost estimates represent the net change in total costs between the mitigation scenario and the reference case scenario.

Cost Data Sources

Table 27. Cost Data Sources for Measure T-3.2 Cost Quantification

Metric	Data Sources
Vehicle capital costs	CARB's cost documentation
Projected diesel price	EIA's Annual Energy Outlook 2025, Table 3
Electricity price	PG&E business electric vehicles schedule
Vehicle maintenance cost	CARB's cost documentation

Results

Table 28. Measure T-3 Cumulative Costs 2025-2045 (Million Real 2025 dollars)

Category	Net Costs
Vehicle Cost	$590
EVSE Cost	$1,153
Fuel Cost	$(689)
Maintenance Cost	$(137)
Net Costs	**$918**

W-1: Support local food and organics management

Measure description: Support local governments and food recovery organizations to more effectively meet their food recovery and composting goals and overcome implementation hurdles to implement the State of California's Senate Bill 1383 goals to reduce landfilled organic waste by 75% and recover 20% of edible food.

Methodology for Estimating GHG Reductions

Modeling of SB1383 composting targets is not included in the future projections of the BARCAP GHG inventory. The BARCAP GHG inventory also does not include waste landfilled tonnage data, which is a required input to quantify this measure. The EPA's State Inventory Tool (SIT) Projection Tool was leveraged because 1) it is based on the first order decay model which matches the framework for emission estimates from the future projections of the BARCAP GHG Inventory, and 2) it uses tonnage data as an input and has default data for the state. SIT was used to calculate the percent reduction possible (statewide) from implementing SB1383 composting targets, assuming landfill profiles are fairly consistent across the state, and applied that percent reduction to the BARCAP Inventory future projection emissions values.

To determine a potential diversion rate of compostable material, ICF used waste composition data from CalRecycle. The SB1383 organic waste diversion target of 75% was used, but delayed the attainment year to 2035, and applied that diversion rate to the share of landfilled waste that is assumed to be organic based on the composition data. The default SIT projected tonnage data was adjusted to reflect the organic waste diversion and applied the resulting change in landfill emissions to the BARCAP Inventory.

The future projections of the BARCAP inventory for composting was used to calculate an increase in composting emissions based on the amount of additional waste diverted to composting. Because SIT uses the first order decay model to estimate emissions, the waste emission reductions are spread out over decades. Therefore, during the initial years of measure implementation, the measure creates positive emissions. However, the measure causes emission reductions beginning in 2036 and the net emissions from 2025 to 2045 are negative (see Table 30).

Assumptions

- 30% of landfilled waste is compostable. Based on CalRecycle waste composition data.
- The composting rate for landfilled waste in the measure scenario increases linearly from 0% above the current existing rate in 2025 to 75% above the current existing in 2035. These are increased diversion rates above current levels.
- Assumed no improvements to compost management over time, compost emission factors stay the same.
- Assumed compost factors are the same as the BARCAP Inventory compost factors.

Limitations

- The SIT Projection Tool assumes the waste composition of all landfills is the same. The tool does not allow for variation to the waste composition. This limitation of the tool will result in an underestimation of emission reductions for this measure as organic waste generates more methane when landfilled than non-organic waste.

Data Sources

Table 29. Data Sources for Measure W-1 GHG Quantification

Data Source	Application
CalRecycle Waste Composition	Percent of landfilled waste that is compostable
Nordahl et al., 2023	Composting emission factors

GHG Quantification Results

Table 30. Annual Reduction in GHG Emissions from Measure W-1 (MMTCO$_2$e)

Source	2025	2030	2035	2040	2045
Landfill Methane Emissions	-	(0.02)	(0.02)	0.00	0.01

Table 31. Annual Reduction in Waste (tons) from Measure W-1

Source	2025	2030	2035	2040	2045
Compostable Waste	-	1,700,499	3,154,113	2,923,274	2,707,626

Measure Cost Approach

To calculate the costs of this measure, StopWaste provided cost data from similar food recovery programs. This data was used to estimate the cost of county-level government staffing, food bank participation, food recovery organization stipends, diversion strategy pilots, and food system research and marketing.

Cost Data Sources

Table 32. Cost Data Sources for Measure W-1 Cost Quantification

Data Source	Application
StopWaste	Cost data from similar organic waste diversion programs

Results

2025-2045 cumulative cost: a net cost of $58 million (2025$ real).

Table 33. Measure W-1 Cumulative Net Costs 2025-2045 (Million Real 2025 dollars)

Category	Net Costs
Total Net Cost	**$58**

P-1: Increase development of local clean energy and storage projects, including behind-the-meter and distributed energy resources

Measure description: Develop small- to medium-scale local clean energy and storage projects (<20MW) that contribute to meeting state goals and exceed anticipated behind-the-meter (BTM) deployment, and support an equitable and affordable transition to clean energy in the BARCAP region. Focus projects where it is the best possible use of land given local and regional considerations (e.g., brownfields, rooftops, parking lots, capped landfills, under-utilized plots). Clean energy and storage projects might include but are not limited to BTM (including rooftop solar), community solar, microgrids, agrivoltaics, and feed-in tariffs. These projects might include storage or storage might be deployed as a standalone project.

Methodology for Estimating GHG Reductions

As a first step, sources for current installed capacity of renewable energy and storage resources in the BARCAP region were identified. This was followed by identifying existing planning processes which forecast renewable and storage resources, preferably at the utility or zonal level. For BTM solar and storage the 2024 IEPR forecast for PG&E was used, while for utility-scale resources the California Independent System Operator (CAISO) Transmission Planning Process (TPP) Busbar Mapping was used. TPP Busbar Mapping generally locates different utility-scale renewable energy and storage resources to various zones within CAISO's footprint to identify transmission constraints and support transmission planning needed to meet state goals. For utility-scale resources, CEC data was used to identify the current installed capacity in the BARCAP region. Starting in 2030, incremental capacity by technology type was added based on the values for the PG&E Greater Bay Study Area through 2040 from CAISO TPP Busbar Mapping. For 2045, the average growth rate across the forecast period was used (the study only included capacity projections through 2040). The future emission projections of the GHG inventory are based on the 2022 Scoping Plan Reference Case, which includes SB100 power sector targets through 2030. As such, the measure modeling only includes growth in grid-scale resources after 2030, assuming the near-term capacity is already included in the baseline.

For distributed resources, the measure quantifies the avoided emissions of incremental BTM solar. To develop a BTM solar forecast, the growth rates from the IEPR 2024 Low and High scenarios were applied to the starting capacity to forecast growth in the BARCAP region through 2040. For 2045, the growth rate in 2040 was assumed to be constant (the IEPR forecast only includes capacity projections through 2040). For 2025-2030, the delta in BTM solar capacity from the Low and High IEPR scenarios was used to represent growth above what's included in the baseline. After 2030, the IEPR High forecast is used and assumed to be fully incremental.

Once incremental capacity additions were established, generation based on CEC historical capacity factors for each resource type was estimated. Avoided GHG emissions using a regional grid emissions factor (ton/MWh) were then estimated from the NREL Cambium Standard Scenarios for CAISO. This reflects the potential emissions reduced both within and outside of the BARCAP region from reduced generation from fossil fuel-fired power plants located across the region that may supply power to the BARCAP region.

Limitations

- GHG emission reduction boundary: The BARCAP region is part of the interconnected CAISO electricity system, allowing for both imports and exports of electricity. As a result, changes in electricity supply and demand within the BARCAP region – such as increased BTM solar generation or demand from EV charging – may not directly reduce natural gas generation within the region. Natural gas power plants in the BARCAP region may also serve broader CAISO demand and may export electricity outside the region. Conversely, power plants outside the region can contribute to electricity consumed within it. Therefore, GHG emission reductions are evaluated using a *consumption-based* approach to estimate avoided GHG emissions from power plants but cannot be directly compared to the Scope I GHG inventory and future emissions for the BARCAP region, since those only cover power plants located within the region.
- Developing regional estimates: The BARCAP region does not directly overlap with geographies used for electricity system operations or planning, nor jurisdictions for which data can be downloaded (i.e., county). This created challenges with allocation of existing and future generation resources in the BARCAP region. The BARCAP region includes all of Alameda, Contra Costa, Marin, Napa, San Francisco, and San Mateo counties, as well as parts of Solano and Sonoma counties. The PG&E Greater Bay Study Area seems to include all of Alameda, Contra Costa, San Francisco, San Joaquin, San Mateo, and Santa Clara counties, while the PG&E North of Greater Bay Study Area includes all PG&E territory north of the counties within the PG&E Greater Bay Study Area. Therefore, the estimated capacity to meet state goals does not perfectly represent what might be assumed for the BARCAP region. Taken together, the planning and data sources in Table 38 estimate a combined total increase of GW of up to one-third in 2030 and five times in 2045 compared to 2025 levels for clean energy and storage in the Bay Area region and some neighboring counties. This approach focuses on total capacity, while the measure focuses on small- to medium-size projects to help meet the capacity needs.
- Solar mix: The modeling does not make assumptions about the types of solar facilities that will be deployed.
    - Different BTM system types (rooftop, carport, etc.) and sizes (e.g., 10 kW residential and up to 1 MW commercial systems) will have very different project costs and impact different customer segments for potential electric bill impacts. The goals and quantification represent generic grid-connected and BTM resources and provide an indicative order or magnitude of potential emission reductions and costs. For example, installing 1,000 10 kW residential rooftop systems in one year would amount to 10 MW of BTM solar capacity and could

cost nearly $29 million for upfront system costs. Annual electric bill savings could total $8,000 per year per household. Commercial system costs and bill impacts may vary greatly depending on any needed site infrastructure upgrades, system size (could range from 100 kW to 1 MW), and utility rate structure.

- Similarly, grid-scale solar facilities face varying costs related to siting and interconnection based on size and location. At the end of 2024, the CAISO interconnection queue contained over 90 GW of active grid-scale solar capacity proposed across 279 projects, the majority of which are hybrid projects (e.g., solar+battery). Only 8 projects are less than 20 MW in size (128 MW total capacity); 29 are 20-80 MW (1.4 GW total capacity), and 242 projects are greater than 80 MW.[10] Based on NREL's capital and fixed O&M cost estimates for 2025, a 20 MW grid-scale facility would cost nearly $30 million to install, with recurring $420,000 annual fixed costs.

Data Sources

Table 34. Data Sources for Measure P-1 GHG Quantification

Data Source	Application
Busbar Mapping for the Proposed Decision 25-26 TPP Base Case	CAISO Busbar Mapping summary of the initial mapping results and data used to conduct the mapping and assess the criteria alignment. Values from the Summary_byCAISO_zone tab used to identify forecasted renewable energy resource capacity in the PG&E Greater Bay Study Area and North of Greater Bay Study Area for 2030, 2035, and 2040.
Behind-the-Meter Distributed Generation Forecast Results: High Case	CEC Behind-the-Meter Distributed Generation Forecast Results. Used the 2024 IEPR PG&E Planning Area PV and Storage Forecasts for 2023, 2025, 2030, 2035, and 2040 across the Base, Low, Medium, and High sensitivities to calculate forecasted growth rates for behind the meter solar and storage.
Utility Renewable Capacity by Type and County: 2023 | California Energy Commission GIS Open Data	CEC Utility Renewable Capacity by Type and County: 2023. Used to quantify the current capacity of utility-scale renewable energy resources in BARCAP counties.
Solar PV Capacity for Systems 1 MW and Smaller: 2023 | California Energy Commission GIS Open Data	CEC Solar PV Capacity for Systems 1 MW and Smaller: 2023. Used to quantify the current capacity of small scale (<1MW) solar PV in BARCAP counties.
California Energy Storage System Survey	CEC California Energy Storage System Survey. Used to quantify the current capacity of residential and commercial energy storage in BARCAP counties.
CaliforniaDGStats	PG&E Distributed Generation (incl. NEM/NBT NEM PV) Interconnection Data Set. Used to validate capacity of behind the meter resources in BARCAP counties.
NREL Cambium 2024 Standard Scenario	CO_2 emissions factor projection for the regional grid.

Data Source	Application
CEC Capacity Factor Data	Used to estimate generation from the new renewable resources.
NREL ATB 2024	Source for capital and operating & maintenance costs for distributed solar and grid-scale solar and wind.

GHG Quantification Results

Table 35. Annual Avoided Emissions from Power Generation ($MMTCO_2e$)

Avoided Emissions	2025	2030	2035	2040	2045
Solar	-	-	0.019	0.111	0.254
Behind-The-Meter Solar	0.004	0.019	0.076	0.087	0.065
Wind	-	-	0.048	0.032	0.016
Total	0.004	0.019	0.143	0.229	0.335

Measure Cost Approach

The costs that would be incurred to build the additional renewable resources in the region were evaluated, focusing on capital and operating and maintenance (O&M) costs. Bill impacts were also estimated based on reductions in electricity purchased from the grid due to behind-the-meter solar.

Data Sources and Assumptions

- NREL's 2024 Annual Technology Baseline was used to provide capital costs and fixed O&M costs for the new utility-scale solar, onshore wind, and behind-the-meter solar. NREL's Moderate scenario projections were used, which include declines in technology costs over time. Costs were multiplied by the new capacity coming online in the region over time.
- All costs are provided in 2025 real dollars.
- Baseline electricity prices were based on the average regional non-CARE residential rate under PG&E's base plan in summer 2024.
- Electricity prices were assumed to escalate at 6.18% annually based on E3's analysis of historical PG&E trends.

Results

2025-2045 cumulative cost: a net savings of $16 billion (2025$ real). This measure results in an overall cost savings due to the large potential for reduced electricity bills, given the region's higher than average electricity retail rates.

Table 36. Measure P-1 Cumulative Net Costs 2025-2045 (Million Real 2025 dollars)

Technology	Net Costs (2025$ Million)
Utility-Scale Solar	$10,389
Wind	$771
Behind-The-Meter Solar	$(27,238)
Total	**$(16,078)**

NWL-2: Prevent Losses of Carbon Held in NWL through Land Conservation, Wildfire Management, and Ecosystem Restoration

Measure description: Prevent losses of carbon held in NWL from development and wildfire, while managing and restoring key carbon-rich lands to maximize carbon sequestration.

This measure addresses the challenge of predicted losses of carbon stocks which are expected statewide through the mid-century. Enhancing carbon sequestration and increasing carbon drawdown must build on a foundation of protecting existing pools of carbon held in regional natural and working lands.

Methodology for Estimating GHG Reductions

The GHG emissions and carbon sequestration associated with the conservation and enhancement of the ecosystems in the BARCAP region was calculated by comparison against the business-as-usual (BAU) land use-land use change (LULUC) scenario. The BAU scenario is based upon the Tier 3 ecosystem carbon stock inventory produced for inventory year 2022 using the methodology and datasets utilized by CARB to produce the statewide ecosystem carbon inventory. Land use change was calculated from 2002 through 2022 using the National Land Cover Database[11] (NLCD) to produce the trend for land use change from 2002-2022. This trend was extrapolated through 2045 to produce the BAU scenario.

Other land cover types from wetlands could be modelled under NWL-2. NWL-2 contains actions to support the achievement of the State of California's 30 x 30 goal[12], but the impact of achieving the 30 x 30 goal was excluded from this analysis due to the varied nature of implementation and wide range of implementers (i.e. MTC cannot achieve 30 x 30 on their own, and there are many implementers working on this landscape not named in the BARCAP).

Measure NWL-2 modelled the following goals and their positive impacts upon the landscapes and ecosystem carbon stocks in the BARCAP region, these targets reflect action NWL 2.4, which contributes to achievement of targets from the 2022 San Francisco Estuary Blueprint Task 10-1,10-2, and 10-3.[13]

1. Conservation of 20,000 acres of San Francisco Bay wetlands by 2045,
2. Restoration of 28,550 acres of wetlands by 2045, and
3. Enhancement of 3,000 acres of wetlands by 2045.

While wildfire mitigation is part of NWL 2 (Action NWL 2.2*: Increase fuel management and reduce wildfire risk on natural and working lands and at the wildland-urban-interface (WUI) through new funding and financing mechanisms, workforce development, and innovation*) and can be quantified using the US Forest Service First Order Fire Effects Model (FOFEM)[14], this analysis omitted this measure quantification as the level of effort required far exceeded the scope of this project.

The land use change projection was adjusted from the BAU to quantify the enhancement of wetland systems, in alignment with NWL 2.4 (*Protect carbon held in the Bay Area's wetlands through protection, restoration, and enhancement of tidal marsh habitat*). Enhanced landscapes were assumed to be implemented on wetlands that were already in the wetland category.

Similarly to conserved lands, implementation was calculated to occur linearly from 2026 – 2045. Ecosystem carbon gains from implementation of enhancement activities were calculated using the IPCC land improvement multiplier.[15]

Assumptions

- Conserved lands were assumed to be the prevented transition of wetlands from developed lands and shrublands.
- The increased ecosystem carbon stock from avoided conversion was assumed to be the difference between the average carbon stock density of the conserved land cover category (i.e. wetlands) and the avoided conversion category (i.e. developed lands and shrublands).
- Land conservation and enhancement activities were assumed to commence in 2026 and conclude in 2045.
- The wetland restoration, enhancement, and conservation targets under this measure (28,500 acres, 3,000 acres, 20,000 acres; respectively) are consistent with Task 10-1,10-2, and 10-3 of the 2022 San Francisco Estuary Blueprint. Despite the Blueprint referencing 2050 as an endpoint, this analysis suggests 2045 instead for continuity with other metrics.

Limitations

- The BAU scenario is based on a historical trend of land use/land use change and does not account for the value of developed lands in the BARCAP region.
- This scenario analysis does not account for the impacts of climate change, wildfires, or other natural disturbances on ecosystem carbon stocks.

Data Sources

Table 37. Data Sources for Measure NWL-2 GHG Quantification

Data Source	Application
LANDFIRE Existing Vegetation Cover, Existing Vegetation Height, and Existing Vegetation Type	Used to map out precise land cover and crosswalk to the CARB database for ecosystem carbon stock by land cover type.
National Land Cover Database | U.S. Geological Survey	Create a historical land cover/land cover change trend from 2002 – 2022 for use in the BAU projection to 2045.
Aboveground live carbon stock changes of California wildland ecosystems, 2001–2010 - ScienceDirect	Ecosystem carbon stock densities of land cover types in the BARCAP region.
IPCC 2019 Refinement to the Guidelines for National GHG Inventories - Volume 4, AFOLU	Improvement multiplier for ecosystem carbon stock on wetlands that receive enhancement or restoration activities.

GHG Quantification Results

The table below shows the annual reduction in GHG emissions. Note that all measures are NA for 2025 because this analysis assumes NWL GHG reduction activities will begin in 2026.

Table 38. Annual Avoided Emissions from NWL-2 Measure (MMTCO₂e)

Source	2025	2030	2035	2040	2045
Conserve 20,000 acres of wetland	NA	0.20	0.20	0.20	0.20
Restore 28,500 acres of wetland	NA	0.36	0.36	0.36	0.36
Enhance 3,000 acres of wetland	NA	0.05	0.05	0.05	0.05
Total	**NA**	**0.61**	**0.61**	**0.61**	**0.61**

Measure Cost Approach

Cost Data Sources and Assumptions

The cost of implementation was calculated on a per unit area basis based on the best available data from published literature. Please note that the San Francisco Estuary Partnership has their own cost estimate listed as part of the 2022 Blueprint. This analysis offers a separate, but not conflicting, data point for potential cost of implementation. The 2022 Blueprint estimates an implementation cost of over $100 million each for Tasks 10-1 and 10-3, and up to $100 million for Task 10-2. While the combined cost estimate from the 2022 Blueprint is higher than the estimate from this analysis, the discrepancy in costs may have occurred due to partitioning of activities. For example, both Tasks 10-2 and 10-3 from the 2022 Blueprint seem to both consider the cost of enhancing tidal habitats, rather than breaking them out into separate cost categories. In contrast, this analysis consolidates overlapping activities into single cost categories, yielding a conservative, area-based estimate. The 2022 Blueprint is updated every 5 years; implementers may update these costs or incorporate their own analysis to reflect current research/implementation conditions.

For the purposes of this NWL-2 action, calculation of the annualized cost of implementing NWL wetland restoration and enhancement actions per year over a 20-year time horizon utilized the following multipliers:

- Conservation: $1,600/acre.
    - Cost estimate from Hansen et al. (2015)[16]. Although the suite of practices for conservation is not as well documented as restoration or enhancement, it is assumed to be less invasive and less expensive as it consists of protecting prior-existing wetlands rather than reconstructing or manipulating hydrology, vegetation, and soil to re-establish wetland functions. Hansen et al. (2015) is meant to describe conservation/restoration of new wetland, for this reason, the lower bound from that source was used. A supporting graphic (Hansen 2015)[17] from the same author further corroborates this cost estimate.
- Restoration: $2,300/acre.
    - Cost estimate from Hansen et al. (2015). In the language of the cited paper "conservation" is defined as "restoring or preserving a new wetland"; as made evident in the Hansen 2015 graphic. The upper bound from this estimated range

was used in this analysis to account for inflation since 2015. In a 2024 report on Restored Wetlands in the CA Central Valley[18], USDA NRCS cites Hansen et al. (2015) and quotes "up to $3,000" as the per-acre cost of wetland "restoration" further corroborating this assumption.

- Enhancement: $6,118/acre.
  - Cost estimate from the Delta Working Lands Program report.[19]
  - In Delta Working Lands Program report, this figure is referred to as the average cost of "wetland restoration", but the description of the implementation more accurately reflects wetland enhancement due to the heavy manipulation of soil and hydrology.

Results

Table 39. NWL-2 Measure Cumulative Net Costs from 2025-2045 (Million Real 2025 Dollars)

Action	Net Costs
Conserve 20,000 acres of Wetland	$32
Restore 28,500 acres of Wetland	$66
Enhance 3,000 acres of Wetland	$18
Total	**$116**

NWL-3: Enhance Carbon Sequestration and Reduce Greenhouse Gas Emissions through Management and Restoration of Agricultural and Working Lands

Measure description: Increase carbon draw-down into agricultural lands by scaling up climate beneficial agriculture and reducing implementation challenges, helping to achieve state and local governments' agricultural targets and goals. Explore areas to increase cross-sector benefits and GHG emission reductions through energy-efficient sustainable water management and integration of renewable energy on agricultural lands.

Action 3.1 (*Scale climate-beneficial agriculture and catalyze widespread adoption of practices that increase or maintain above- and below-ground carbon stocks, and achieve climate resilience on working lands*) calls for implementation of scaled adoption of climate-beneficial agriculture practices including silvopasture, hedgerows, cover crops, conservation cover, windbreaks, compost application, riparian forest buffer, and critical area planting.

Methodology for Estimating GHG Reductions

The quantitative GHG benefits for measure NWL 3.1 were calculated through the following quantifiable implementation actions, all summing to ~36.5% (this figure comes from a proportional scaling of the 2024 California Nature-Based Solutions Climate Targets[20] to BARCAP region crop area, as established in 2022 Inventory):

- Apply compost to 10% of croplands,
- Implement cover cropping on 10% of croplands,
- Plant hedgerows on 5% of croplands,
- Increase riparian buffers by 5% on croplands/grazing lands, and

- Implement no-till on 6.5% of croplands.

The benefits were calculated using the Tier 3, California-specific California Department of Food and Agricultures (CDFA) COMET-Planner tool[21] for the Healthy Soils Program (HSP). This is a CPRG approved tool for both GHG and cost quantification that offers the additional benefits of reflecting the unique ecosystems and implementation measures in California.

Benefits were calculated on a per unit area basis.

Assumptions

- GHG and cost benefits of measure implementation were assumed to be consistent with the outcomes estimated by the CDFA COMET-Planner tool for the Healthy Soils Program.
- Compost was assumed to be applied to 10% of croplands (~17,500 acres) from 2026 through 2045; the annual acres implemented was ~900 acres.
- Cover cropping was assumed to be implemented on 10% of croplands (~17,500 acres) from 2026 through 2045; the annual acres implemented was ~900 acres.
- Hedgerows were assumed to be implemented on 5% of croplands (~8,800 acres) from 2026 through 2045; annual acres implemented was ~400 acres.
- Riparian buffers were assumed to increase by 5% (~4,800 acres) from 2026 through 2045; annual acres implemented was ~240 acres).
- No-till agriculture was assumed to be implemented on 6.5% of croplands (~11,400 acres) from 2026 through 2045; annual acres implemented was ~570 acres.
- Compost application was assumed to be applied compost with a C/N<or=11 and purchased from a certified compost facility.
- Cover crops were assumed to be addition of legume seasonal cover crop to irrigated cropland.
- Hedgerow planting was assumed to replace a strip of cropland with 1 row of woody plants.
- Increasing riparian buffers was assumed to replace a strip of grassland near watercourses or water bodies with woody plants.
- No-till implementation was assumed to replace intensive till on irrigated cropland.
- The implementation of all practices results in a 36.5% increase of adoption on BARCAP region cropland. This figure comes from a proportional scaling of California's statewide annual healthy soils practice adoption target to BARCAP region cropland area (detailed below).
    - The figure of 36.5% was calculated based on proportional scaling from statewide to BARCAP region. Annual and perennial cropland cover ~9% of CA (9.5 million acres), and the 2024 California Nature-Based Solutions Climate Targets calls for between 140K-190K acres/year of implementation of healthy soils practices between now and 2045. Cropland covers 175,244 acres for BARCAP region (70867.52 hectares, from 2022 Inventory), and BARCAP region spans 2,751,350 acres (1,113,384.26 hectares), meaning a proportionally aligned target would be

approximately ~3,045 acres per year or ~1.74% annually (summing to ~36.5% by 2045).
  - This target is in line with the CARB 2022 scoping plan target of implementing climate smart practices for annual and perennial crops on ~80,000 acres annually.
- Percent contributions of individual practices assigned using expert judgement of feasibility and impact in the region, informed by CARB documentation.
  - All practices under this action are listed in CARB 2025 NWL Proposed Inventory for Croplands (*"Practices under this approach include compost application, cover cropping, planting of hedgerows and riparian buffers, and no-till methods, which can improve soil health, increase organic carbon content, and reduce erosion.*")[22] and also called out in CARB 2022 Scoping Plan.[23]

Limitations

- The CDFA COMET-Planner tool cannot account for variation by soil type within a county, which can vary significantly in the BARCAP region; most notably, around the organic soils of the Sacrament-San Joaquin Delta.

Data Sources

Table 40. Data Sources for Measure NWL-3 GHG Quantification

Data Source	Application
COMET-Planner (CDFA)	GHG and cost quantification for measure implementation.

GHG Quantification Results

The table below shows the annual reduction in GHG emissions. Note that all measures are NA for 2025 because this analysis assumes NWL GHG reduction activities will begin in 2026.

Table 41. Annual Avoided Emissions from NWL-3 Measure (MMTCO$_2$e)

Source	2025	2030	2035	2040	2045
Compost to 10% of croplands	NA	0.002	0.002	0.002	0.002
Cover cropping on 10% of croplands	NA	0.0004	0.0004	0.0004	0.0004
Hedgerows on 5% of croplands	NA	0.004	0.004	0.004	0.004
Increase riparian buffers by 5%	NA	0.00004	0.00004	0.00004	0.00004
No-till on 6.5% of croplands	NA	0.0001	0.0001	0.0001	0.0001
Total	**NA**	**0.01**	**0.01**	**0.01**	**0.01**

Measure Cost Approach

Cost Data Sources and Assumptions

To calculate the annualized cost of implementing each action per year over a 20-year time horizon, this analysis used the following multipliers, also from CDFA COMET-Planner (sub-bullets represent the terms used by COMET-Planner to describe the action):

- Apply compost to croplands: $750/acre.

  - From Compost Application (CDFA): Compost (C/N < or = 11) Application to Annual Crops, Purchased from a certified composting facility - 5 tons/acre
- Implement cover cropping on croplands: $309/acre.
  - From Cover Crop (CPS 340): Add Legume Seasonal Cover Crop to Irrigated Cropland - Basic (Organic and Non-organic)
- Plant hedgerows on croplands: $2,147/acre.
  - From Hedgerow Planting (CPS 433): Replace a Strip of Cropland with 1 Row of Woody Plants - Single Row (208 linear feet converted to 1 acre)
- Increase riparian buffers on croplands and grazing lands: $3,315/acre.
  - From Riparian Forest Buffer (CPS 391): Replace a Strip of Cropland Near Watercourses or Water Bodies with Woody Plants - Cuttings/Small to Medium
- Implement no-till on croplands: $95/acre.
  - From Residue and Tillage Management - No Till (CPS 329): Intensive Till to No Till or Strip Till on Irrigated Cropland - No-till or Strip-till

The screenshot below shows the costs directly from CDFA COMET-Planner for each of the actions.

NRCS Conservation Practices	Unit Value (acres or feet)	Carbon Dioxide	Nitrous Oxide	Methane	Total CO2 Equivalent	Estimated Payment*
Compost (C/N < or = 11) Application to Annual Crops, On-farm produced compost - 5 tons/acre	1 Acre(s)	2	--	--	2	$750
Add Legume Seasonal Cover Crop to Irrigated Cropland - Basic (Organic and Non-organic)	1 Acre(s)	--	--	--	--	$309
Replace a Strip of Cropland with 1 Row of Woody Plants - Single Row	208 Linear Feet	--	--	N.E.**	--	$2,147
Replace a Strip of Grassland Near Watercourses or Water Bodies with Woody Plants - Cuttings/Small to Medium	1 Acre(s)	2	N.E.**	N.E.**	2	$3,315
Intensive Till to No Till or Strip Till on Irrigated Cropland - No-till or Strip-till	1 Acre(s)	--	--	--	--	$95
Totals		5	-0	0	5	$6,616

Figure 4. CDFA COMET-Planner Source Data

Results

Table 46 below shows the total cost of implementing these actions.

Table 42. NWL-3 Measures Cumulative Net Costs from 2025-2045 (Million Real 2025 Dollars)

Action	Net Costs
Apply compost to 10% of croplands	$13
Implement cover cropping on 10% of croplands	$5
Plant hedgerows on 5% of croplands	$19

Action	Net Costs
Increase riparian buffers by 5% on croplands and grazing lands	$16
Implement no-till on 6.5% of croplands	$1
Total	**$54**

NWL-4: Expand and Maintain Urban Green Spaces While Advancing Environmental Justice Outcomes

Measure description: Increase carbon stored in urban plants and soils through expansion and maintenance of green spaces that reduce the effects of flooding and extreme heat, build food sovereignty, and beautify and connect communities. Achieve these outcomes through new regional funding, staffing, and technical assistance resources. Ensure that frontline communities benefit from urban green spaces and avoid unintended consequences by supporting a policy shift towards community-led planning to embed environmental justice and anti-gentrification approaches in urban greening.

Action 4.1 (*Expand urban green spaces and prevent loss through new regional funding and technical support, prioritizing green spaces that benefit frontline communities*) calls for the contribution to and advancement beyond state and local goals for urban forestry investment and drought resistant watering. Green spaces that may garner particular focus because of air quality, environmental justice, or climate resilience benefits include parks and trees in formerly redlined or under-greened communities, community farms and gardens, freight corridor buffers, and green stormwater infrastructure.

Methodology for Estimating GHG Reductions

This methodology calculated expansion of the urban tree canopy using the land cover classifications from the 2022 Carbon Stock Inventory for the BARCAP region conducted by ICF. The implementation of this practice targets the expansion of urban tree canopy by 15% (target set by proportionally scaling the 2024 California Nature-Based Solutions Climate Targets to BARCAP region's urban area, as established in 2022 Inventory). Linear interpolation of target between years 2026 and 2045 was assumed, with high density urban landscapes (carbon density of 0 MT CO_2e/hectare) being afforested to urban forest (carbon density of 66 MT CO_2e/hectare).

Assumptions

- All existing urban tree canopy was assumed to be conserved during the measure implementation period from 2026 – 2045.
- Urban tree canopy expansion was assumed to occur on existing developed lands; land cover change for urban tree canopy expansion was assumed not to occur. This is in alignment with the assumptions of measure NWL 2.1.
- The additional ecosystem carbon stock accrued from expansion of the urban tree canopy is assumed to be the difference between the total ecosystem carbon stock for urban forest and high density urban in the CARB database.
- This methodology assumed that implementation occurred linearly from 2026 – 2045.

- The implementation of this practice targets the expansion of urban tree canopy by 15% (and conserve existing). This figure comes from a proportional scaling of the 2024 California Nature-Based Solutions Climate Targets[24] to BARCAP region's urban area (detailed below).
  - Developed lands cover ~6% of California (6.8 million acres), and the 2024 California Nature-Based Solutions Climate Targets calls for between 52.1K-52.2K acres/year of afforestation, conservation, and urban and community greening/forestry between now and 2045. Developed lands cover 753179.155 acres for BARCAP region (304800.79 hectares, from 2022 Inventory), and BARCAP region spans 2,751,350 acres (1,113,384.26 hectares), meaning a proportionally aligned target would be ~5,779 acres/year or ~0.77% per year (~15% by 2045). This target is in line with the AB 2251 directive (Calderon, Chapter 186, Statutes of 2022)[25] which sets a target to increase urban tree canopy 10% by 2035.

Limitations

- This method does not account for annual tree growth over time.
- This method does not account for differences in urban tree carbon stock based on urban forest type (e.g. Redwood versus eucalyptus groves).
- This methodology assumed that urban tree canopy expansion occurred solely on high-density urban spaces and does not incorporate urban tree canopy densification on lands that were already classified as urban canopy.

Data Sources

Table 43. Data Sources for Measure NWL-4 GHG Quantification

Data Source	Application
Aboveground live carbon stock changes of California wildland ecosystems, 2001–2010 - ScienceDirect	Ecosystem carbon stock densities of urban landscapes in the BARCAP region.

GHG Quantification Results

The table below shows the annual reduction in GHG emissions. Note that this measure is NA for 2025 because this analysis assumes NWL GHG reduction activities will begin in 2026.

Table 44. Annual Avoided Emissions from NWL-4 Measure (MMTCO$_2$e)

Source	2025	2030	2035	2040	2045
Expand & conserve urban tree canopy by 15%	-	0.56	0.56	0.56	0.56

Measure Cost Approach

Cost Data Sources and Assumptions

To calculate the annualized cost of implementing the expansion & conservation of urban tree canopy per year over a 20-year time horizon, this analysis used the following:

- Expand & conserve urban tree canopy: $1,980.20/acre

- This figure comes from the urban greening RFP response submitted by Tree Fresno to San Joaquin Valley proposing the greening of 505 acres with $1M. Tree Fresno went on to win this work and is currently under contract.[26]

Results

Table 45. NWL-4 Measure Cumulative Net Costs from 2025-2045 (Million Real 2025 Dollars)

Action	Net Costs
Expand & conserve urban tree canopy by 15%	$228

Other Measures

Greenhouse gas emissions and potential costs to implement were not assessed for five measures in the BARCAP. Measures T-4, B-3, W-2, P-2, and NWL-1 are considered supporting measures without direct GHG emission reductions themselves. As a regulatory measure, estimates of GHG reductions and costs for *W-3: Reduce Methane Emissions from Waste Management Facilities* require more detailed exploration of the options to minimize emissions of methane, volatile and toxic organic compounds, and odorous substances from organic waste handling facilities, including large composting facilities, which the Air District will conduct at a future date. Costs to implement were not estimated for supporting measures since quantifying costs requires a similar level of detailed assumptions as those used to quantify GHG reductions.

Co-Pollutants Impacts Quantification

In addition to greenhouse gases (GHGs), emissions from criteria air pollutants and their precursors (CAPs) and toxic air contaminants (TACs) can pose serious risks to public health and the environment. Like GHG inventories, tracking these co-pollutants over time helps identify what pollutants are being emitted, in what quantities, and from which key sources.

These two categories of air pollutants impact both human health and the environment:

- **Criteria Air Pollutants and their Precursors (CAPs)** include ozone, particulate matter ($PM_{2.5}$ and PM_{10}), carbon monoxide (CO), nitrogen oxides (NO_x), sulfur dioxide (SO_2), and lead.
- **Toxic Air Contaminants (TACs)** include over 180 chemicals such as benzene and mercury, many of which are known to cause cancer and other serious health effects.

Two examples of important co-pollutants to assess include:

- Volatile Organic Compounds (VOCs) are gases emitted from sources such as fertilizers, paints, cleaning supplies, fuels, and building materials. VOCs react with NO_x to form ozone (a CAP), and some—like benzene and formaldehyde—are classified as HAPs.
  - The California Air Resources Board (CARB) does not report VOC emissions separately. Instead, it reports Total Organic Gases (TOG), which includes all gaseous organic compounds—both reactive and non-reactive. TOG encompasses compounds like methane and ethane, which are typically excluded from regulatory VOC definitions due to their low reactivity. For ozone-related analyses, CARB uses Reactive Organic Gases (ROG)—a subset of TOG limited to compounds that contribute to ozone formation. While TOG provides a comprehensive estimate of total organic emissions, it may overstate VOC levels compared to federal or regulatory definitions.
- Ammonia (NH_3) contributes to the formation of $PM_{2.5}$ (a CAP) by reacting with NO_x and SO_2 in the atmosphere.

Table 50 provides a summary of co-pollutant emissions in the region by sector and pollutant, with a focus on criteria pollutants. The data is compiled from the Air District's Emissions Lookup Tool[27].

Table 46. Bay Area Regional Co-Pollutant Emissions (Short Tons), 2022

Category	CO	NO_x	PM_{10}	$PM_{2.5}$	SO2	NH3	TOG
AFOLU (Agriculture, Forestry, and Other Land Uses)	4,412	1,039	2,780	649	17	2,576	14,218
IPPU (Industrial Processes and Product Use)	51,613	9,547	6,554	2,024	1,897	8	6,956
Mobile	193,890	40,043	10,443	2,243	961	1,778	16,386

Category	CO	NO_x	PM_{10}	$PM_{2.5}$	SO2	NH3	TOG
Stationary	131,115	8,920	3,176	2,660	313	4,074	64,310
Waste	544	262	1,193	231	232	535	64,421
Total	**381,574**	**59,813**	**24,145**	**7,808**	**3,420**	**8,972**	**164,293**

Methodology for Estimating Co-Pollutant Impacts

This analysis covers the entire geographic area of the BARCAP region and evaluates potential changes in co-pollutant emissions resulting from implementation of mitigation measures for the plan as a whole. The sections below describe the methodologies used to estimate changes in co-pollutant emissions. Cumulative emission reductions by pollutant across the BARCAP region are presented below.

CAPs were quantified because they are common pollutants with widespread public health impacts, causing respiratory and cardiovascular diseases, asthma aggravation, and premature death. Their reductions are directly linked to clear public health benefits and regulatory air quality standards, supported by well-established emissions factors and monitoring methods. TACs which tend to be emitted in smaller quantities with more complex sources lack widely available emissions factors, making their reductions harder to quantify.

Although TAC reductions are not quantitatively represented, the reduction of TACs that will result from the implementation of BARCAP measures will still be beneficial. Reducing energy use in buildings by increasing efficiency and transitioning to cleaner energy sources lowers the need for burning fossil fuels, which in turn can decrease emissions of TACs like formaldehyde, benzene, and other hazardous substances. When more electric vehicles are used and vehicle miles traveled decrease, emissions of hazardous air pollutants from gasoline and diesel engines, such as 1,3-butadiene, acetaldehyde, and benzene, are also reduced. These shifts generally improve air quality, lessen the public's exposure to a variety of air toxics, and support better respiratory and overall health outcomes, particularly in densely populated or heavily trafficked areas.

For PM, the values throughout the report represents the total for $PM_{2.5}$ and PM_{10} because AP-42 emission factors from EPA are not always broken out by $PM_{2.5}$ or PM_{10}. To ensure consistency across sectors, all PM is reported as PM_{10}, since PM_{10} includes all particles with diameters up to 10 micrometers, and therefore encompasses $PM_{2.5}$. However, this approach limits the ability to evaluate potential health impacts specific to fine particulates ($PM_{2.5}$), which differ from those associated with coarse particles. This limitation is acknowledged in interpreting results related to PM exposure and health outcomes.

On-Site Fuel Combustion

The following steps were used to quantify co-pollutant emission reductions from reduced on-site fuel combustion:

- Quantify Fuel Savings: Calculate the amount of each fuel type saved by comparing the baseline scenario to the mitigation scenario.
- Apply Emission Factors: Use standard EPA AP-42[28] emission factors for each fuel type to estimate emissions of NO_x, SO_2, lead (Pb), CO, and particulate matter (PM) that would have occurred without mitigation.
- Calculate Emissions Reductions: Multiply the amount of fuel saved by its corresponding emission factor to estimate the avoided emissions for each pollutant.

Mobile Source Emissions

To estimate reductions from mobile sources:

- Co-pollutant inventory data from CARB was used to determine emissions per vehicle mile traveled (VMT) for each vehicle type in the baseline year (e.g., grams of CO per passenger vehicle mile in 2025).
- Emission rates were calculated by dividing total pollutant emissions by total VMT for each vehicle category.
- These rates were then multiplied by the reduction in VMT (i.e., baseline or "business-as-usual" minus mitigation scenario) to estimate avoided emissions for each vehicle type.
- The current methodology estimates avoided emissions by applying standard EMFAC and EPA AP-42 emission factors to the amount of fuel saved. However, this approach does not account for the additional emission controls already implemented under the Air District's regulatory programs, which often result in lower effective emission rates than the AP-42 "controlled" factors. As a result, the methodology may overstate baseline emissions and the magnitude of co-pollutant reductions relative to local conditions. Unlike the Air District's approach, which applies locally derived control efficiencies and source-specific data to develop representative emission factors, this simplified method prioritizes consistency and transparency but acknowledges reduced accuracy in reflecting the Air District's actual emissions profile.

Waste

To estimate emissions reductions from solid waste measures:

- Quantify Waste Diverted: Determine the amount of waste prevented from entering landfills due to waste reduction initiatives.
- Estimate Avoided Methane Generation: Estimate the methane that would have been generated by the landfilled waste, assuming that 50% of landfill gas is methane. Any additional savings of co-pollutants that are not combusted will depend on the nature of how measure W3 may be implemented, which is not known as this time, adding to the uncertainty of these results.
- Apply Emission Factors: Use standard EPA emission factors to estimate emissions of NO_x, CO, and PM from flaring the methane that would have been produced.

Natural Lands

To assess the co-benefits of natural and working lands, EPA's i-Tree Landscape Module was used to estimate ecosystem services provided by increased tree cover. The assessment was conducted at the county level and looked at annual avoided runoff, rainfall interception, transpiration, and air pollution removal. The results showed that annually there would be 2,118 MG/yr of avoided runoff; 71,111 MG/yr of rainfall interception; and 112,283 MG/yr additional transpiration, which helps combat urban heat island effects, enhance stormwater management by managing water volume, and improve water quality by reducing stormwater runoff and promoting infiltration. i-Tree was selected for its ability to provide standardized, spatially explicit estimates across large areas. i-Tree is an industry standard tool (employed by the California Air Resources Board NWL inventories for 2018[29] and proposed for use in 2025[30]) and was selected for use in this work to balance statewide consistency with administrative overhead. By relying on one unified data source, the use of i-Tree in this work eliminates the need to merge multiple empirical, remote-sensing, or process-based models across fragmented urban parcels, reducing uncertainty introduced by mixed data resolutions and overlapping estimation methods.

Electricity Demand Changes

Measures such as building and transportation electrification and behind-the-meter solar installations lead to changes in electricity demand. This in turn changes how power plants across the broader regions – within and outside of the BARCAP region – operate. Because the changes in power plants occur across a broader region and not just within the BARCAP region, these co-pollutant emission changes are reported separately, although a portion would likely occur within the region.

On net, electricity demand increases with measure implementation of building and transportation electrification, leading to increased co-pollutant emissions. Consistent with the methodology used for GHG emissions, changes in co-pollutant emission associated with the increases in electricity use from the implementation of this transportation and building measures were excluded from this analysis. This is a potential disbenefit to communities that live around power plants that increase their output to meet this increased electricity demand and emphasizes the importance of measure P-1, which focuses on increasing the amount of clean energy capacity deployed.

- Projected changes in the electricity grid mix from NREL's Cambium Standard Scenarios were used to estimate the net change in co-pollutant emissions across the broader power grid (which extends beyond the BARCAP region) needed to meet the increased demand.
- Emissions results are shown in Table 52 below.

Results

The co-pollutant emissions reductions from energy use reduction shown in the table results below are primarily from using less fossil fuel-intensive fuels, such as natural gas in buildings and gasoline and diesel in vehicles. These fuel shifts reduce overall fossil fuel consumption and associated emissions. In contrast, removals from natural and working lands (NWL) do not directly decrease pollution emissions but instead absorb air pollutants already released, providing complementary environmental benefits.

Table 47. Cumulative Changes in Co-Pollutant Emissions (MT), 2025-2045

Pollutant	Cumulative Reductions from Change in Energy Use	Removals from NWL
CO	245,971	14,827
NO_x	11,463	85,554
PM_{10}	630	143,734

Pollutant	Cumulative Reductions from Change in Energy Use	Removals from NWL
SO_2	123	20,300
Lead	0.01	0

Table 48. Indirect Changes in Power Sector Co-Pollutant Emissions (MT), 2025-2045

Pollutant	Cumulative Increase (MT)
NO_x	1,027
SO_2	130
PM_{10}	234
NH_3	158
VOC	76

Analysis of BARCAP Region's Contributions to State Goals by 2030

The state of California has statewide GHG emission reduction targets of 40% below 1990 levels by 2030 and carbon neutrality by 2045, with most of the goal being achieved by reducing direct GHG emissions by 85% below 1990 levels. The BARCAP aligns with and contributes to achieving the state targets. A series of sector-specific goals and the 2022 Scoping Plan (Scoping Plan) lay out the state's pathway to meet these targets, which relies on state, regional, and local action.

This first analysis examines the GHG emissions impact of meeting key sector-specific state goals in the BARCAP region. These goals were referenced in each sector chapter of the BARCAP. [31] Table 53 shows these key sector-specific state goals downscaled to the region and quantified. While meeting most goals would reduce GHG emissions, realizing the medium- and heavy-duty vehicles and landfill methane goals would result in increased emissions in 2030 as compared to 1990. For medium- and heavy-duty vehicles, this is due to the growth in numbers of medium- and heavy-duty vehicles in 2030 as compared to 1990 and for landfills methane, this is the result of organic materials that already exist in the landfills breaking down. When considered together, the regionally scaled goals listed below in Table 53 nearly achieve a 40% reduction in 2030 as compared to 1990.

Table 53. Statewide Sector-Specific 2030 Goals Scaled to the Region and Quantified

State Goal or Result	Regionally Scaled Goal or Result	Emission Reductions from Achieving Regionally Scaled Goals (MMT CO_2e)
7.1 million Light-Duty (LD) ZEVs by 2030[32]	1.1million LD EVs	12.2
155,000 Medium- and Heavy-Duty (MHD) ZEVs by 2030[33]	23,000 MHD EVs	-1.3
Deploy 6 million heat pumps and 3 million climate-ready homes[34] by 2030	900,000 heat pumps	5.9

State Goal or Result	Regionally Scaled Goal or Result	Emission Reductions from Achieving Regionally Scaled Goals (MMT CO_2e)
60% RPS by 2030[35]	60% RPS	1.8
75% waste diversion by 2025 with 20% food recovery[36]	75% diversion	0.1
40% reduction in statewide methane emissions below 2013 levels by 2030[37]	10% landfill methane control	-0.3
Industrial emissions reductions from Scoping Plan by 2030	47% reduction from 1990	7.9

The BARCAP measures help achieve the regionally scaled goals and support implementation of the Scoping Plan. For example, the state has a goal of deploying 6 million heat pumps statewide by 2030, which is roughly 900,000 heat pumps in the BARCAP region. Modeling of estimated early replacements of fossil fuel-based water and space heaters plus implementation of the Air District's Rules 9-4 and 9-6 and BARCAP measures B1 and B2 aligns with this goal. When modeling implementation of ACCII and T1, the region would adopt nearly 800,000 LD EVs by 2030, well on the path to contributing to state goals. Local actions to increase charging infrastructure are a key enabling factor to successfully achieve this goal.

The BARCAP measures also help to create enabling conditions to achieve specific state and local government climate policies and goals. This is done by focusing on what must happen regionally to support local implementation of state policies and initiatives and ensure that implementation is efficient, effective, and equitable. Though some BARCAP measures will have a direct GHG emission reduction on their own, many will also complement work at the state level or remove potential implementation barriers at the local level.

Since meeting the key sector-specific state goals scaled to the region would not achieve the state target for 2030, as shown in Table 53, a second analysis was done to show the emission reductions by sector for the BARCAP region if state, regional, and local actions are successful in fully implementing the Scoping Plan. The sector-specific emission reduction trends shown in Table 54 include the expected emission reductions for the regionally scaled goals shown in Table 53, as well as additional actions that the state has identified to fully achieve the 2030 goal statewide. When applied to the BARCAP region's GHG inventory, the emission reduction trends from the Scoping Plan demonstrate the level of reductions that might be expected to occur in the region from implementation of state policy and regulations, the BARCAP, and local climate action plans. This analysis shows that when taken together, state, regional, and local action could achieve a 45% reduction in total GHG emission reductions below 1990 levels in 2030, surpassing the state goal. Note that the significant increase in high GWP gases is due to the increase in the use of these gases as refrigerants in 2022 and 2030 as compared to 1990.

Table 54. Scoping Plan Aligned Projections for the BARCAP Region (MMTCO2e)

Sector	1990	2022	2030	% Change in 2030 from 1990
Agriculture	1.72	1.14	0.71	-59%
Power	8.17	7.08	5.92	-28%

Industrial	17.04	16.25	9.10	-47%
Waste	1.86	1.93	1.80	-3%
Buildings	8.56	7.92	6.04	-29%
Transportation	24.23	16.77	8.86	-63%
High GWP	0.19	3.01	1.47	681%
Total	**61.77**	**54.11**	**33.89**	**-45%**

The next update to the Scoping Plan is scheduled for 2027 and will incorporate the latest market trends, technological advancements, and any updates to state policies or emission targets. The state remains firmly committed to achieving its GHG reduction goals, and the BARCAP region will continue to play a critical role in supporting its success. The measures included in the BARCAP report will build upon implementation of state regulations and policies, working towards a more resilient, equitable, and low-carbon future for the region.

Methodology

Regionally Scaled Goals and Results

The sector goals shown in Table 53 were identified as key activity targets or sector results from state goals and state modeling for the Scoping Plan. To downscale these goals and results to the BARCAP region, the following approach was taken for each sector:

- ZEV Goals: Statewide ZEV adoption goals for 2030 were downscaled to the BARCAP region based on the region's population share (~15%). Using the EMFAC2021 model, the ZEV population and electric VMT fraction for 2030 were updated, and the percentage reduction in ICE VMT, along with the corresponding decrease in fuel consumption and associated GHG emissions, were estimated. This percentage reduction was applied to the vehicle emissions inventory to calculate the projected GHG reductions.
- Buildings Goal: Statewide heat pump deployment goals for 2030 were downscaled to the BARCAP region based on the region's population share (~15%). Emission reductions are inclusive of the future projections, which include the impact of Rules 9-4 and 9-6, and the impact of the building sector measures.
- Power Goal: The state's goal for the power sector for 2030 is reflected in the Renewable Portfolio Standard, which looks to source 60% of electricity from renewable energy by 2030. The GHG reductions for 2030 were taken from the Air District's GHG inventory and projections, which are based on the 2022 California Scoping Plan Reference Scenario. The Scoping Plan Reference Scenario incorporates the 2030 Renewables Portfolio Standard (RPS) target.
- Waste Goal: The state's 75% waste diversion goal by 2025 was applied directly to the BARCAP region. EPA's SIT Projection Tool was used to assess the potential GHG emissions benefit by 2030 of the waste division goal applied to the BARCAP region's waste generated tonnage. This is the same method used to quantify the GHG reductions from measure W1, and more detail can be found in that section. The main difference is that measure W1 delayed attainment of the 75% target to 2035, whereas for this 2030 analysis, the 2025 goal date was used.

The statewide methane reduction target was not directly applied to the BARCAP region. Rather, the Scoping Plan assumption of 10% landfill methane control was used to estimate potential GHG reductions by 2030. The GHG reductions for 2030 were taken from the Air District's GHG inventory and projections, which are based on the 2022 California Scoping Plan Reference Scenario. The Scoping Plan Reference Scenario incorporates the 10% landfill methane control assumption.

- Industry: Since the state does not have any GHG goals for the industrial sector by 2030, the Scoping Plan projections were used to define a benchmark GHG reduction for 2030. The Scoping Plan trendline for the state from 2022-2030 was applied directly to the BARCAP 2022 inventory. The Scoping Plan trendline was sourced from the pathways analysis[38] and compared to the state's 1990 GHG inventory data[39] to assess GHG reductions from 1990 to 2030, which showed a 47% reduction in GHG emissions.

Scoping Plan Aligned Projections

To provide a trajectory of BARCAP region GHG emissions by 2030 that align with the Scoping Plan assessment, the Scoping Plan[40] GHG trendline for the state from 2022-2030 by sector was applied directly to the BARCAP GHG inventory to develop projections to 2030 by sector.

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